MENINGKATKAN INOVASI DALAM PERKHIDMATAN MENGGUNAKAN TRIZ

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Jabatan Kejuruteraan Mekanikal dan Pembuatan

Universiti Putra Malaysia

Теория Решения Изобретательских Задач

TRIZ Level 0.5

Theory of Inventive Problem Solving

Innovation

all innovations emerge from the application of a very small number of inventive principles and strategies.

TRIZ Agenda

Time	Agenda
0830 – 0900	Registration
0900 – 0915	Welcome and Introduction
0915 – 1045	Basic Concept of TRIZ
1045 – 1100	Break
1045 – 1115	Level of Innovation
1115 – 1200	Function Analysis
1200 - 1300	Cause & Effect Chain Analysis
1300 – 1400	Lunch
1400 – 1430	Trimming
1430 – 1450	9 Windows
1450 – 1500	Break
1500 – 1545	S Curve
1545 – 1630	40 Inventive Principle

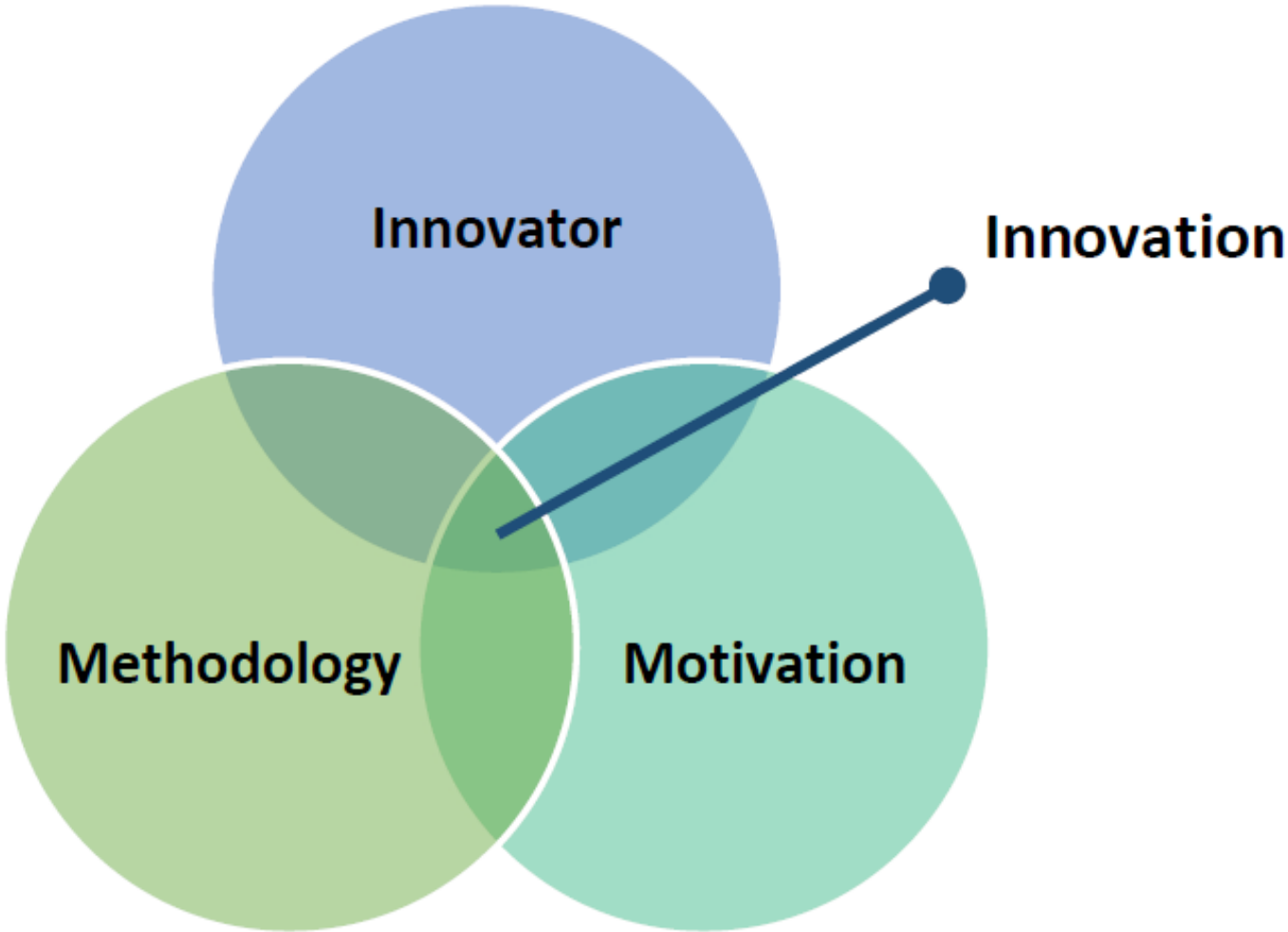
Introduction

What is innovation?

The process of translating an idea or invention into a good or service that creates value or for which customers will pay.

What is the different between Research and Innovation?

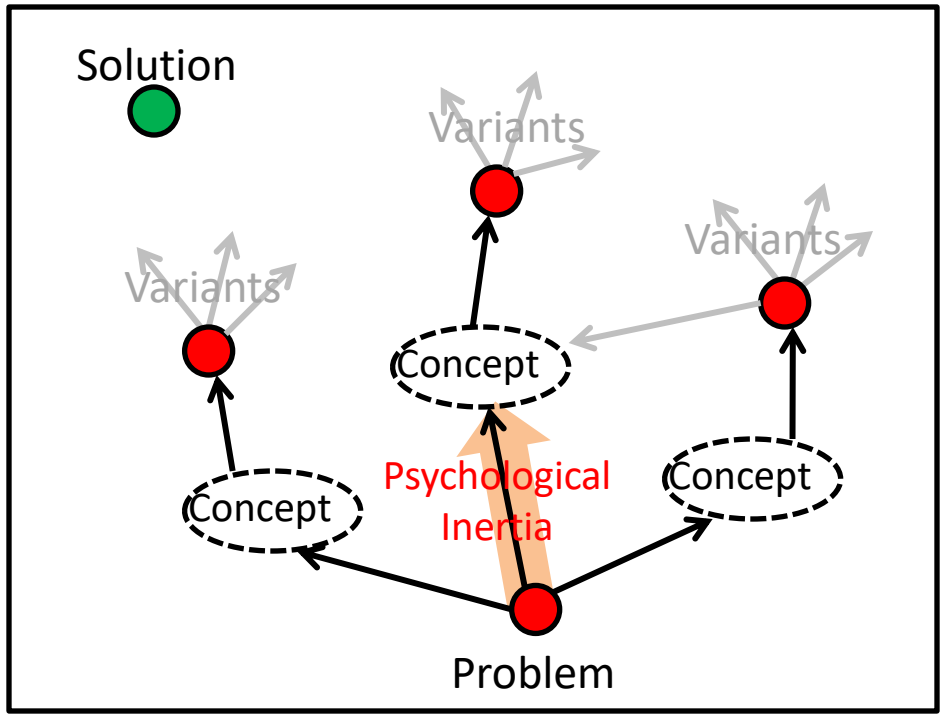
Think outside the box!!!
National Blue Ocean Strategies
Industry 4.0
Society 5.0

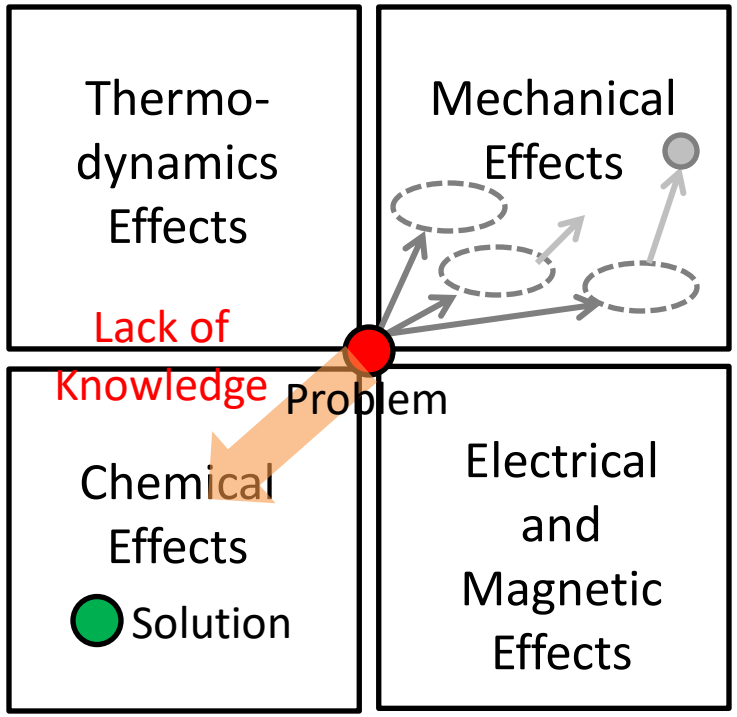


Elements of Innovation in Education Framework

Limitation of usual problem solving methods

- Lack of knowledge
- Wrong objective or goal
- Avoid conflict or contradiction
- Do not know actual root cause
- PSYCHOLOGICAL INERTIA





Psychological Inertia

- The barrier created by the mind when there is an attempt to break the current state to enter a new state.
- *Inertia* is the state of rest so long and until an external force acts upon it. Therefore *Psychological Inertia* is a lack of required action.

- Normally they expect others to think similar to what they are thinking.

For Example: Psychological Inertia

- Remaining in our comfort zone
- “This is the way we’ve always done it”
- “Don’t rock the boat” or “If it ain’t broke, don’t fix it”
- Result of life experiences / Educational backgrounds

Why is this so difficult?

- What if Kodak had left its comfort zone and pursued what its own R&D was telling it about the future?

Kodak Digital Camera —

B1 (Official Form 1) (12/11)

UNITED STATES BANKRUPTCY COURT
Southern District of New York

Name of Debtor (if individual, enter Last, First, Middle):
Eastman Kodak Company

All Other Names used by the Debtor in the last 8 years
(include married, maiden, and trade names):

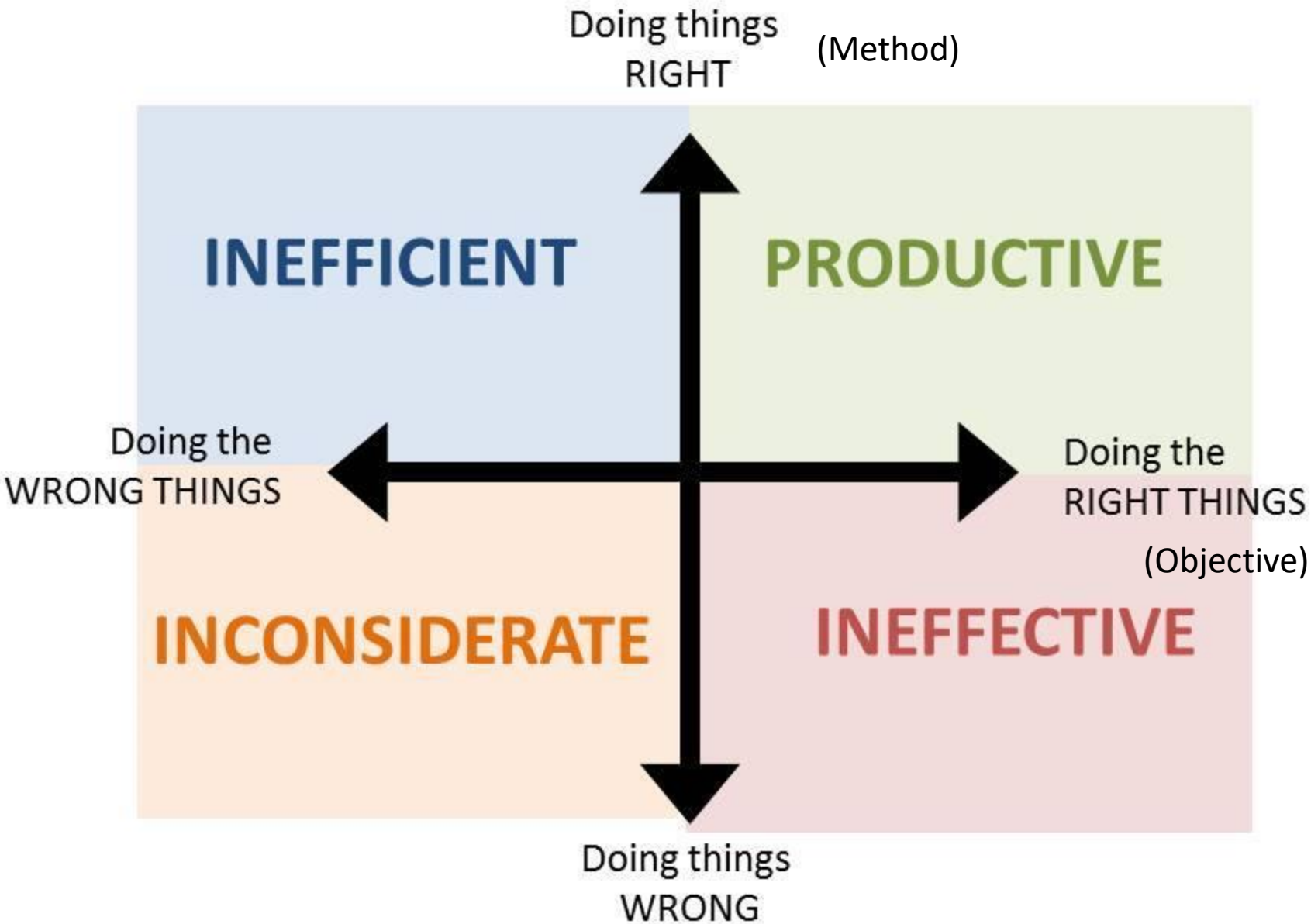
Last four digits of Soc. Sec. or Individual-Taxpayer I.D. (ITIN)/Complete EIN
(if more than one, state all):
16-0417150

Street Address of Debtor (No. and Street, City, and State):
343 State Street
Rochester, New York

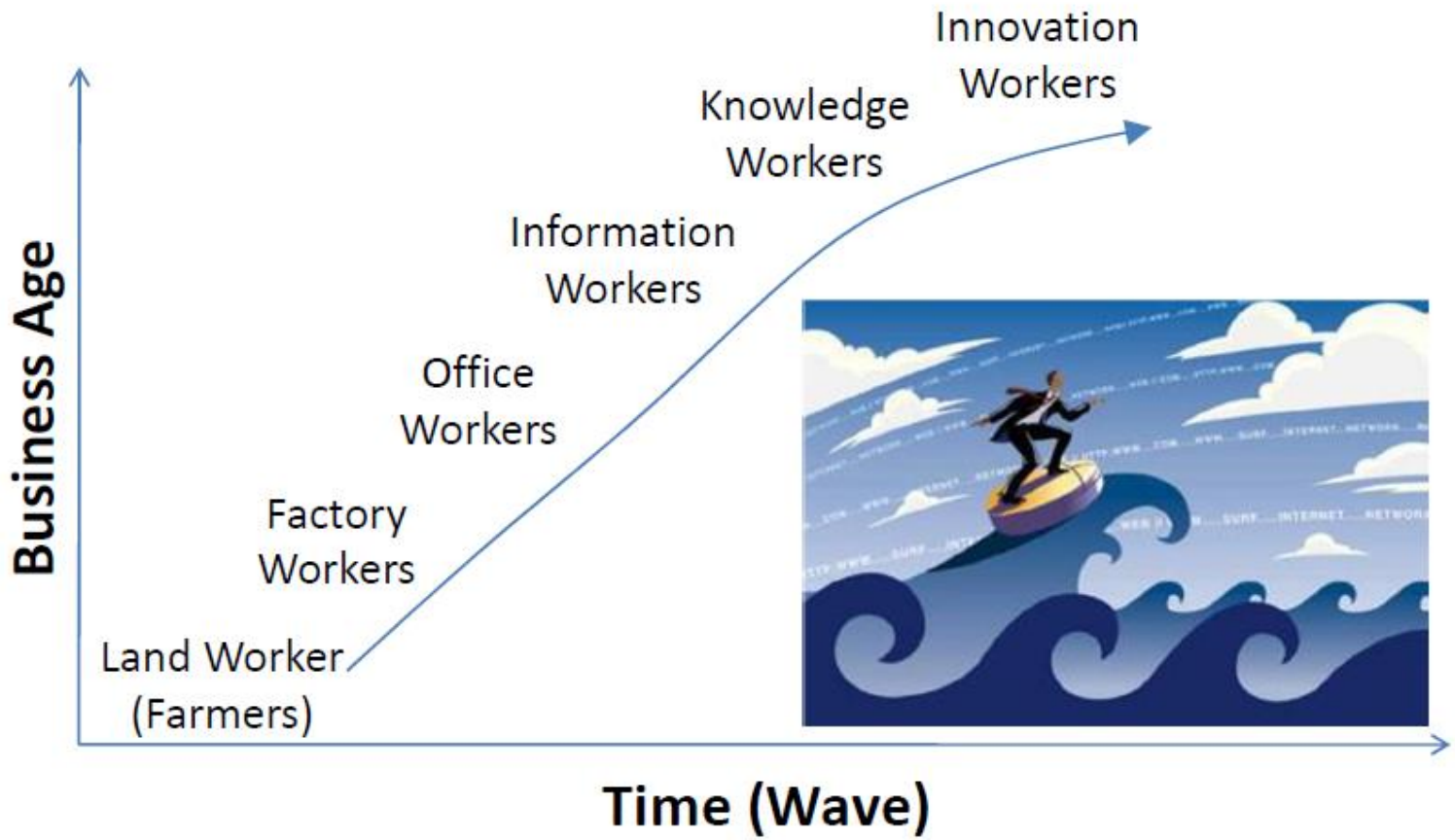
ZIP CODE 146

County of Residence or of the Principal Place of Business:

Kodak Bankruptcy Filing —


Doing things
RIGHT
(Method)
INEFFICIENT
PRODUCTIVE
Doing the
WRONG THINGS
Doing the
RIGHT THINGS
(Objective)
INCONSIDERATE
INEFFECTIVE
Doing things
WRONG

Business Age Evolution

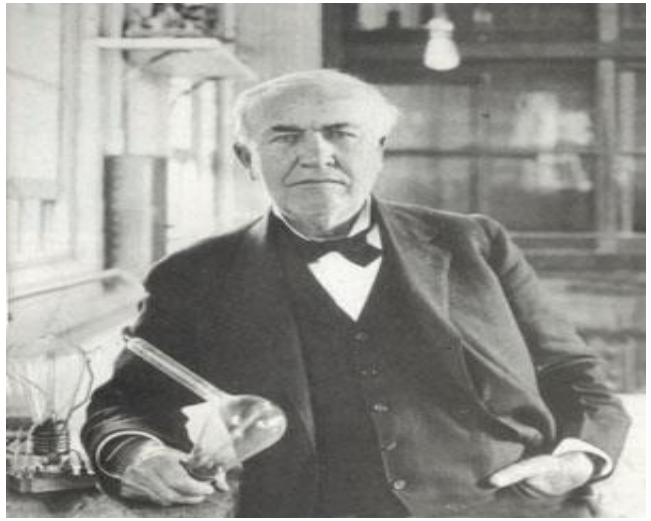


Why TRIZ?

Trial and error problem solving approach

Structured and systematic problem solving approach

Increase efficiency and speed of innovation



Thomas Alva Edison (1847 – 1931)
"Genius is one percent inspiration, ninety-nine percent perspiration"

In 1879, after spending $40,000, and performing 1,200 experiments with 5,000 researchers, Edison succeeded in making a light bulb using carbonized filaments from cotton thread. The light bulb burned for two days. The electric light took the greatest amount of time and required the most complicated experiments of all his experiments.

What is TRIZ?

- TRIZ is the Russian acronym for the "Theory of Inventive Problem Solving" (Teoriya Resheniya Izobretatelskih Zadach).
- It is a systematic problem solving method based on logic and data, not intuition or spontaneous creativity of individuals or groups

- Developed by Genrich Altshuller and his colleagues from 1946 through to 1985 in the former Union of Soviet Socialist Republics (USSR)
- It is based on the study of patterns of problems and solutions
- TRIZ provides repeatability, predictability, and reliability due to its structure and algorithmic approach
- It improves individual or team's ability to solve problems

Key Discoveries

Initial analysis of patents (worldwide)

200,000

Synthesized down to just innovative patents

40,000

Are mined for…

* Today >2.8M patents have been analyzed & investigated

TRIZ is a statistically based family of principles and strategies enabling engineers to identify potential solution paths of technical problems

1. Problems and solutions were repeated across industries & sciences → 40 Inventive Principles for solving Problems

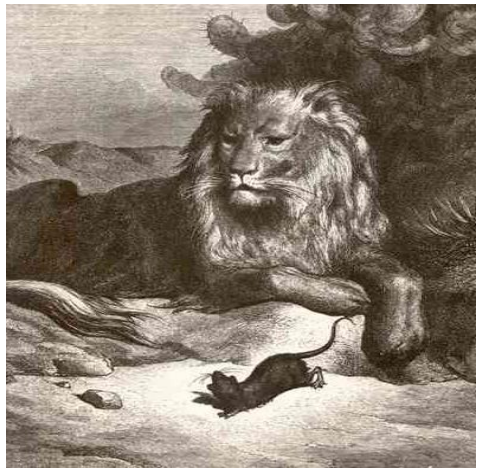
2. Patterns of technical evolution were repeated across industries & sciences → Technology Trends to evolve a technical system to the next generation

3. Innovations used scientific effects outside the field from where the original problem was found → Scientific Effects can be used to solve problems in unique ways

TRIZ Hypothesis

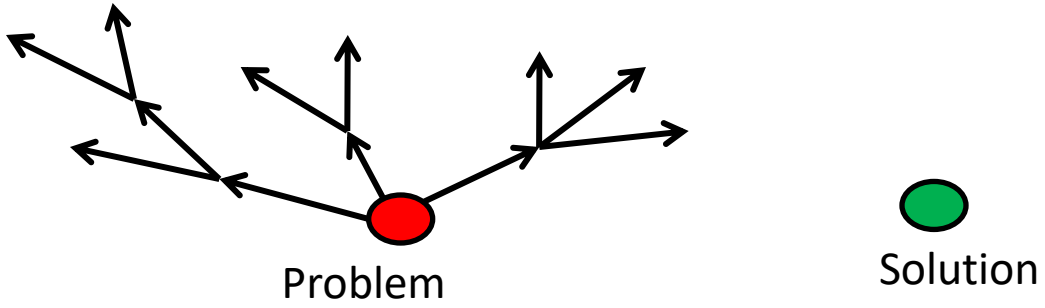
Someone somewhere has already solved this problem *or one very similar to it*

Creativity is now finding that solution and adapting it to this particular problem



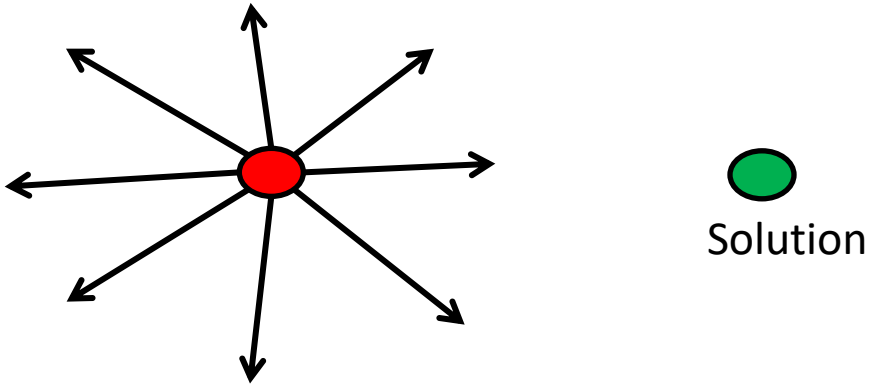
Ways to solve a problem

Trial and error way



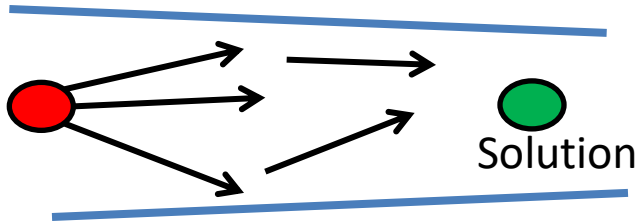
Structured ways

Brainstorming
Trigger Approach
Checklist
Morphological Approach



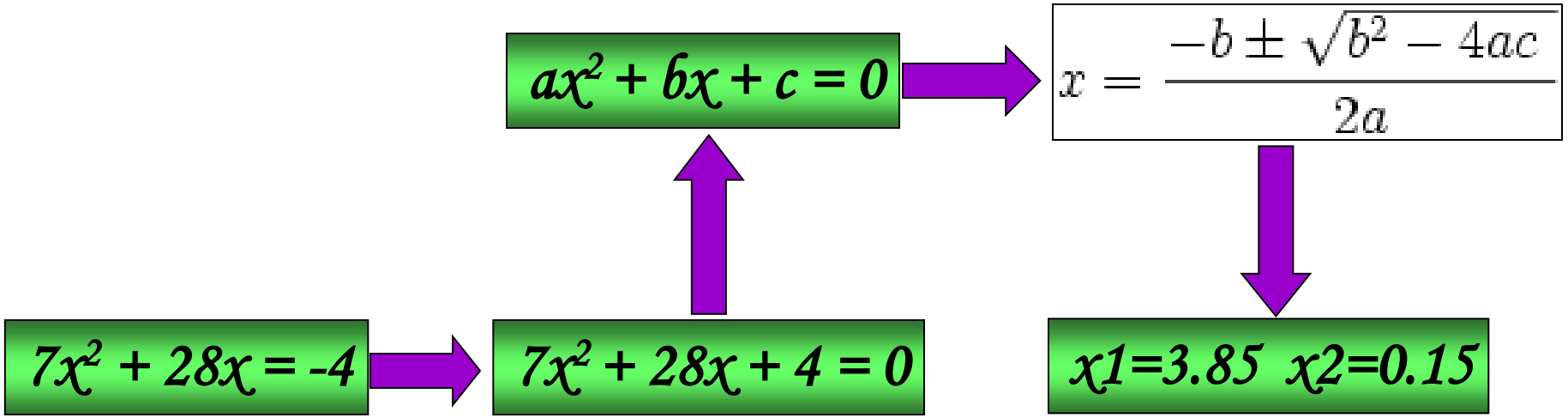
TRIZ way

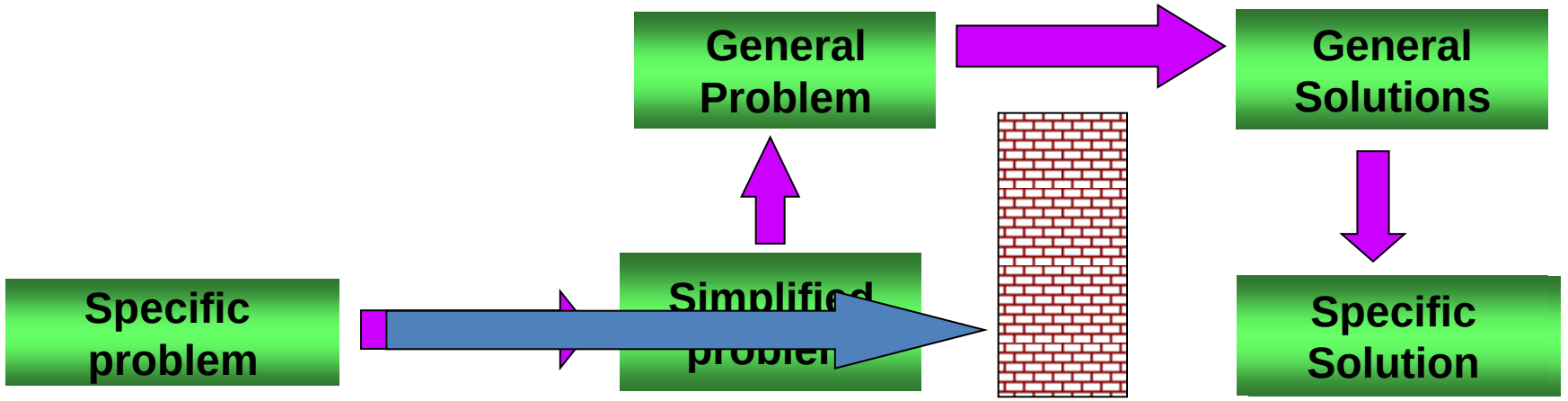
Function Analysis, Cause & Effect Chain Analysis, Trimming, S-curve, etc.



TRIZ provides very structured methodologies through various tools which accelerate time to problem solve and solution innovation

How Does TRIZ Work?





Solution from TRIZ should be

- Faster
- Cheaper
- Better

Basic Concept of TRIZ

1. What is contradiction?

Contradiction is the opposition between two conflicting forces or ideas

Contra = opposing or opposite
Diction = point or speech
Contradiction = opposing point

Living dead	Friendly fire
New classic	Serious joke
Open secret	Deafening silence
Solid water	Kalah menang
Glass hammer	Hidup mati
Invisible ink	Lawak gila

TRIZ definition: The contradiction occurs when we are trying to improve one parameter of a technical system and then the same or other parameters of the technique are affected negatively.

Look for contradictions

- A key characteristic of an inventive problem
- Usual solution – trade-off or compromise
- Eliminating contradictions typically lead to invention

Speed ↑

GOOD

Petrol Usage ↑

BAD

Car travels faster (good), but petrol consumption is higher (bad)

Boil ↑

GOOD

Gas Usage ↑

BAD

Kettle of water boils faster (good), but gas usage is higher (bad)

The inventor must find and remove contradictions

2. What is resource?

- Every system has resources, some of which are fully used, some are partially used and some may not be used at all
- Resources are things (including waste), information, energy or properties of the materials that are already in or near the system
- Using resources, one can solve the problem and evolve towards the ideal state – the inventor has to evaluate what all resources are available in the system
- There may be resources in the system which are not yet identified - in many cases, identification of unidentified resources solve a problem very nicely
- Resource should be free or low cost and should be easily available

Types of resources

Substances

All substances in the system or in the external environment

Energy

All kinds of energies and fields such as electrical, electromagnetic, thermal fields, etc in the system or in the external environment

Time

All kinds of time before, during and after running of the system

Functional

All possible functions of substance, fields, properties or object – can work as great resources

Information

All kinds of data on parameters of substance, fields, change of properties or of object – typically used for measuring, detection and separation

Combined

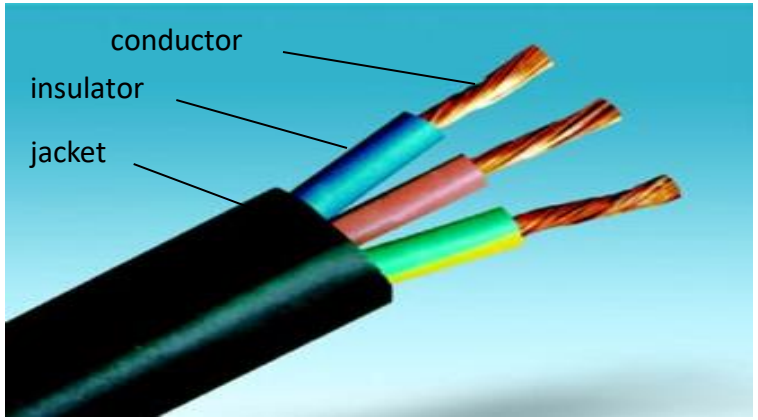
A combination of prime resources – a new resource could emerge through specific resource combination

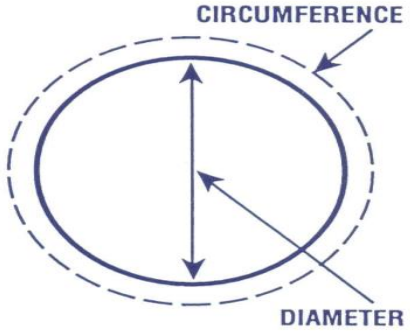
Looking for resources

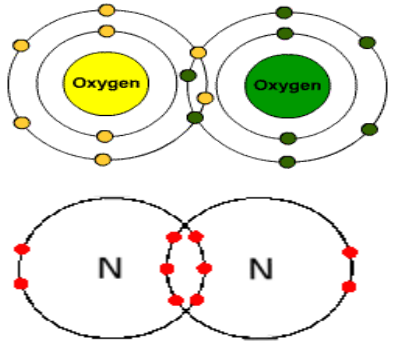
What kind of resources are available in an electric wire?

Normally we will find the following resources:

- The wire itself
- Insulation around the wire
- The current in the wire
- Air around the wire
- … and so on







- In TRIZ, we includes the geometrical aspects of the wire such as diameter, circumference, surface area, surface roughness, etc.
- The air as a resource is not just air, but the oxygen, nitrogen, carbon dioxide and other gases in the air

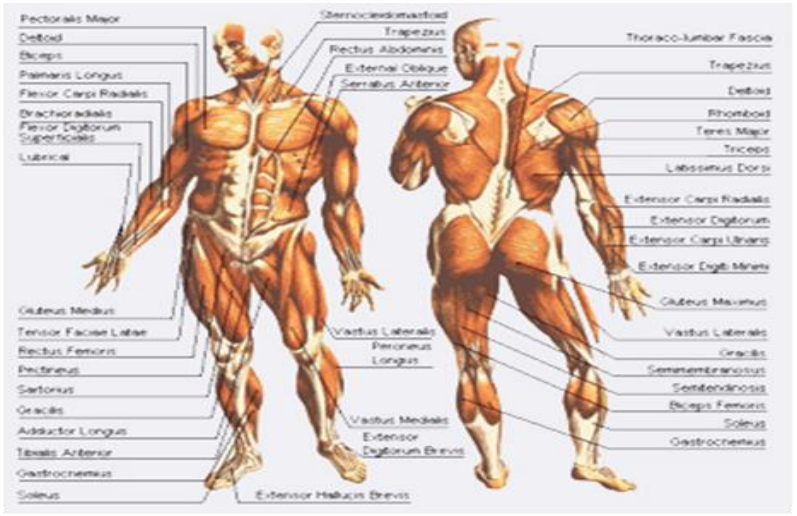
How many more resources can you think of?

3. What is systems approach?

A system

An organized, purposeful structure regarded as a 'whole' consisting of interrelated and interdependent elements (or components)

These elements (or components) continually influence one another (directly or indirectly) to maintain their activity and the existence of the system, in order to achieve the common purpose (or function) of the system



Functionality

- People buy Functions or functionality, not products

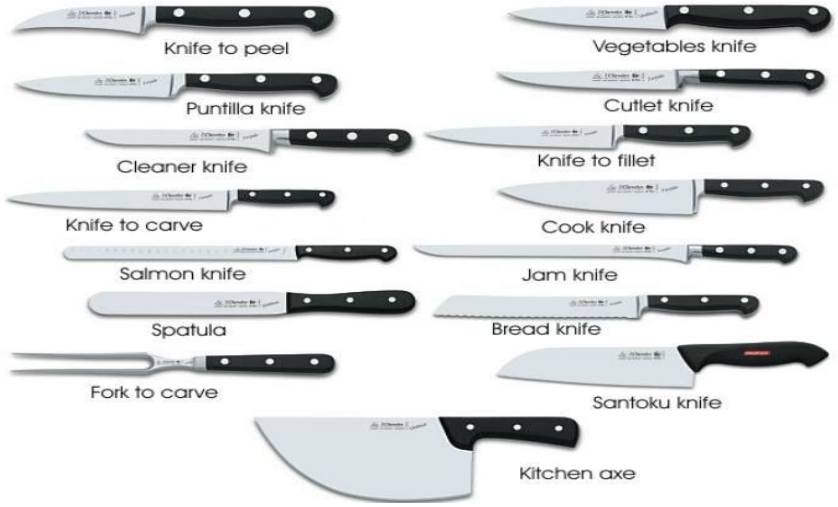
- Understanding Functions and functionality at the most basic level is fundamental to the successful application of TRIZ
- Solutions change, but Functions stay the same
- Knowledge classification by Function allows ready access to other’s solutions

Engineering Systems

- Everything that performs a main useful function is an engineering system e.g. car, pen, book, knife, etc.
- The system components are the elements that are an integral part of the system design
- The supersystem components contain elements that influence the system (but were not designed as part of the system)
- The product is the focal element of the system; primary reason the system was designed

BASIC ELEMENT OF INNOVATION

People **buy** functions or **<u>functionality</u>**, **not** products



Solutions **change**, but Functions stay the **same**

Function Vs Product

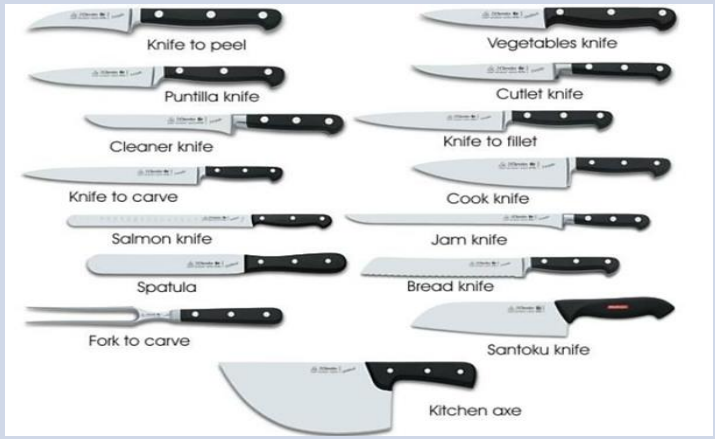
- People buy function not product

- Function can be classified into 3 groups,
  - 1. Main function (100%) – Wajib/wajib
  - 2. Auxilliary Function (80%) – Wajib/Sunat
  - 3. Additional function (30%) - Harus

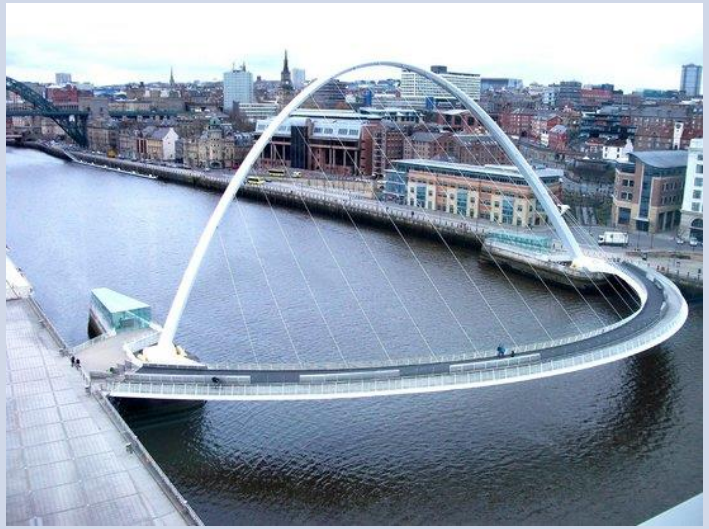
Function of Maggi

Main	Auxiliary	Additional
		

Function of Knife

Main	Auxilliary	Additional
		

Function of Bridge

Main	Auxilliary	Additional
		

Function of Airport

Main	Auxilliary	Additional
		

4. What is ideality?

- Each system evolve towards its ideal state
- The ideal state of the system is where it has all the benefits with none of the harm or none of the costs
- The system is better, faster, low cost, low error, low maintenance and so on
- The ideal system consists of all positives and no negatives

Ideal System

- The ideal system is a system that does not materially exist, while its functions are achieved
- “Ideal system is no system”

- In the absolute sense Ideality is impossible to achieve, but in a relative sense ideality is achievable

Evolve towards ideality

Let's take a look at the basic definition of value:

$$\text{value} = \frac{\text{functionality}}{\text{cost + harm}} = \frac{\sum F_{\text{useful}}}{\sum F_{\text{harmful}} + \sum F_{\text{cost}}}$$

If a system is to operate in an ideal stage, then the system must have at least 1 main useful function without any cost and harmfulness

$$\text{value} = \frac{\text{1 useful function}}{\text{0 cost + 0 harm}} = \overset{\textit{Infinity}}{\infty} = \text{ideality}$$

Final result: it has all the benefits and none of the costs and harmfulness

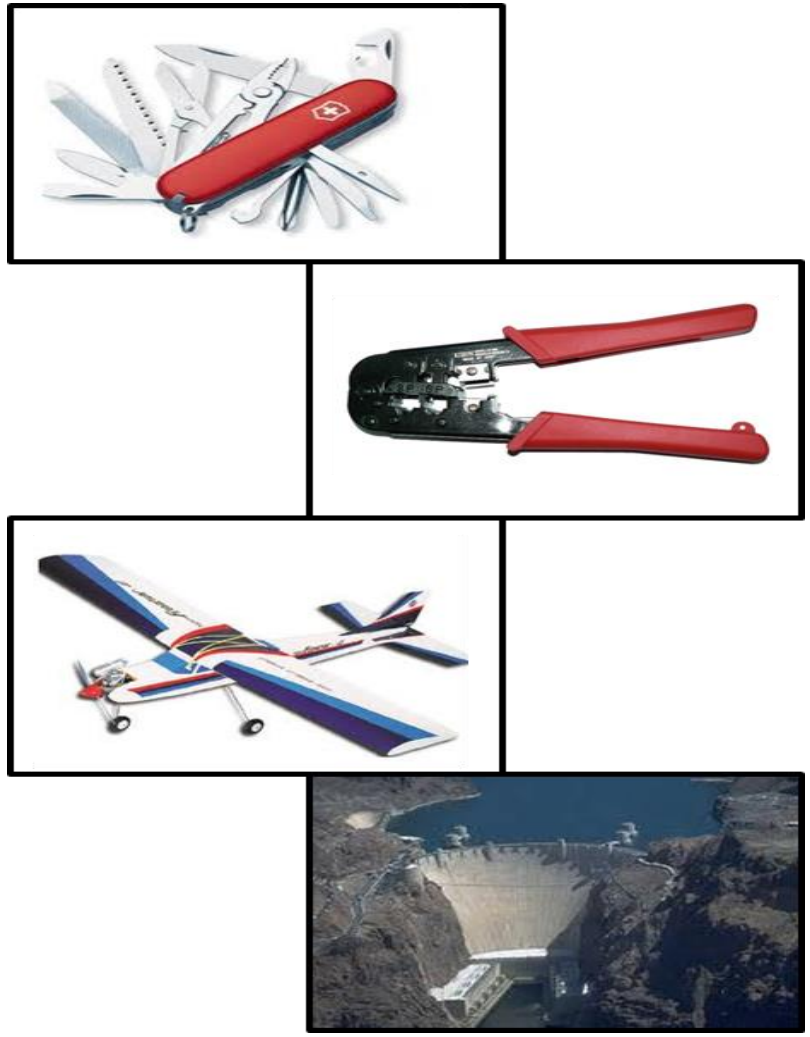
Ways to make a system more ideal

A. Increase the amount of functions of the system

B. Transfer as many functions as possible to the working component which produces the system's final action

C. Transfer some functions of the system to a supersystem or to the outside environment

D. Utilize internal and external resources that already exist and are available



Levels of Innovation

TRIZ Five Levels of Innovation

Level	Features	Explanation
Level 5 *(Green Ocean)*	Discovery	Discovering a new business principle (1000% profit) -Disruptive Innovation
Level 4 *(Blue Ocean)*	Pioneering Invention	Creating a radically new Function/Principle combination. Invention outside the border of current technology. (500% Profit)
Level 3 *(Blue Ocean)*	Apply New Principle/ Concept Transfer	The use of known Function/Principle combination in a new application area (100% profit)
Level 2 *(Red Ocean)*	Non-linear System Change	Reconfiguring and improving an existing system within the same Function (50% profit)
Level 1 *(Red Ocean)*	Linear System Change	Solution method is known and applicable, only parameter value change is required (20% profit)

TRIZ Five Levels of Innovation

Level	Features	Examples (Research output)
Level 5 *(Green Ocean)*	Discovery	Noble Prize
Level 4 *(Blue Ocean)*	Pioneering Invention	MERDEKA Award
Level 3 *(Blue Ocean)*	Apply New Principle/ Concept Transfer	PhD project
Level 2 *(Red Ocean)*	Non-linear System Change	Master Project
Level 1 *(Red Ocean)*	Linear System Change	Final Year Project

TRIZ Five Levels of Innovation

Level	Features	Examples (Automotive)
Level 5 *(Green Ocean)*	Discovery	Car with fuel from air. Vertical take off flying car Fully autonomous car (no driver)
Level 4 *(Blue Ocean)*	Pioneering Invention	Tesla Electric car (500km)
Level 3 *(Blue Ocean)*	Apply New Principle/ Concept Transfer	Hybrid car Electric car (120 km)
Level 2 *(Red Ocean)*	Non-linear System Change	Introduce New Model
Level 1 *(Red Ocean)*	Linear System Change	Increase price Reduce price

TRIZ Five Levels of Innovation

Level	Features	Examples (Water supply)
Level 5 *(Green Ocean)*	Discovery	Underground Dam with recycle and processing
Level 4 *(Blue Ocean)*	Pioneering Invention	Underground Dam
Level 3 *(Blue Ocean)*	Apply New Principle/ Concept Transfer	Underground water Horizontal water collector (telaga jejari)
Level 2 *(Red Ocean)*	Non-linear System Change	Water from Undergroud water Tube wells Perigi
Level 1 *(Red Ocean)*	Linear System Change	Water from lake Water from river Water from Rain

TRIZ Five Levels of Innovation

Level	Features	Examples (Cancer Treatment)
Level 5 *(Green Ocean)*	Discovery	Food to stop from cancer cell from growing.
Level 4 *(Blue Ocean)*	Pioneering Invention	Supplement to stop from growing cancer cell.
Level 3 *(Blue Ocean)*	Apply New Principle/ Concept Transfer	Medicine to remove cancer cell. Nanorobot
Level 2 *(Red Ocean)*	Non-linear System Change	Chemotherapy
Level 1 *(Red Ocean)*	Linear System Change	Remove cancer cell using operation

TRIZ Tool : Function Analysis

Content

- Engineering Systems
- Understanding function and functionality
- Elements of Function Analysis
  - Component Analysis
  - Interaction Analysis
  - Function Model

Exercise

- Function Analysis Case Study

Engineering Systems

- Everything that performs a main useful function is an engineering system e.g. car, pen, book, knife, etc
- The system components are the elements that are an integral part of the system design
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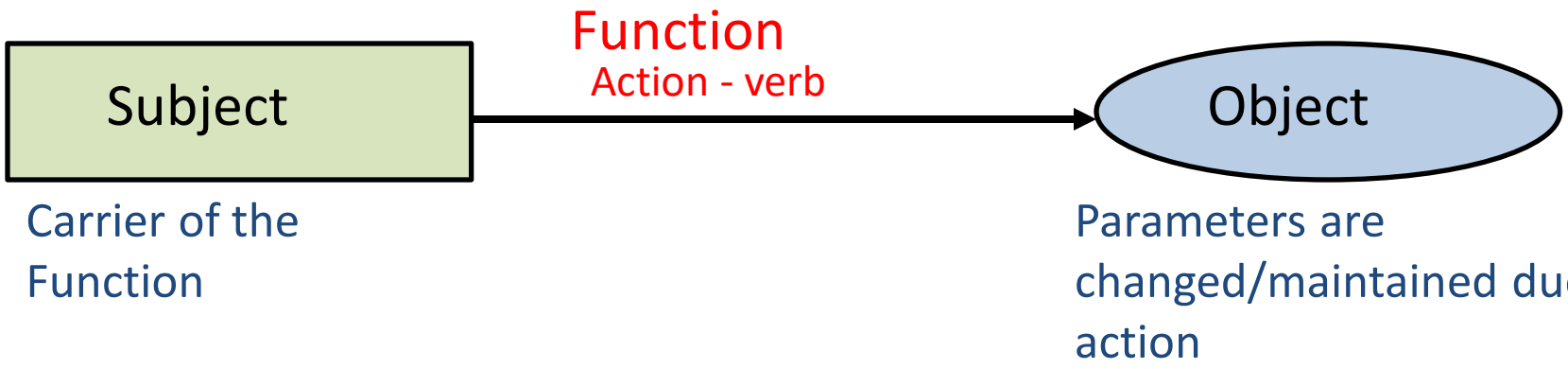
Function Analysis

Identifies Components of the Engineering System and its Supersystem

Identifies the interaction between the Components

Identifies and evaluates the Functions performed by the Components

Function Analysis



- Function Analysis is an analytical tool that identifies Functions, their characteristics, and the cost of the System and the Supersystem Components
- Subject and Object are both Components in, or interact with, the Engineering System
- A Function is an action between a Subject and an Object, in which the Subject acts upon and modifies or maintains a parameter of the Object
- A parameter describes some inherent property of a Component

Function Analysis

Subject(Tool)	Function	Object
Hammer	hit	Nail
Hammer	pull	Nail
Paper Weight	hold	Money

Function Language

Function Models use simple language (which a child can easily understand) to describe functions

Function Language

Bristle —remove→ Food

String —remove→ Food

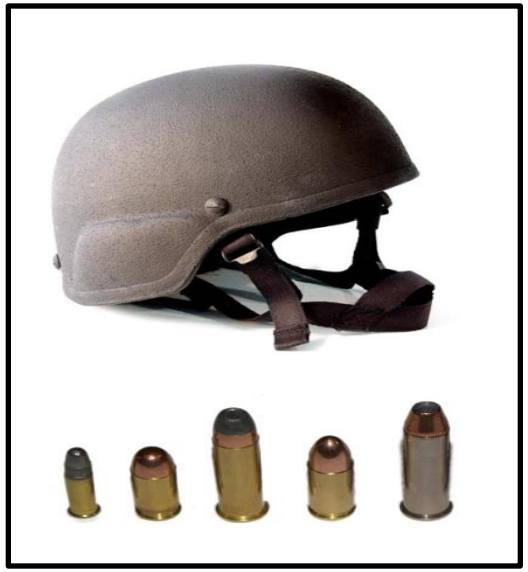
Stick —remove→ Food

What is the function?

Describe in simple language the function of the following systems:

Mirror ?

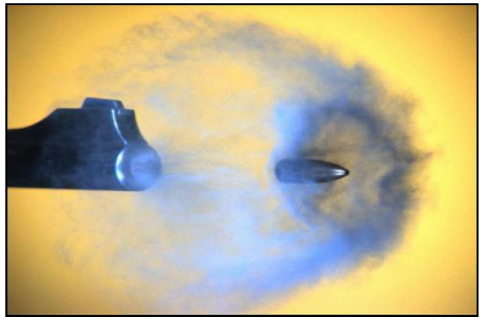
Helmet ?



Belt ?

What is the function?

Mirror — inform → People



Helmet — stop → Bullet

Belt — hold → Pants

Avoid technical jargon

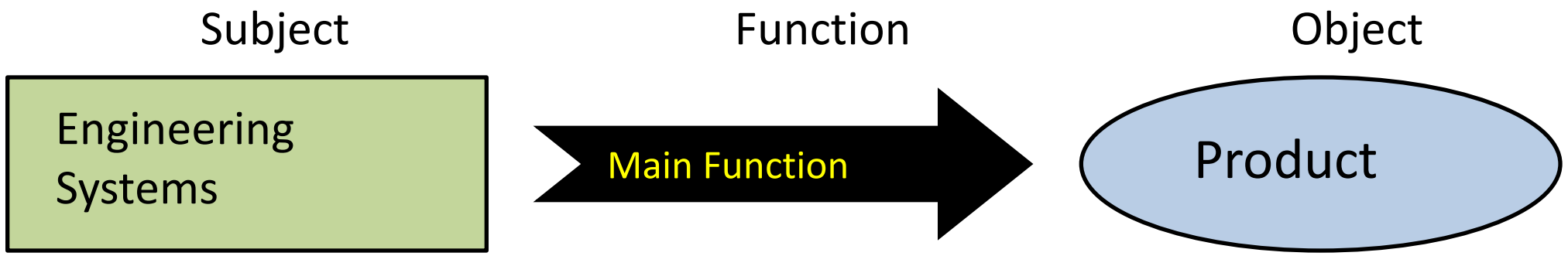
- Technical language is sometimes difficult for people to mentally image & restrict potential solutions
- Function language enables a bigger scope of potential solutions

Technical language	Function language
Etch	Remove
Distill	Separate
Encapsulate	Include
Stream	Deliver
Zip	Reduce

Main Function: Delivers the system product

- The Product is what the Engineering System was designed to do or produce and the one that people pay for

- Most Engineering Systems contain only one Main Function



What is the Main Useful Function?

When analyzing an Engineering System, firstly, define or decide what the system is designed to do, or to achieve. Understand its main useful function

What is the purpose of the chair?

Holds

Person

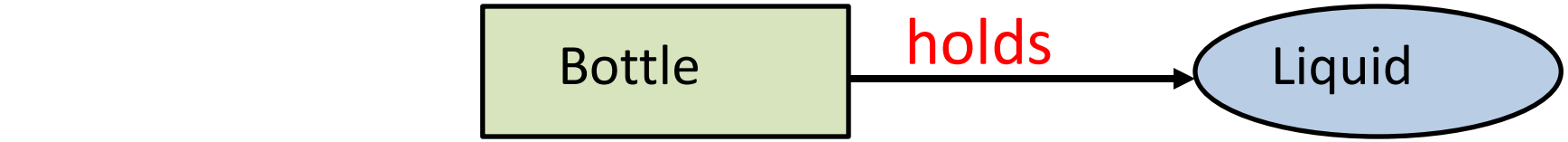
What is the purpose of the car?

Transports

Driver

Exercise: What is the main useful function of the table?

Exercise: What is the main useful function of the bottle?

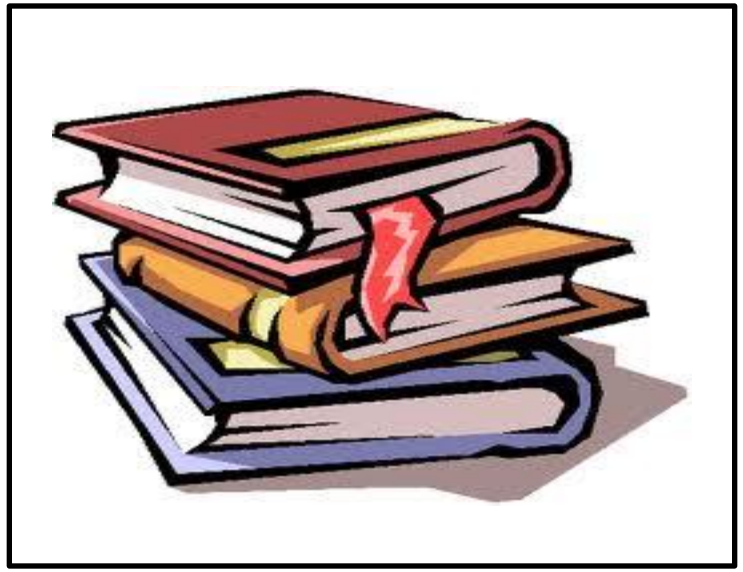


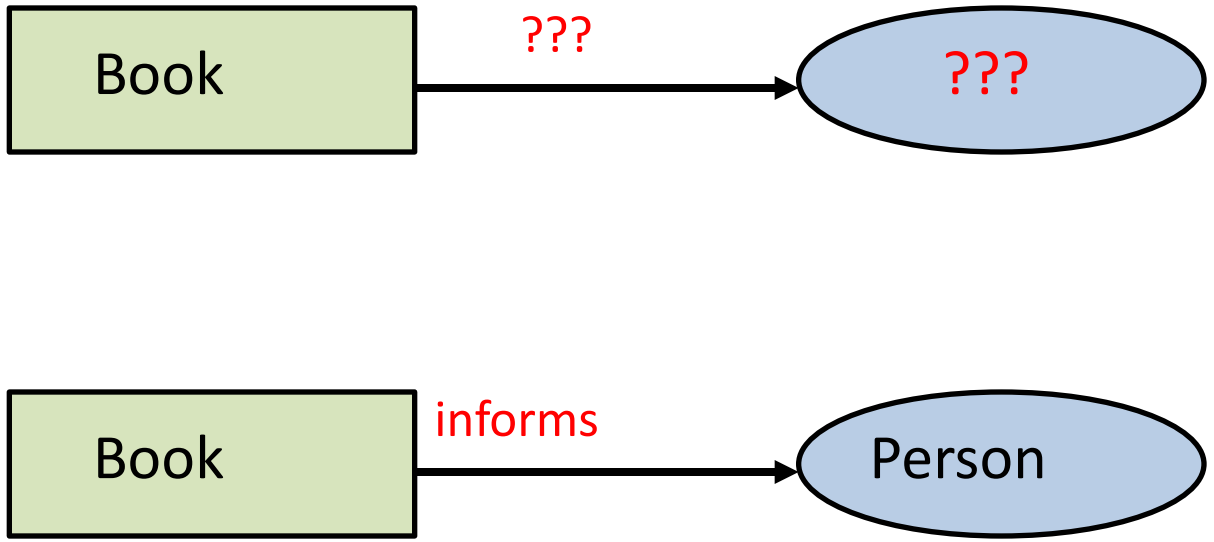
Exercise: What is the main useful function of the cap?

Exercise: What is the main useful function of the cap?

Exercise: What is the main useful function of the cap?

Exercise: What is the main useful function of the book?





Function Analysis: Tooth Brush Function

- ~~To clean teeth~~
- ~~To brighten teeth~~
- ~~To keep teeth clean~~
- ~~To prevent cavities~~
- ~~To make teeth healthy~~

- To remove plaque (from teeth)
- To remove food (from teeth)

Component Analysis

- To understand an Engineering System, we need to analyze and identify the “interrelated and interdependent” Components that are organized and structured to deliver the main useful function of the system

- The Components of the Engineering System contain internal and external elements with which the object of analysis interacts, or co-exists with

- These elements continually “interact” and influence one another, directly or indirectly to maintain their activity and the existence of the system

What is Component ?

- Component is an identifiable Object that make up a part of an Engineering System
- Component can be Substances and/or Fields
  - Substance is defined as an Object with rest mass (e.g. table, book, hammer, nail)
  - Field is defined as an Object without rest mass that transfers an interaction between Substances (e.g. magnetic field, electric field)

List of Components in and around the Engineering System

back rest

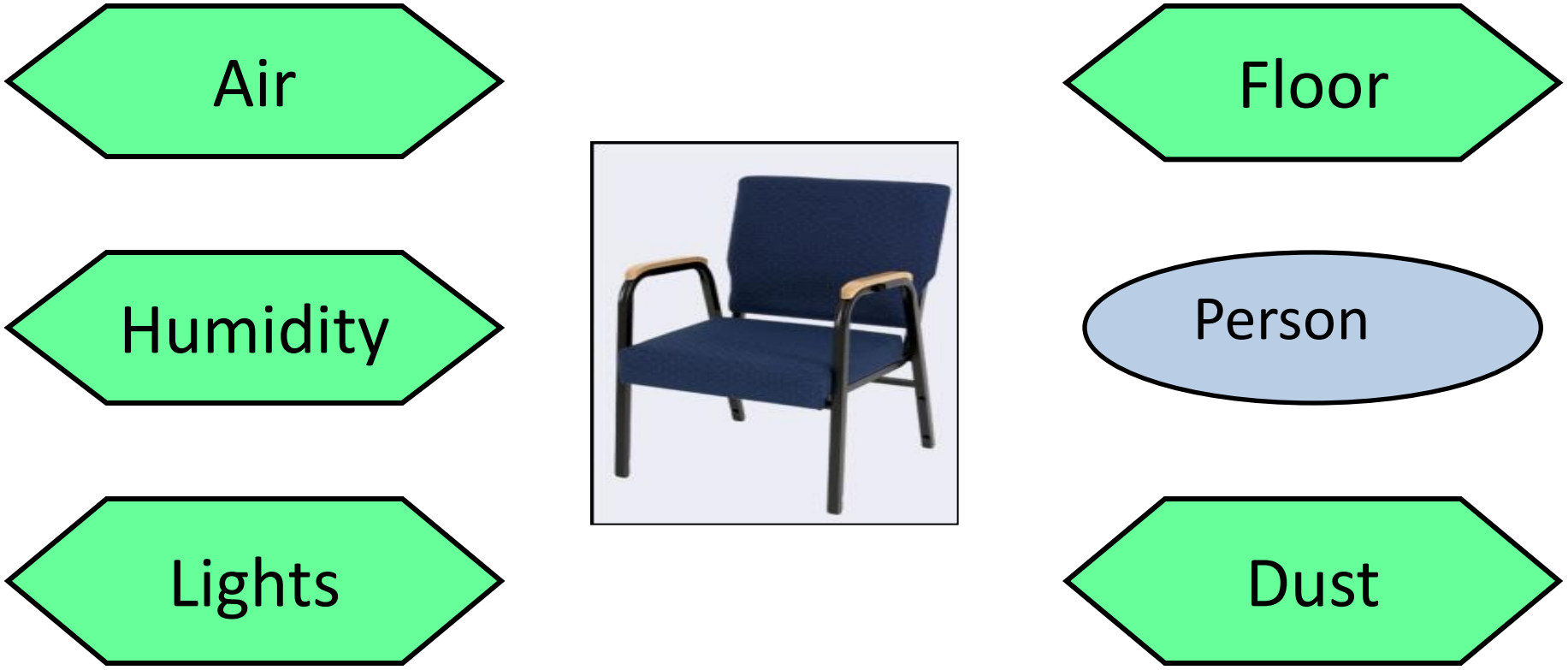
frame

seat

screws

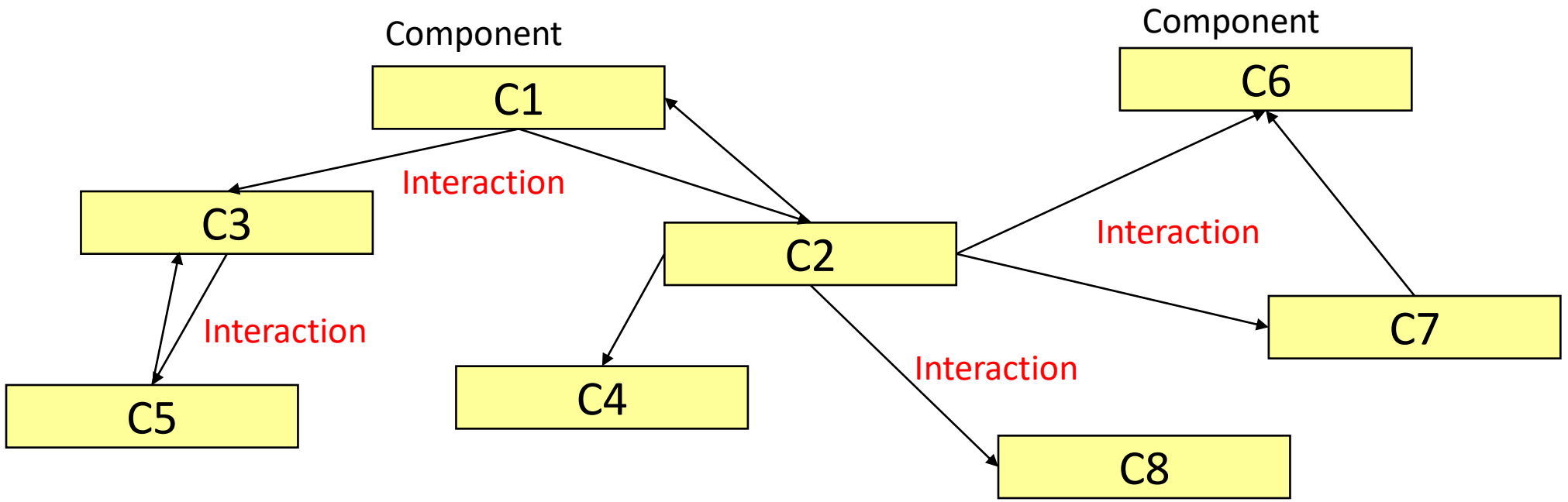
Supersystem Components

Supersystem Components interact with Engineering System but are not *part* of System



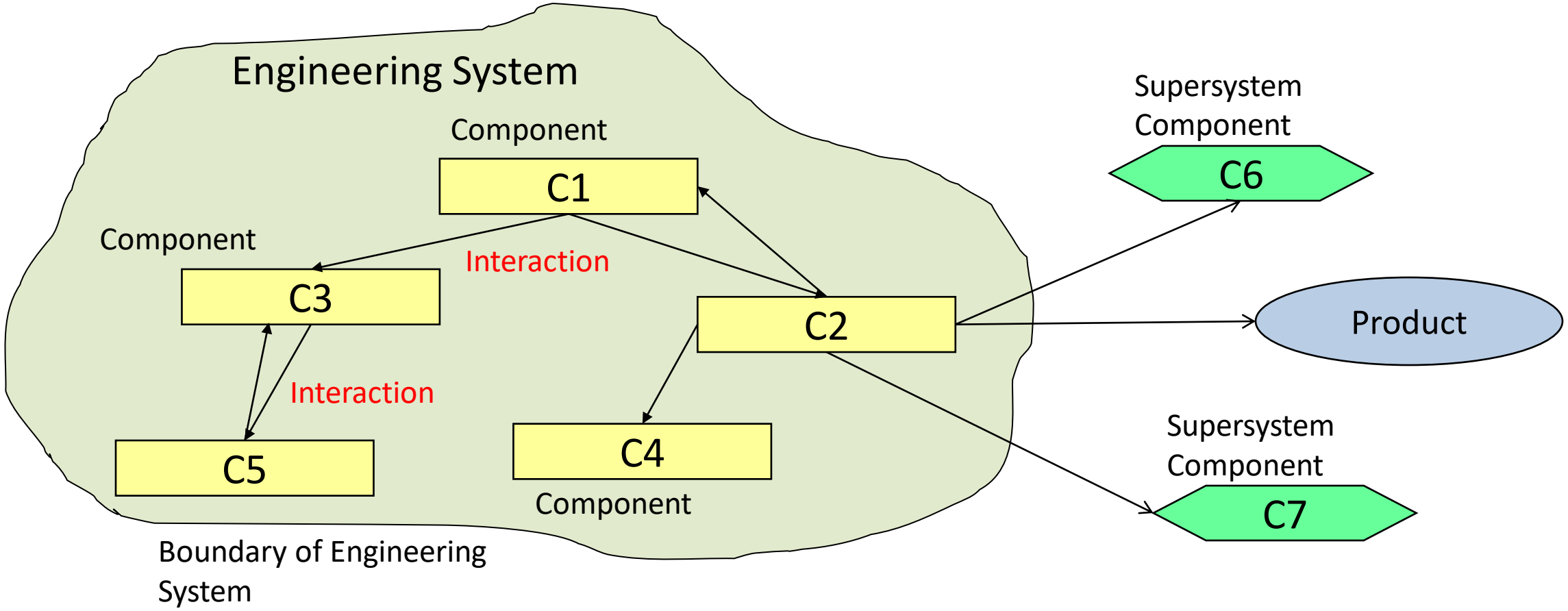
Interaction Analysis

Interaction Analysis is an analytical tool that identifies and understands the interaction between the components of the Engineering System



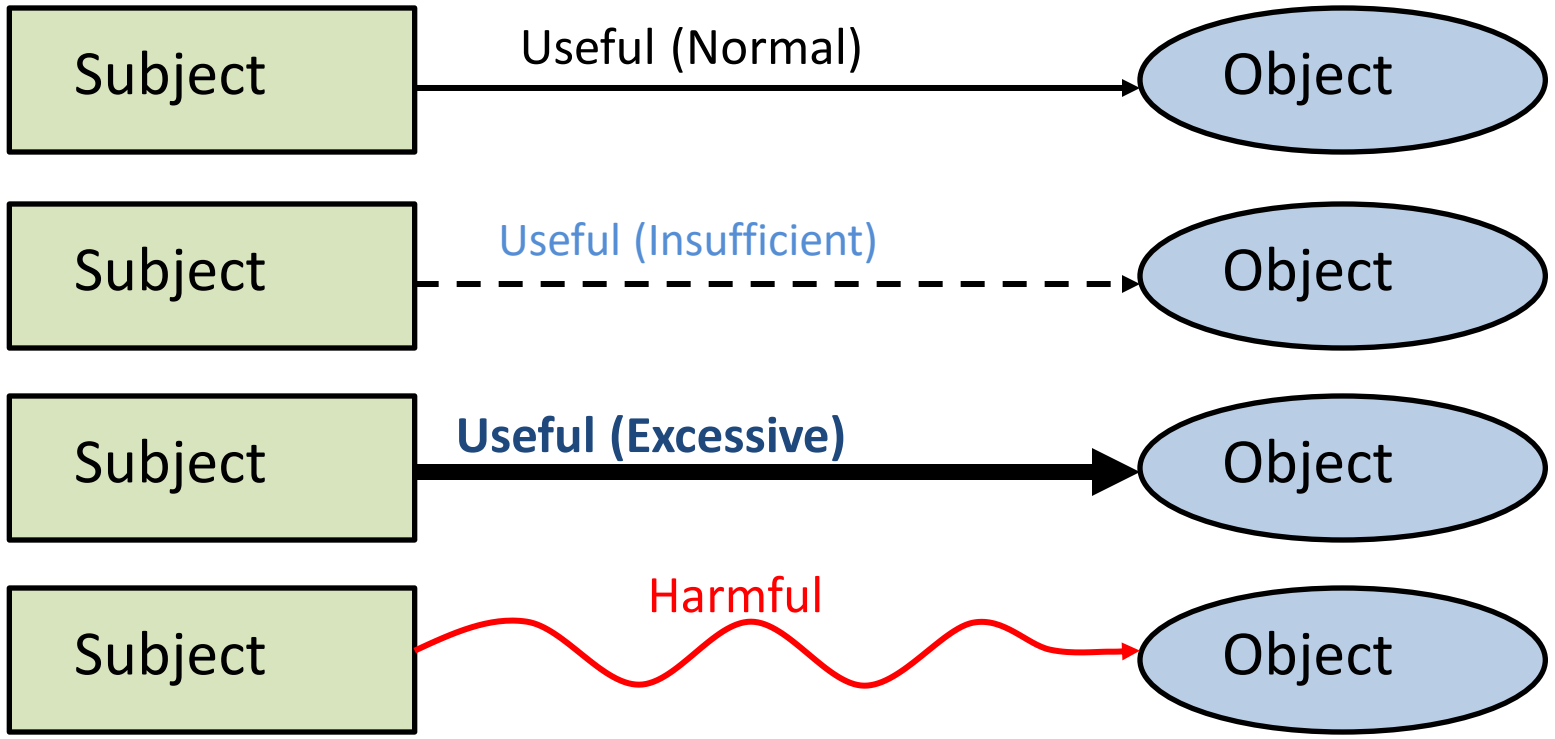
Function Model

Function Model is an analysis of the interaction between components of the Engineering System and Supersystem . It identifies the advantages and disadvantages of the functions acting on each of the components.



What is Function Model ?

The main goal of Function Analysis is to identify specific disadvantages of an Object - namely, harmful Functions as well as useful Functions performed insufficiently, and those that are performed **excessively**



Definition of Interactions – Useful Functions

Useful Function is defined as the product that delivers the purpose or functional requirement to its users as designed

1. Equal or Normal
   If the actual parameter value equal the required or designed value, the related Function is defined as NORMAL

2. Insufficient
   If the actual parameter value is less or falls below the required or designed value, the related Function is defined as INSUFFICIENT

3. Excessive
   If the actual parameter value is more or falls above the required value, the Function is defined as **EXCESSIVE**

Example:
Interaction between Robotic arm and Plastic Bottle

Normal Useful Function: Robotic arm holds Plastic bottle

Insufficient Useful Function: Robotic arm drops Plastic bottle

Excessive Useful Function: Robotic arm crushes Plastic bottle

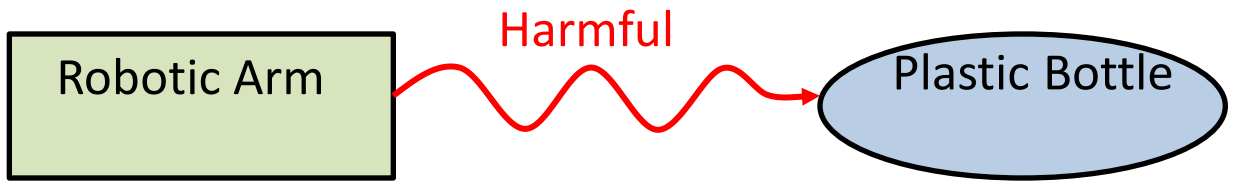
Definition of Interactions – Harmful Functions

A harmful function is defined as a function that worsens the parameters of the object of the function

4

Harmful

If the actual parameter value generate damaging or undesirable effects on their objects, the related Function is defined as HARMFUL



Example:
Interaction between Robotic arm and Plastic Bottle

Harmful Function:
Robotic arm scratches Plastic bottle

Robotic arm stained Plastic bottle with grease

Function Analysis Summary

Identifies Components of the Engineering System and its Supersystem

Identifies the interaction between the Components

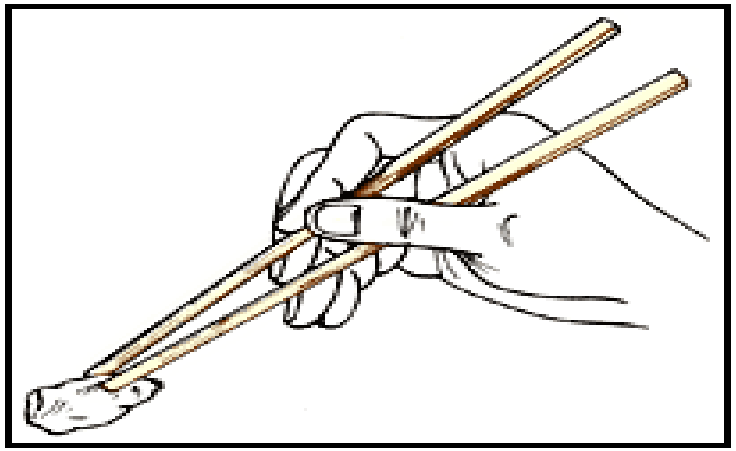
Identifies and evaluates the Functions performed by the Components

Exercise – Function Analysis Case Study

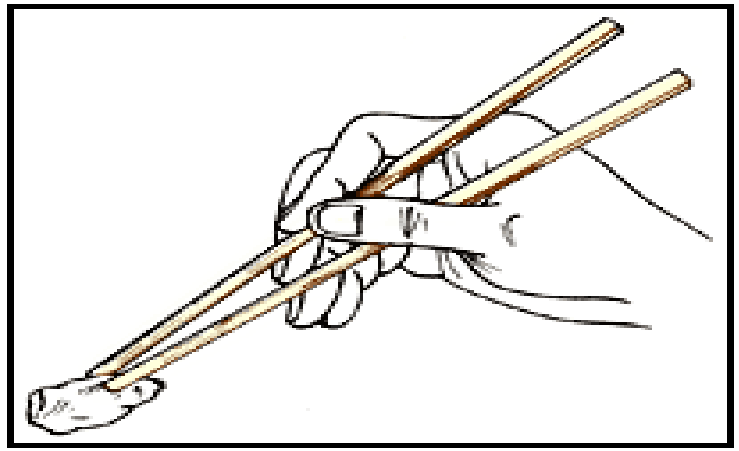
Problem: Unable to pick up small pieces of food with chopsticks

Exercise: Apply and perform Function Analysis on “chopsticks” system

- Step #1: Component Analysis
  - Identify Components of Engineering System & Supersystem
- Step #2: Interaction Analysis
  - Draw Components and their interactions
- Step #3: Function Model
  - Indicate Function Types



Exercise – Step #1 Component Analysis



1 Product

Food

2 System Components

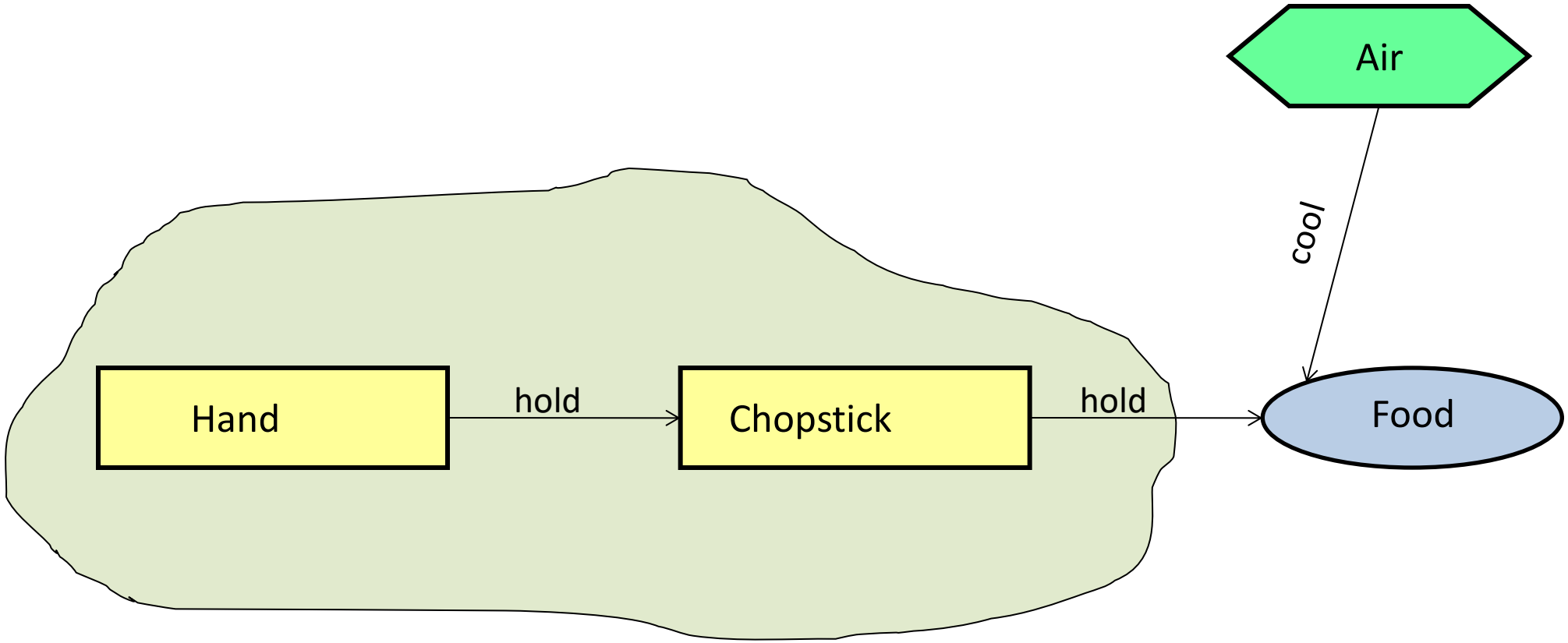
Hand

Chopstick

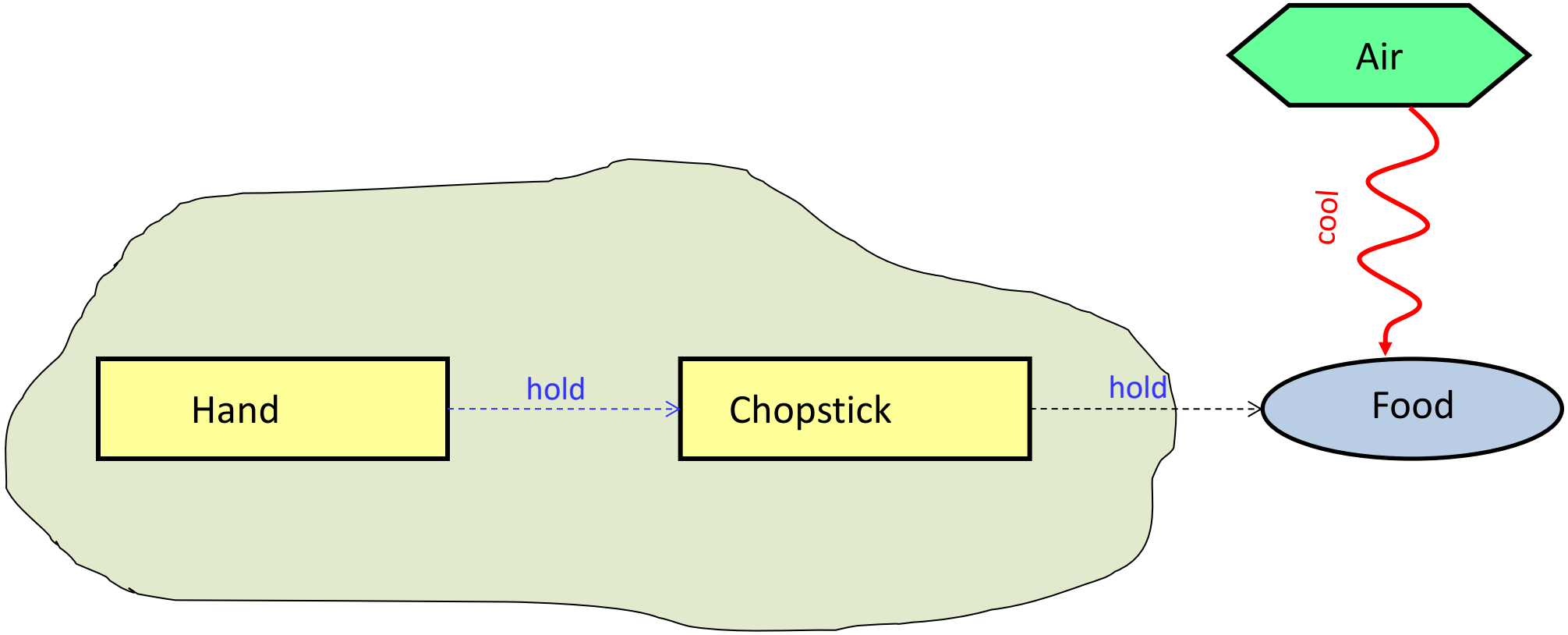
3 Supersystem Components

Air

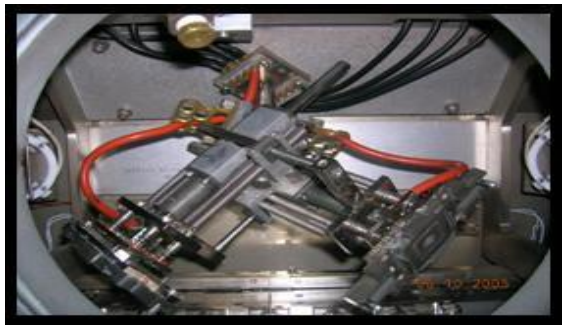
Exercise – Step #2 Interaction Analysis



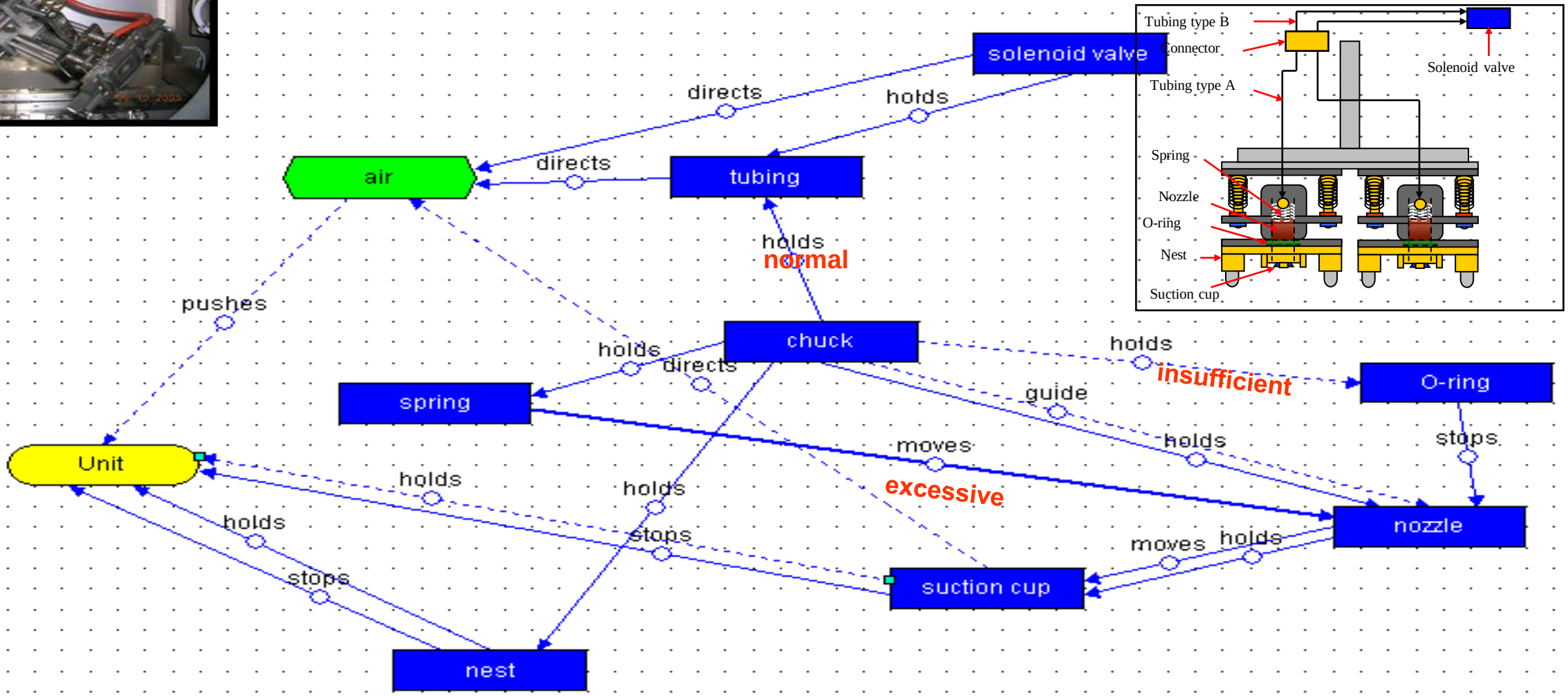
Exercise – Step #3 Function Model



Function model of Engineering System



<u>Actual Problem Statement:</u> How to ensure vacuum is consistently strong during cold test and chuck movement



TRIZ Tool : Cause & Effect Analysis

Content

- What is Cause-and-Effect Analysis?
- Types of Cause-and-Effect Analysis
- How to use Cause-and-Effect Analysis?

Exercise

- Cause-and-Effect Analysis Case Study

What is Cause & Effect Chain analysis?

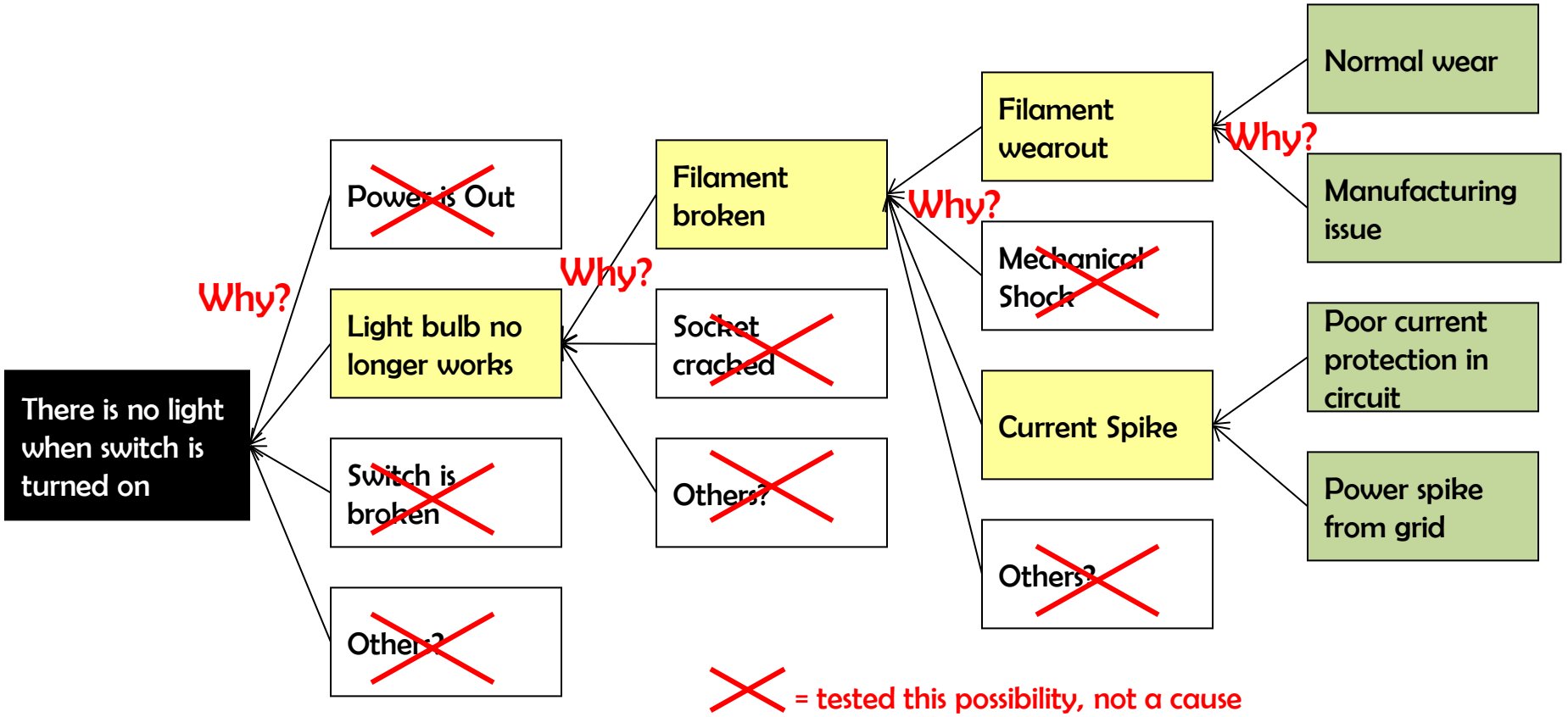
- A cause-and-effect analysis generates hypotheses about possible causes(reasons) and effects(results) of problems
- A Cause & Effect Chain (CEC) analysis diagram is a structured way of expressing hypothesis about the causes of a problem or about why something is not happening as desired
- It helps to focus attention on the process where a problem is occurring and to allow for constructive use of facts to narrow down on the actual causes
- It cannot replace empirical testing of these hypotheses, it does not tell which is the root cause, but rather the possibilities

How to use Cause & Effect Chain analysis?

Step	Process
Step 1	Agree on the problem and write it in the *effect* box
Step 2	Brainstorm about likely causes and then sort them into major categories or branches depending on the method chosen
Step 3	Continue to brainstorm and generate a list of causes and fill them in the appropriate categories or branches
Step 4	Keep asking "Why?" and "Why else?" for each cause until a potential root cause has been identified
Step 5	Use team's best collective judgment to choose several areas they feel are most likely causes and eliminate the unlikely causes
Step 6	Use the reduced list of likely causes to develop respective hypothesis to prove the group's theory
Step 7	Validate hypothesis to confirm the likely root cause, and proceed to implement the solution

Go back and choose other causes for testing if the initial selection is incorrect

Cause & Effect Chain Analysis



- Continue until the "why" cannot be answered. You will reach the cause that is a fundamental law of physics or chemistry, or technology limit
- The end of the chain is a potential actual root cause

TRIZ Tool : Trimming

Content

- What is Trimming?
- Understand Trimming Rules
- How to use Trimming?

Exercise

- Trimming Case Study

What is Trimming?

- Trimming is a method of eliminating Components from an Engineering System to reduce or eliminate the disadvantages of those trimmed Components
- Trimming is used to increase the efficiency and reduce the cost of the Engineering System



Trimming Rules

RULE A

The Function is not needed any more because the Object of the Function no longer exists

RULE B

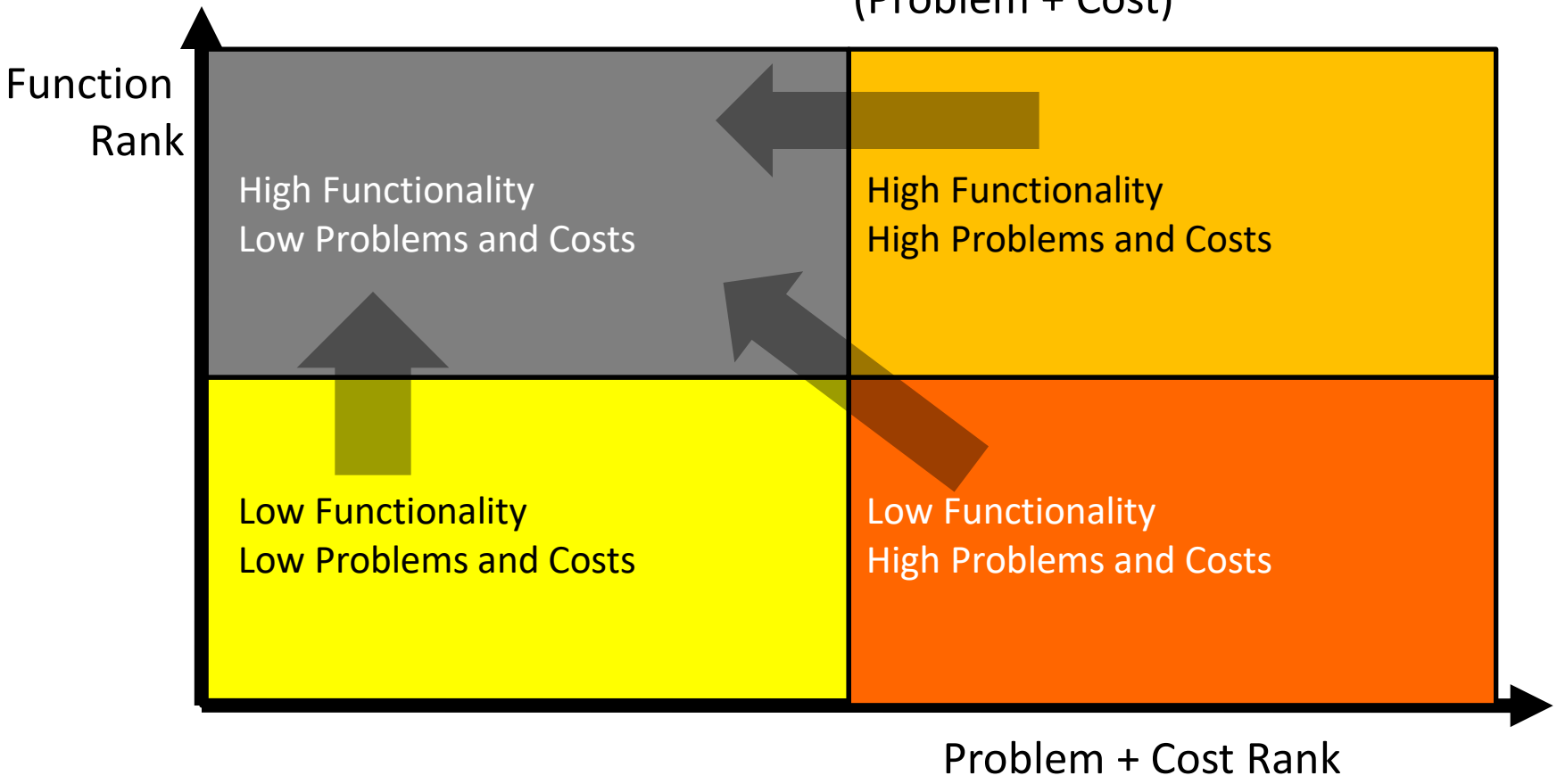
The Object being worked by the Function performs the Function itself

RULE C

The Function is transferred to another Component in the System or Supersystem

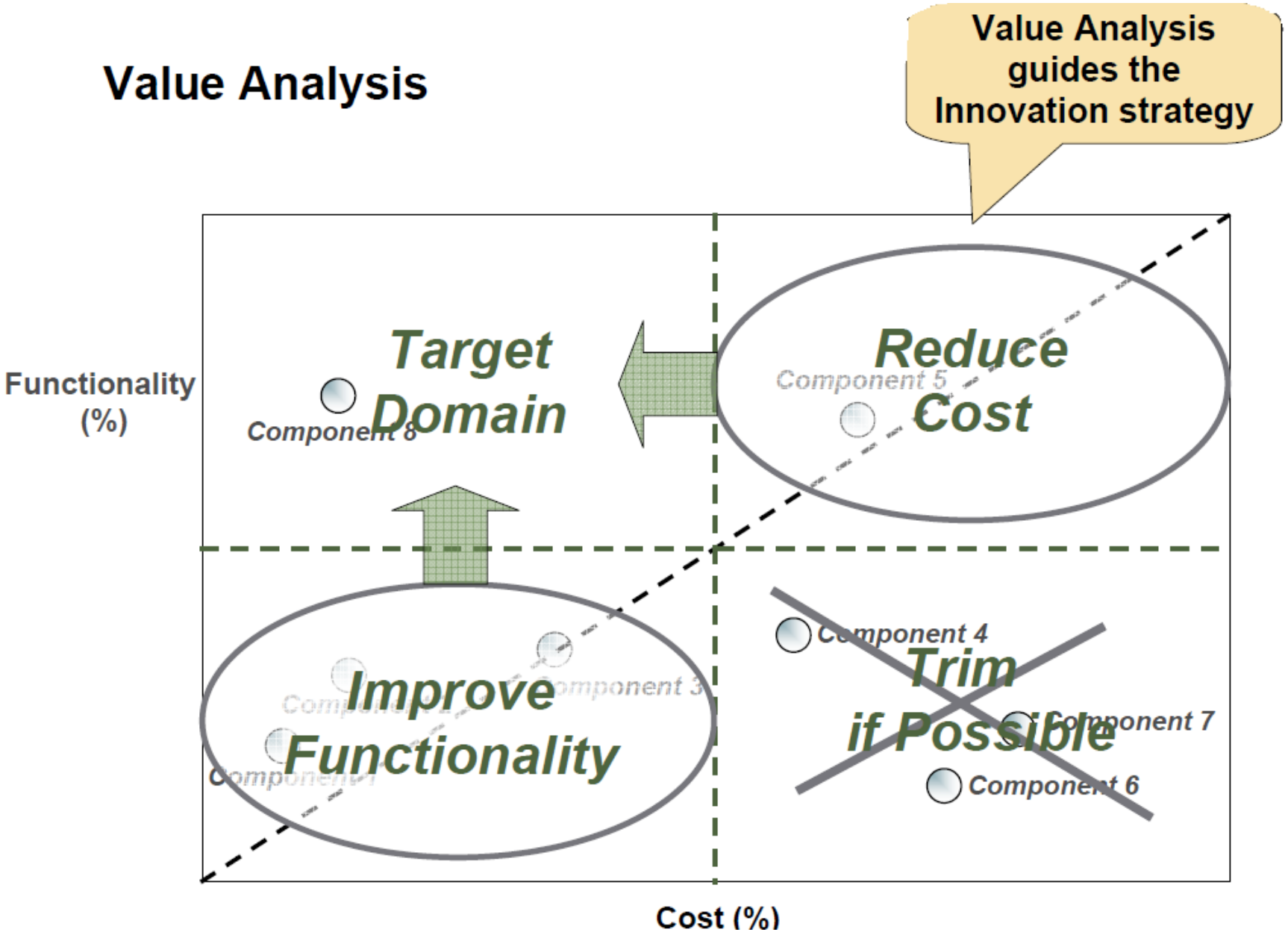
Trimming Factor – Product Diagnostic Analysis

$$\text{Trimming factor (T)} = \frac{\text{Function}^2}{(\text{Problem} + \text{Cost})}$$



A more ideal system is one that is less costly and has fewer components

Value Analysis



SONY WALKMAN

BEFORE

AFTER

Exercise - Trimming Case Study #1

1. How do you trim a toothbrush?

Step 1: Do a component analysis - what are the components of the system?
Step 2: Understand the interaction - what is the main useful function?
Step 3: Build a function model – which part can be trimmed?

2. Which trimming rules did you apply?

Rule A: You don’t need the function anymore
Rule B: The object performs the function itself
Rule C: Some other components does the function

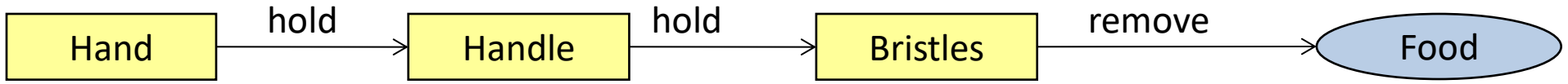
3. What does it look like?

Exercise - Trimming Case Study #1

1. What is the main useful function of a toothbrush?

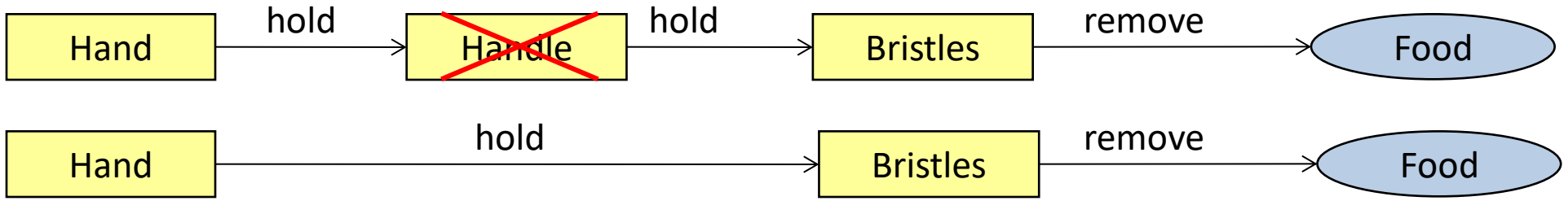
   To remove plaque from teeth

2. Perform Function Analysis of a toothbrush

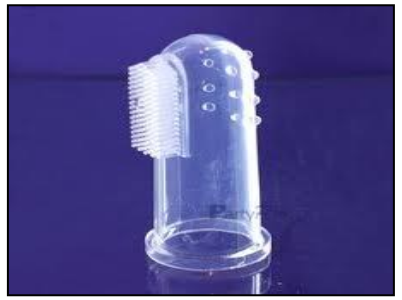


3. Perform Trimming. Which trimming rules did you apply?

   ✓ Rule C: Some other components does the function



4. What does it look like?



Exercise - Trimming Case Study #2

1 How do you trim a skipping rope?

Step 1: Do a component analysis - what are the components of the system?
Step 2: Understand the interaction - what is the main useful function?
Step 3: Build a function model – which part can be trimmed?

2 Which trimming rules did you apply?

Rule A: You don’t need the function anymore
Rule B: The object performs the function itself
Rule C: Some other components does the function

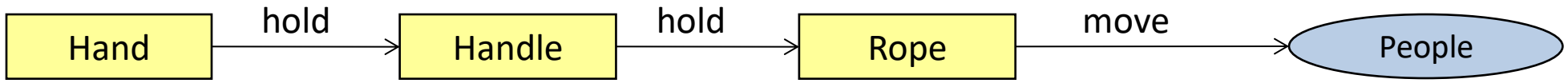
3 What does it look like?

Exercise - Trimming Case Study #2

1. What is the main useful function of a skipping rope?

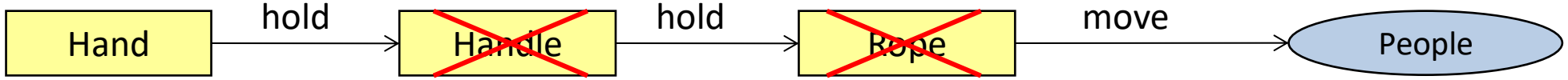
   To exercise

2. Perform Function Analysis of a skipping rope

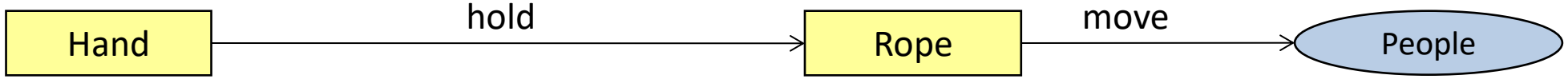


3. Perform Trimming. Which trimming rules did you apply?

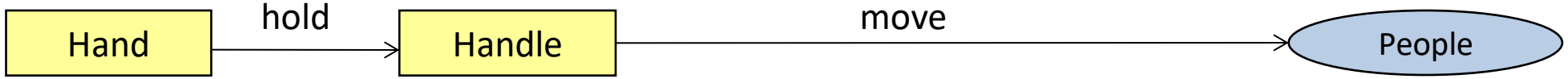
✓ Rule C: Some other components does the function



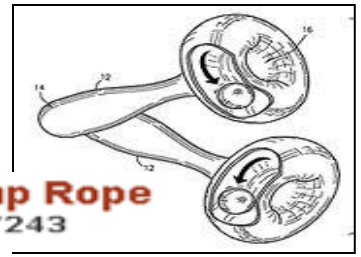
Solution 1



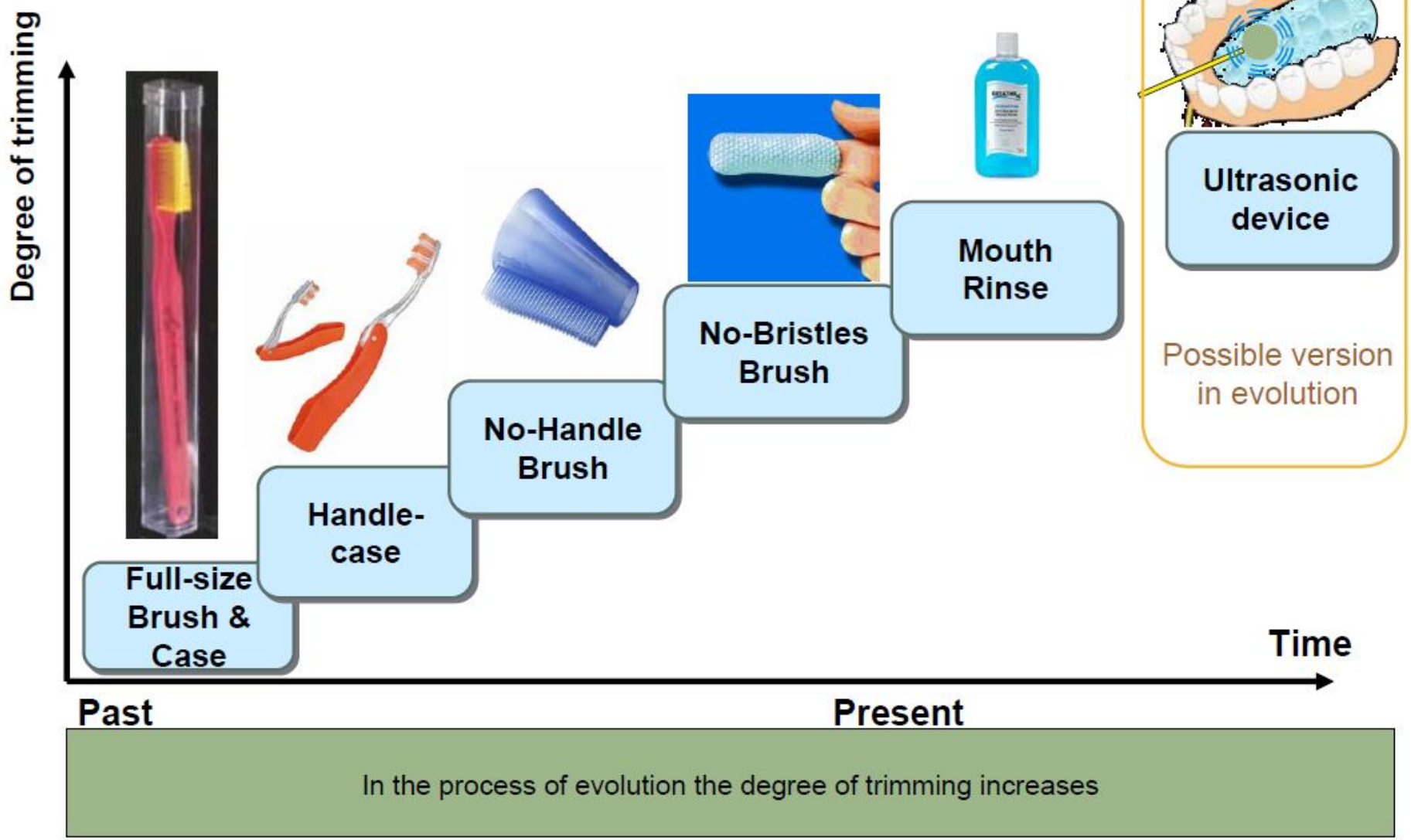
Solution 2



4. What does it look like?



Trend of Increasing Degree of Trimming



When innovation is needed?

TRIZ Tool : 9 Windows

	Past	Current	Future
Supersystem	**Past External Components**	**Current External components**	**Future External Components**
System	Past System	**Current System**	Future System
Subsystem	Past components	Current components	Future Components

TRIZ Tool : 9 Windows

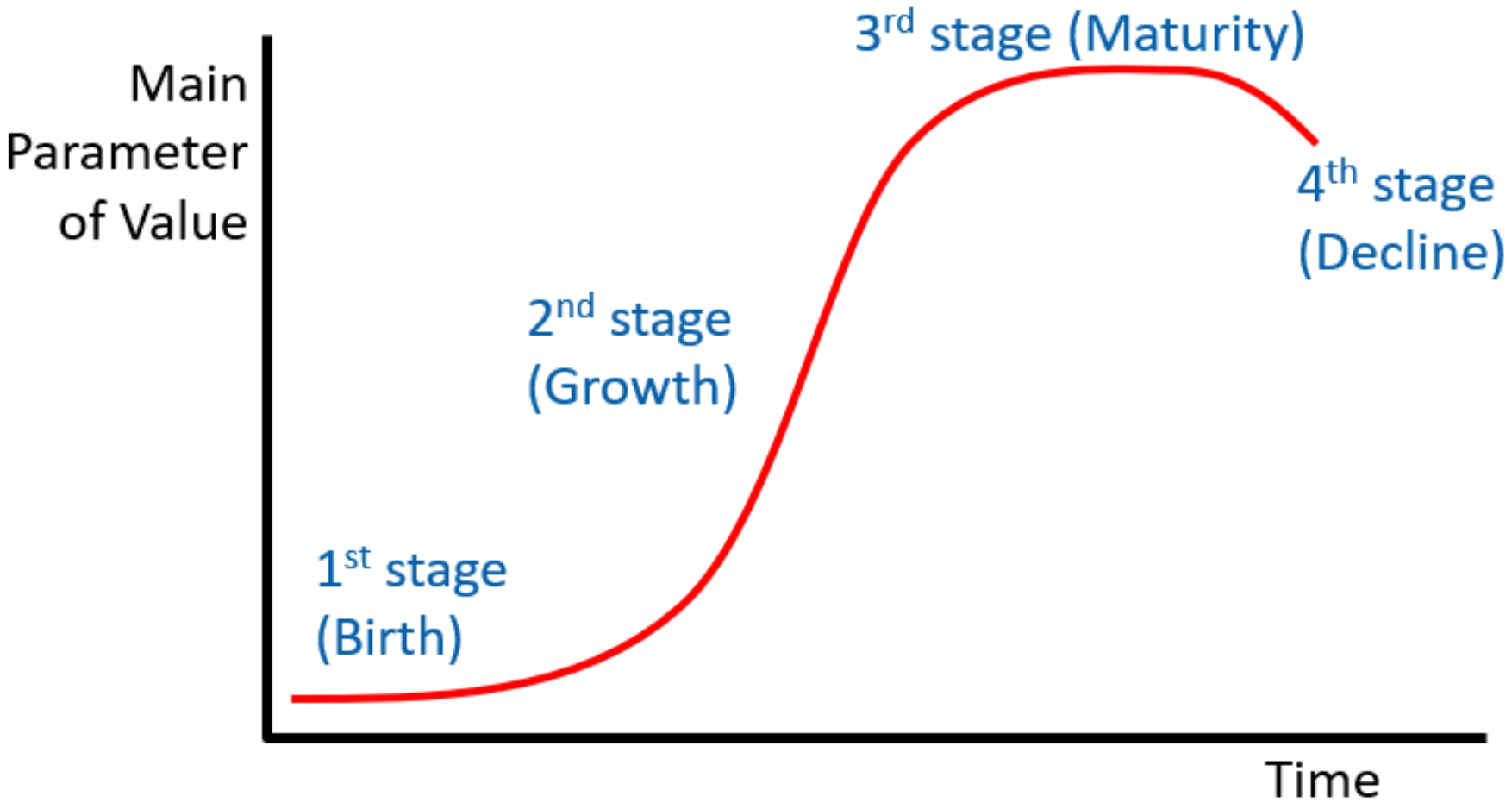
	Past	Current	Future
Supersystem	**External Environment:** Economic , Politic, technology	**External Environment:** Economic , Global, Politic, Social culture, Demographics, technology	**External Environment:** Economic , Global, Politic, Social culture, Demographics, technology
System	Organisation : Enterprise	**Organisation: Sdn Bhd**	Organisation: Berhad, Holding
Subsystem	Money, office, van	Staff, money, Office, shop, store, lorry, Bank account,	Staff, money, credit facility, Factory, training centre, container, Shipping

9 Windows : UPM

	Past	Current	Future
Supersystem	Kerajaan Malaysia Rakyat Malaysian Industri	Kerajaan Malaysia Rakyat Malaysia Industri Teknologi International Student	Kerajaan Malaysia Rakyat Malaysia Industri Teknologi Global Student Alumni
System	Universiti Pertanian Malaysia	**Universiti Putra Malaysia**	UPM Global University
Subsystem	Canselori Perpustakaan Fakulti	Canselori Perpustakaan Fakulti Research Institute UPM Holding	Canselori Information Centre Fakulti Institute UPM Holding Alumni Endowment

TRIZ Tool: S Curve

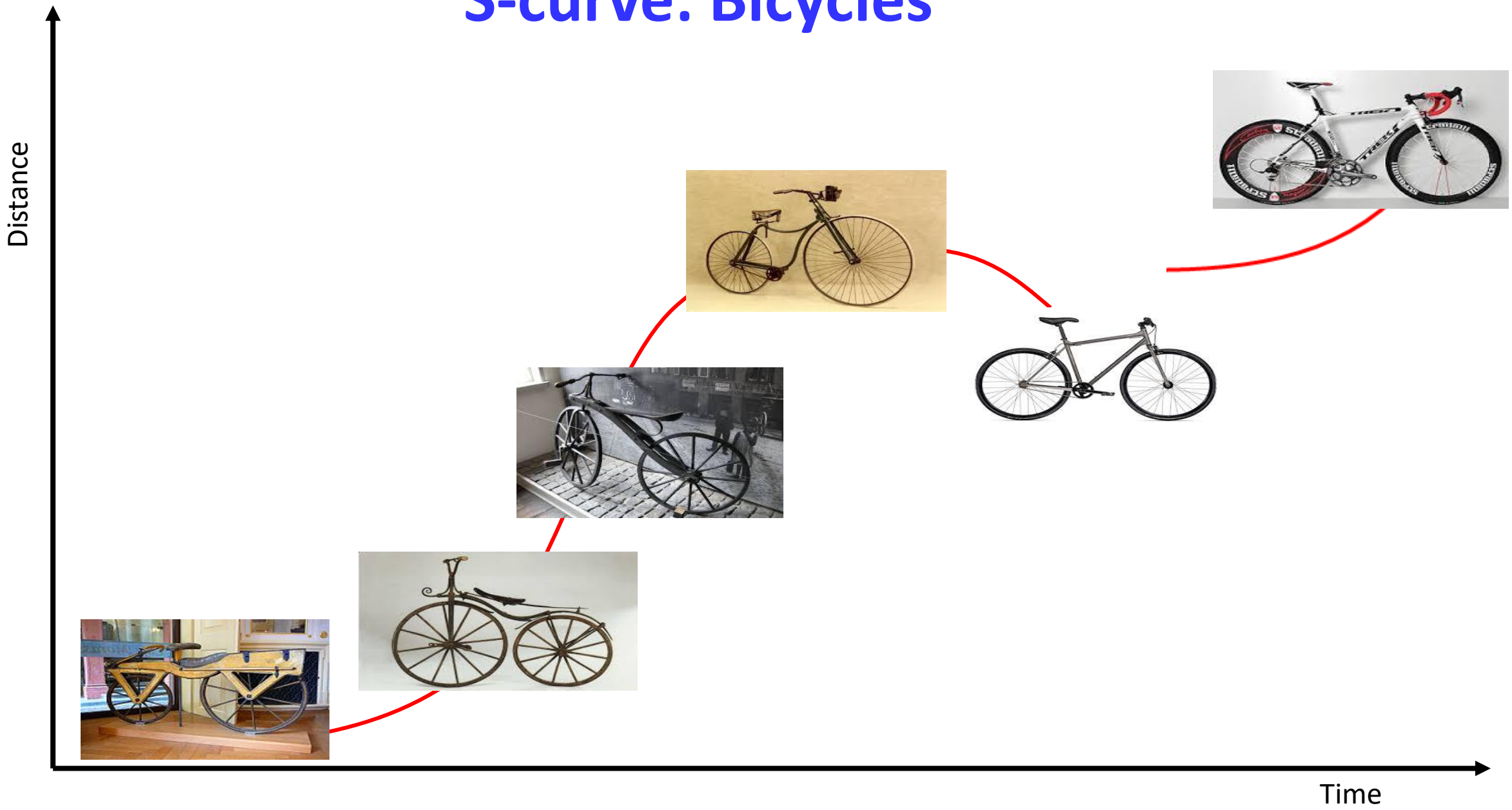
TRIZ S Curve Evolution



Main Parameter of Value (MPV):
Key attribute/outcome of a product/service that is hereto unsatisfied and important to the purchase decision process

Innovation:
Significant improvement along at least one Main Parameter of Value

S-curve: Bicycles



1st Stage Analysis

- Overview
  - The system is born where the principle of action is first applied to deliver its main function
  - The system design and components are not refined
  - Face intense competition with emerging and leading technologies
- Indicators
  - The System is new and has a champion parameter, but has not yet entered the market
- Examples
  - Stem cell research, software beta version, BIOME car
- Recommendations
  - Major changes to system including its principle of operation are allowed
  - Must launch into the market as quickly as possible
  - Focus on market where the champion parameter is most important

2nd Stage Analysis

- Overview
  - Main parameter of value improves rapidly
  - Production volume growth
  - Expand to new applications
- Indicators
  - The system moves into mass production
  - Differentiation between system application increases
  - The system gains functions that are closely connected to the main function
- Examples
  - GPS, tablet computer, smart phones
- Recommendations
  - Optimization is the principal method of improving the system
  - Adapt the system to new fields or applications
  - Adding components to gain more functions

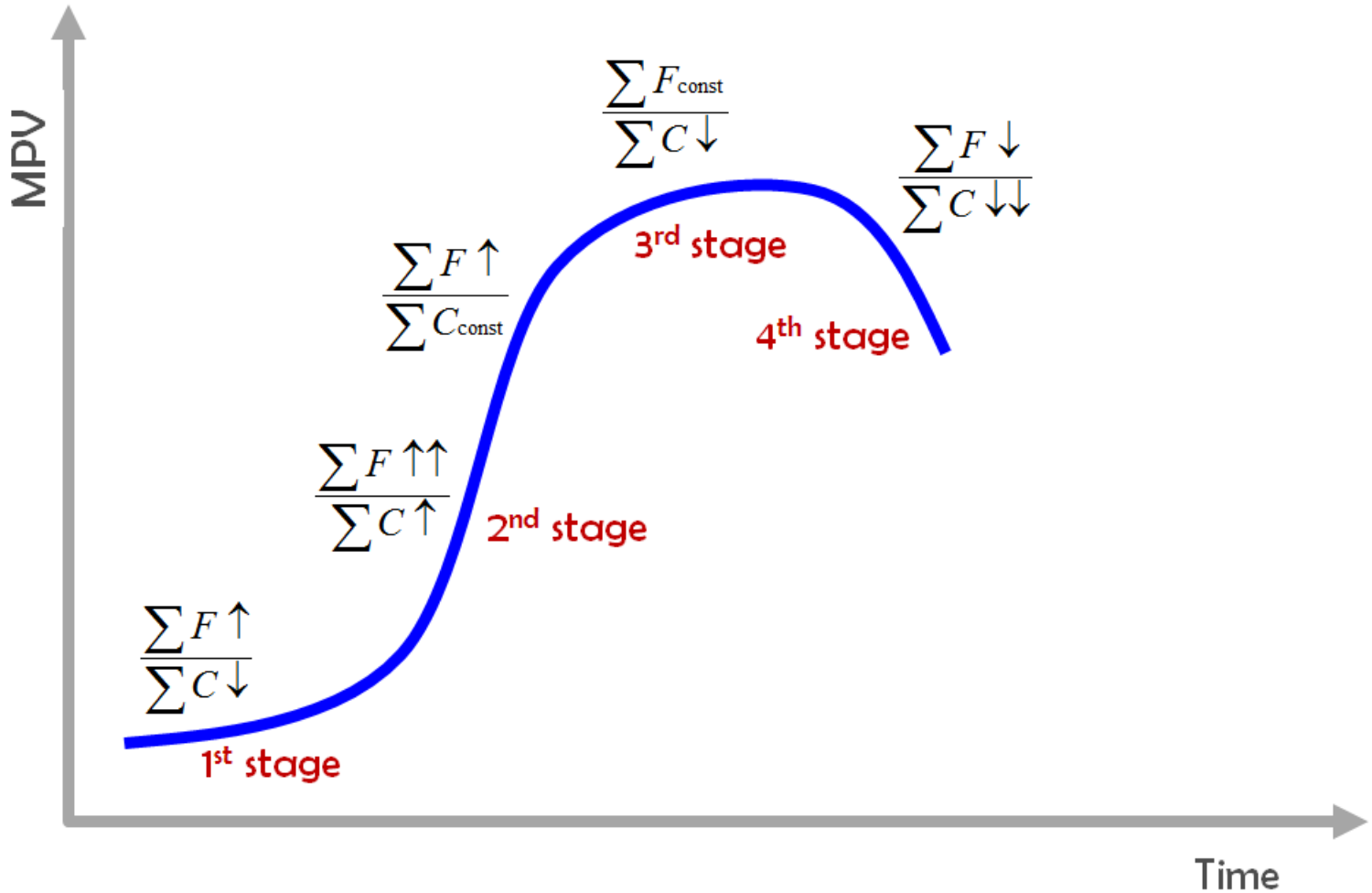
3rd Stage Analysis

- Overview
  - The system development slows enormously, despite increasing efforts
  - Production volume become stable
  - One or more contradictions increase exponentially, hindering further growth of the function/cost ratio
- Indicators
  - The system consumes highly specialized resources
  - Supersystem components are designed to accommodate the system
  - Variations differ from one another mainly by design
  - The system acquires additional functions that are of little relevance to the main function
- Examples
  - Computers, cars, mirrors
- Recommendations
  - Reduce costs, develop service components, improve aesthetic design
  - Deep trimming, integration of alternative system or transition to supersystem
  - Look for a Main Parameter of Value that is in an earlier stage to develop

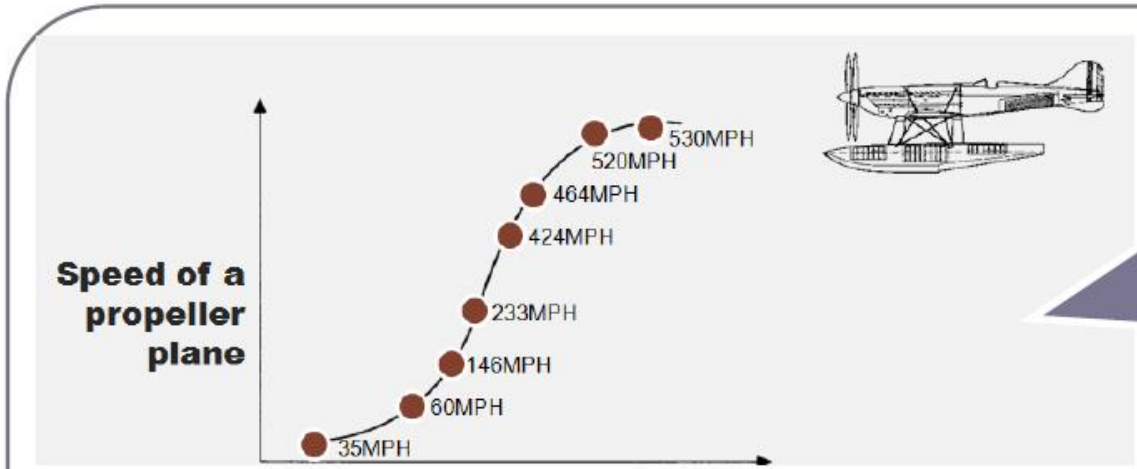
4th Stage Analysis

- Overview
  - The system functionality and revenue decline
  - Production volume drops considerably
  - More effective systems have reached their 2nd stage and are beginning to force the system out
- Indicators
  - Main function of the system loses its utility become non-utilitarian such as toy, souvenir, decoration or sport equipment, entertainment, etc
  - The system continues to function only in highly specialized fields
  - The system continues to function within a Supersystem
- Examples
  - Typewriters, film camera, ink blotter
- Recommendations
  - Look for the market where the System would be competitive
  - Further reduce costs, develop service component, improve design
  - Deep trimming and transition to supersystem

Trends of Increasing Value and S-Curve Evolution

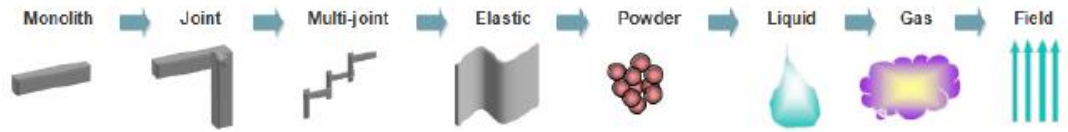


Understand Evolutionary Trends – Example



Trend of S-Curve Evolution
Propeller planes have reached their maximum speed potential

Trend of Increasing Dynamicity



Example: Measuring distance

Monolith: Ruler

Multi-joint: Folding Ruler

Elastic: Tape Measure

Field: Laser Measure

Innovation Challenge

How can we take a commodity product and find new opportunities for growth?

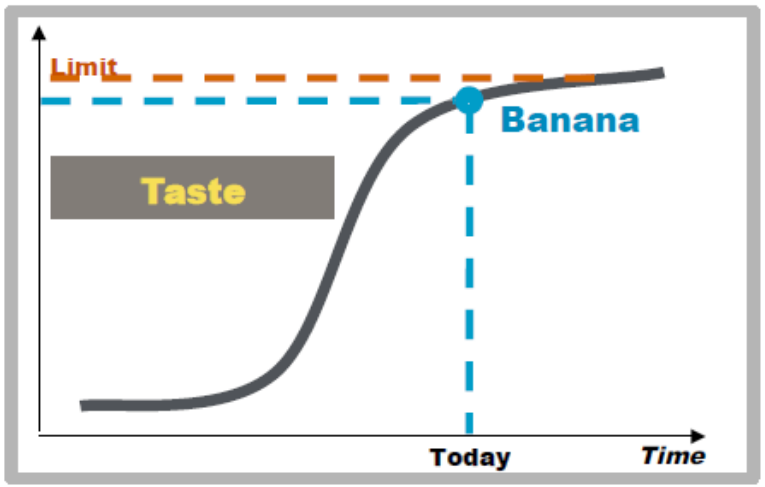
Main Parameters of Value?

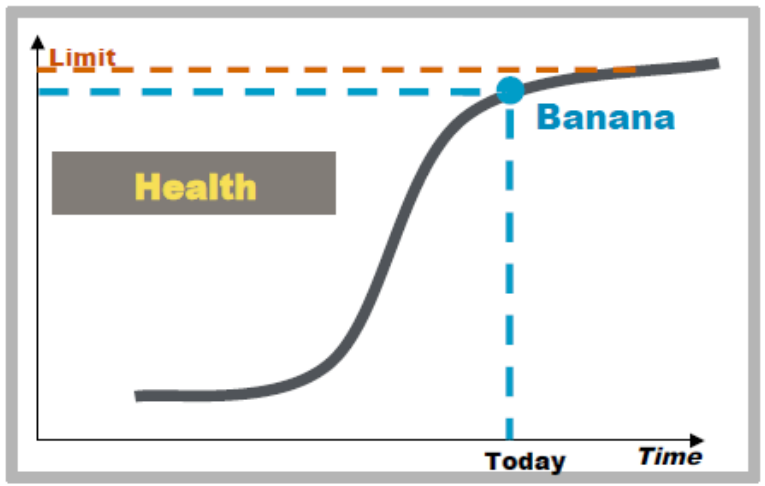
- Taste
- Health
- Appearance
- Convenience
- Brand

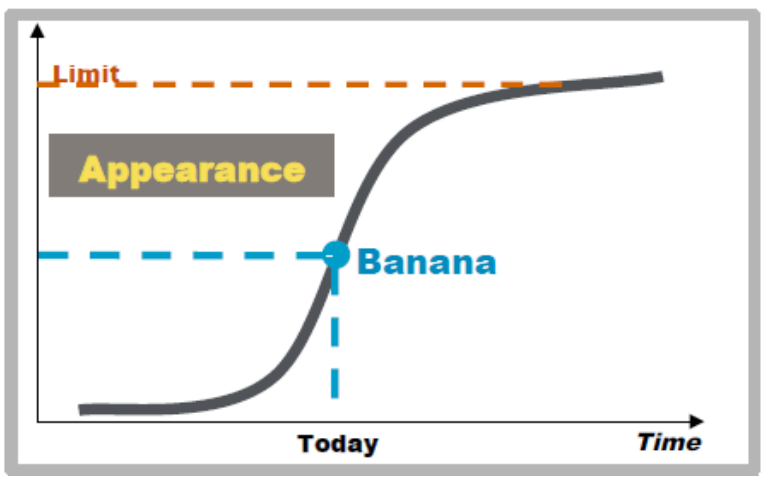
But what is the development potential along each MPV?

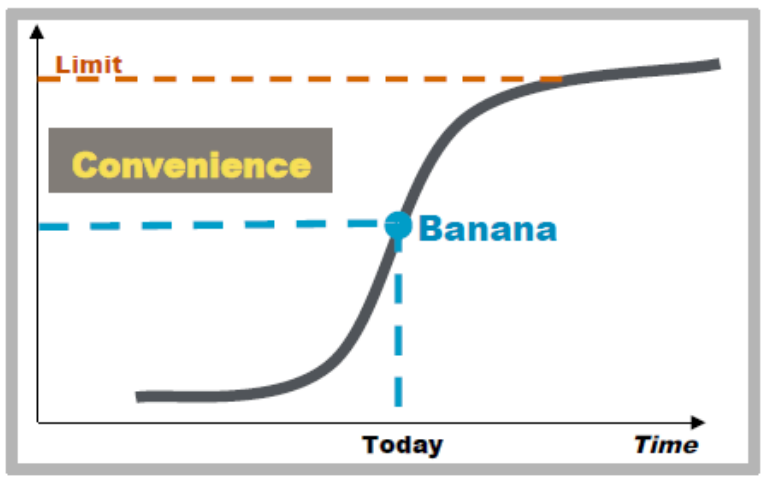
Innovation Challenge

S-Curve Analysis of Banana Products – Opportunities for growth/improvement?









Innovation Solution

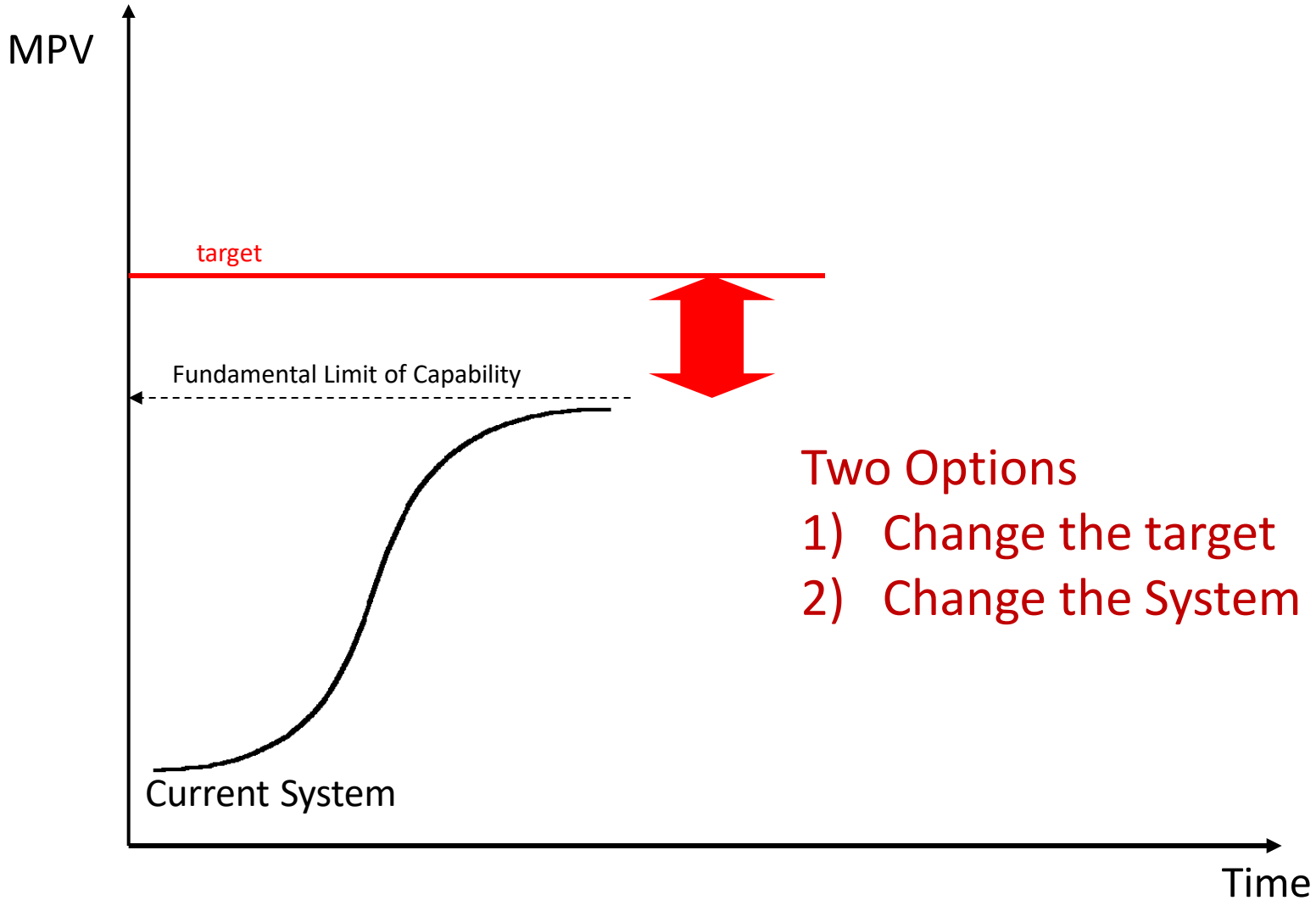
Solution:

Synchronize the velocity of the supply chain with the natural biological processes for the ripening of the fruit

- Regulates in-flow of oxygen and outflow of carbon dioxide

New channels offer new profit potential

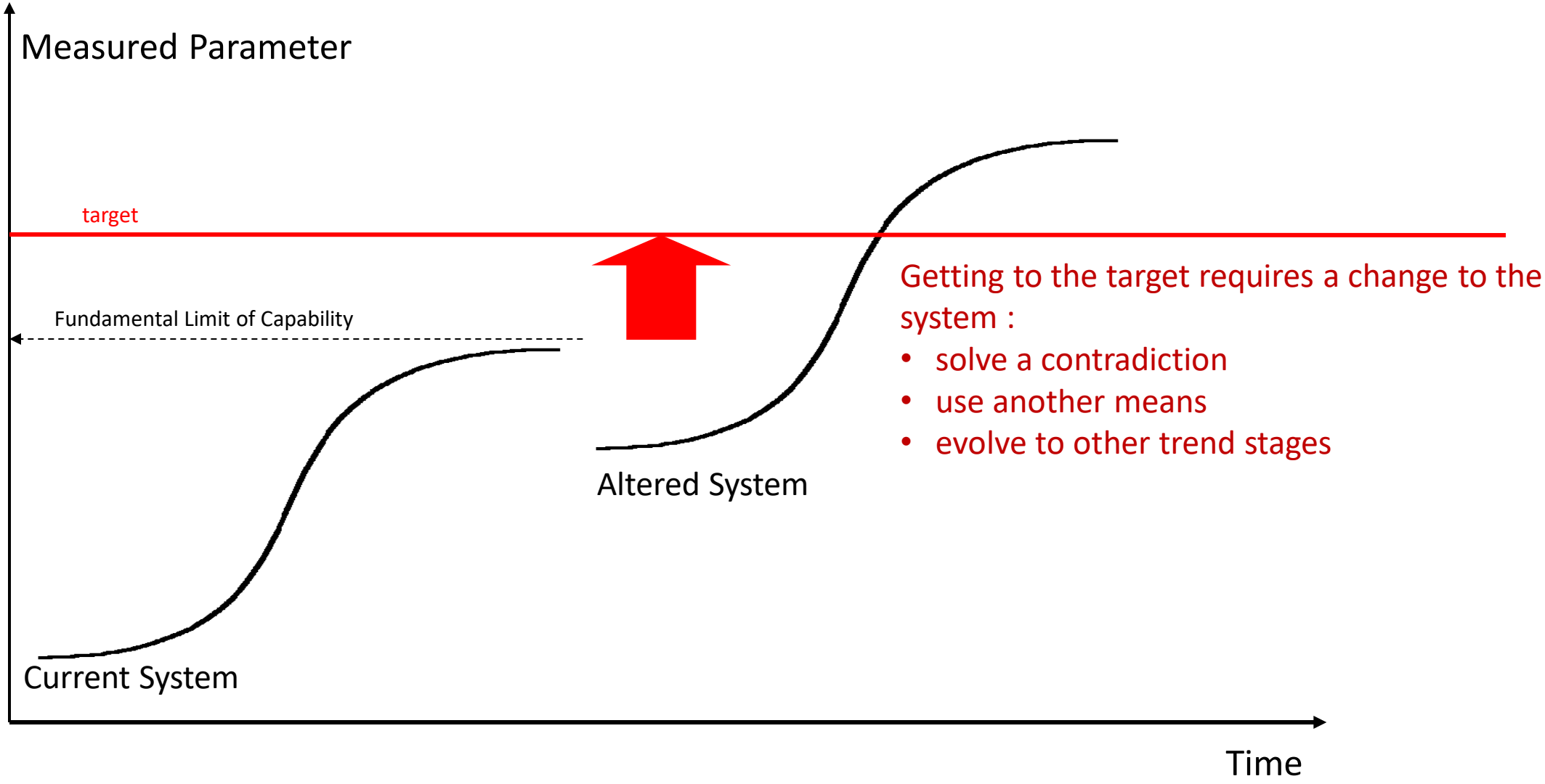
The Overriding Importance of Evolutionary S-Curves



Two Options

1) Change the target
2) Change the System

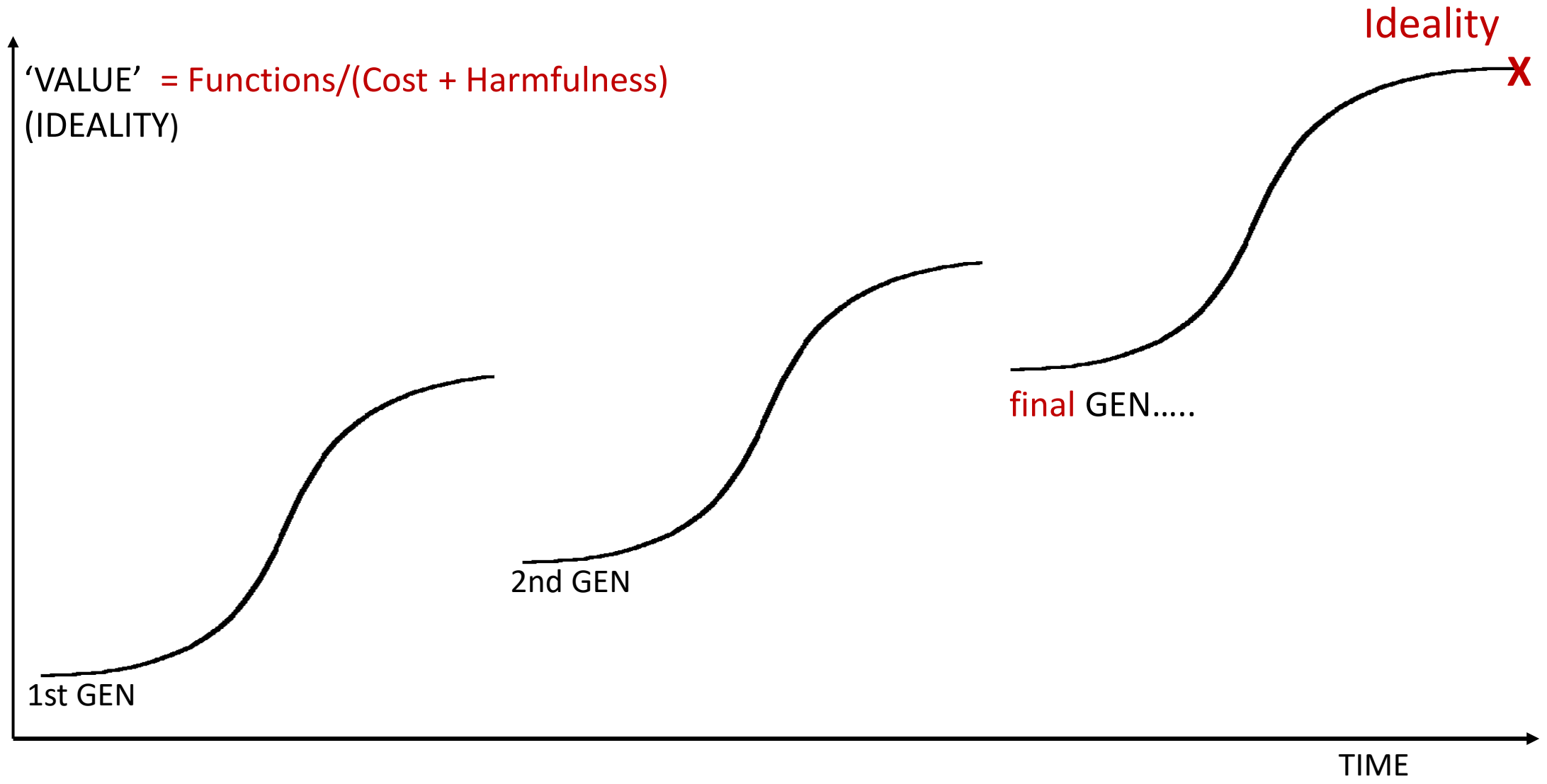
The Overriding Importance of Evolutionary S-Curves



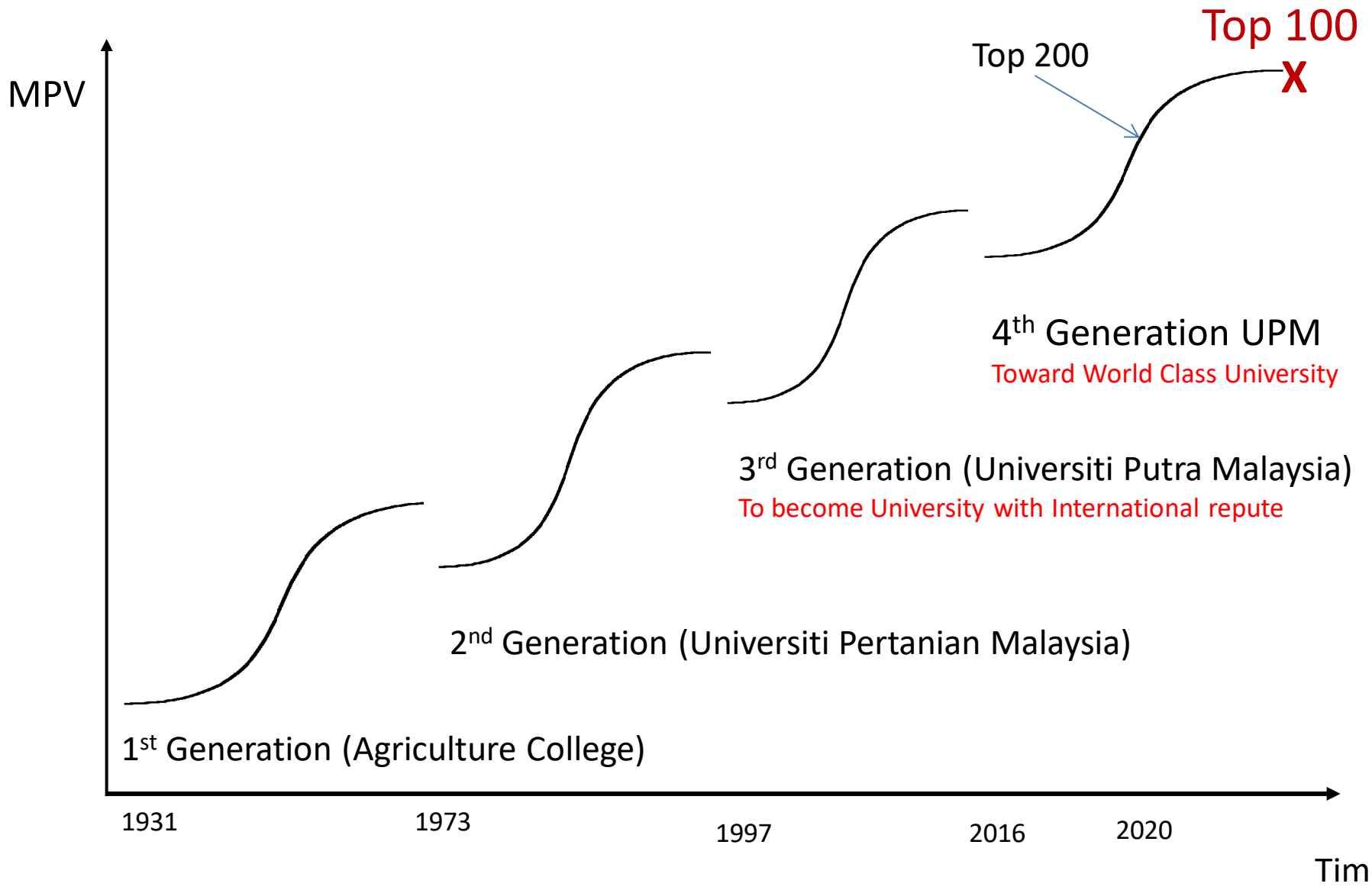
Getting to the target requires a change to the system :

- solve a contradiction
- use another means
- evolve to other trend stages

Predictable Trends of Evolution

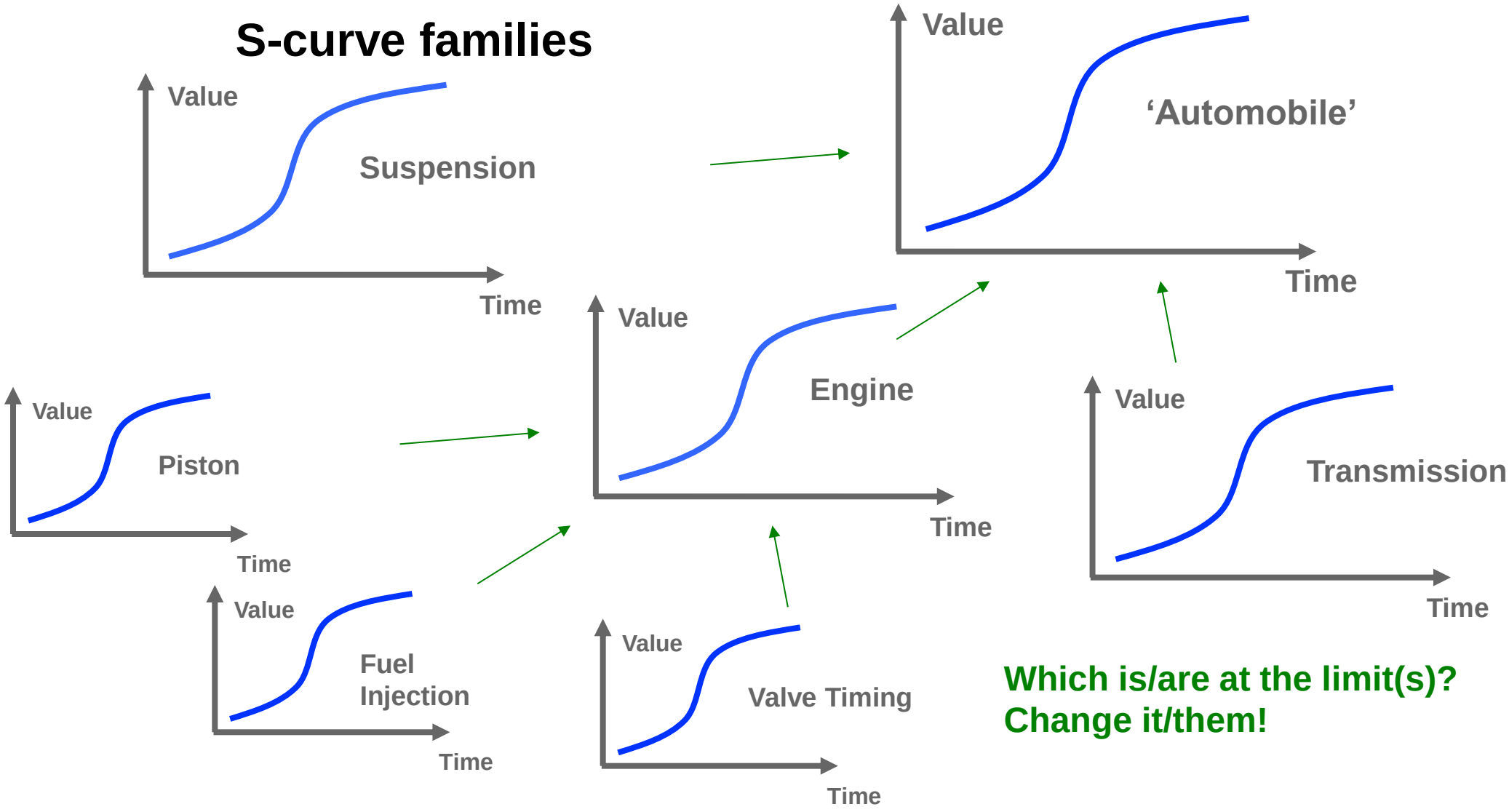


Predictable Trends of Evolution



Ideality – System Dynamics

S-curve families



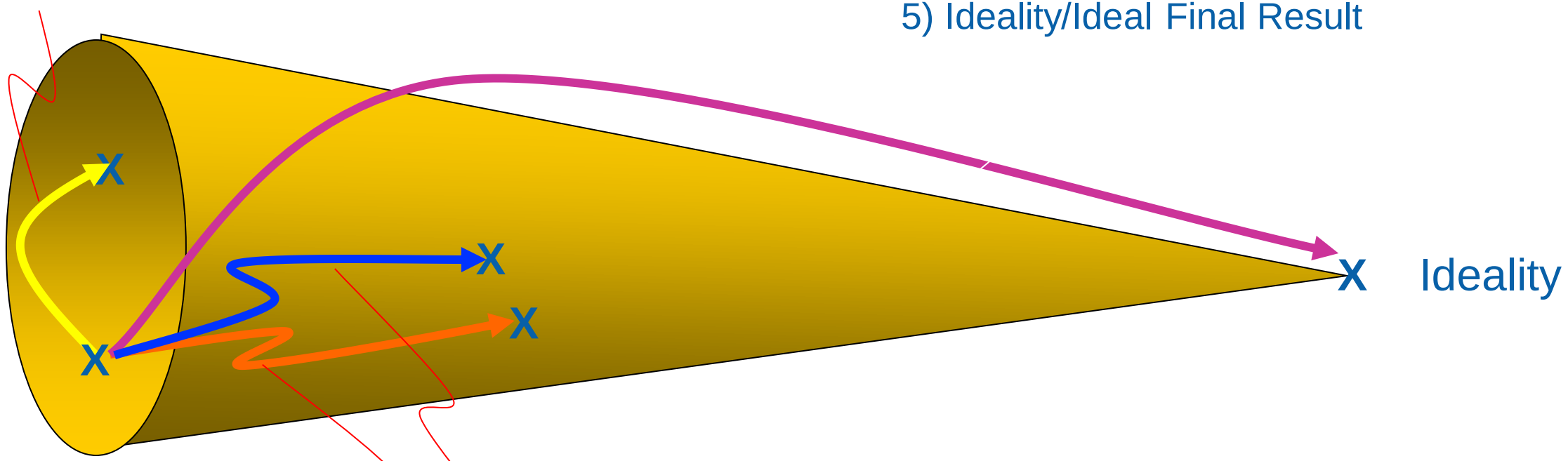
Which is/are at the limit(s)?
Change it/them!

System Evolution Paths

Ideality = $\frac{\Sigma \text{ Functionality}}{\Sigma \text{ Costs} + \Sigma \text{ Harm}}$

4) Knowledge/Effects

5) Ideality/Ideal Final Result



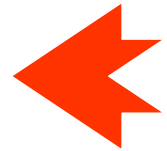
Ideality

System Today

1) Function Analysis – using Trimming
2) Contradictions & Principles
3) Technology Trends

TRIZ – 40 Prinsip Inventif

40 Inventive Principles



1. Segmentation
2. Taking out / Extraction
3. Local Quality
4. Asymmetry
5. Merging / Combination
6. Universality
7. “Nested Doll”
8. Anti-weight / Counter-weight
9. Preliminary anti action / Prior counter-action
10. Preliminary action / Prior action
11. Beforehand cushioning / Prior cushioning
12. Equi-potentiality / Remove tension
13. ‘The other way round’
14. Spheroidality-Curvature
15. Dynamics
16. Partial or excessive actions
17. Another dimension
18. Mechanical Vibration
19. Periodic action
20. Continuity of useful action
21. Skipping / Hurrying
22. ‘Blessing in Disguise’
23. Feedback
24. Intermediary
25. Self- Service
26. Copying
27. Cheap / short Living
28. Mechanics substitution / Another sense
29. Pneumatics and hydraulics / Fluidity
30. Flexible shells and thin films / Thin & flexible
31. Porous Materials / Holes
32. Color changes
33. Homogeneity
34. Discarding and recovering
35. Parameter changes
36. Phase transitions
37. Thermal expansion / Relative change
38. Strong oxidants / Enriched atmosphere
39. Inert atmosphere / Calmed atmosphere
40. Composite materials / Composite structures

40 Prinsip Inventif

1. Pembahagian *(Segmentation)*
2. Pengekstrakan *(Extraction)*
3. Kualiti Setempat *(Local Quality)*
4. Ketidaksamaan *(Asymmetry)*
5. Gabungan *(Merging)*
6. Pelbagai Fungsi *(Universality)*
7. "Nested Doll"
8. Mengurangkan Berat *(Anti-weight)*
9. Pencegahan Awal *(Preliminary Anti-action)*
10. Tindakan Awal *(Preliminary Action)*
11. Perlindungan Awal *(Beforehand Cushioning)*
12. Potensi yang Sama *(Equipotentiality)*
13. Disebaliknya *(The Other Way Round)*
14. Lengkungan *(Curvature)*
15. Dinamik *(Dynamization)*
16. Tindakan Separa atau Berlebihan *(Partial Action or Excessive Action)*
17. Dimensi Lain *(Another Dimension)*
18. Getaran Mekanikal *(Mechanical Vibration)*
19. Tindakan Berkala *(Periodic Action)*
20. Tindakan Berfaedah yang Berterusan *(Continuity of Useful Action)*
21. Langkau *(Skipping)*
22. Mengubah Keburukan kepada Faedah *(Convert Harm Into Benefits)*
23. Maklumbalas *(Feedback)*
24. Perantaraan *(Intermediary/Mediator)*
25. Layan Diri *(Self Service)*
26. Menyalin *(Copying)*
27. Murah/ Pakai Buang/ Tidak Tahan Lama *(Cheap/Short Living Objects)*
28. Penggantian Mekanik *(Mechanical Substitution)*
29. Pneumatik/ Hidraulik *(Pneumatics/ Hydraulics)*
30. Lapisan Fleksibel dan Filem Nipis *(Flexible Membrane or Thin Films)*
31. Bahan Berongga *(Porous Material)*
32. Ubah Warna *(Colour Change)*
33. Keseragaman *(Homogeneity)*
34. Membuang & Memulihkan *(Discarding & Recovering)*
35. Perubahan Parameter *(Parameter Change)*
36. Peralihan Fasa *(Phase Transitions)*
37. Pengembangan Haba *(Thermal Expansive)*
38. Pengoksida Kuat *(Strong Oxidants)*
39. Persekitaran Lengai *(Inert Atmosphere)*
40. Bahan Komposit *(Composite Materials)*

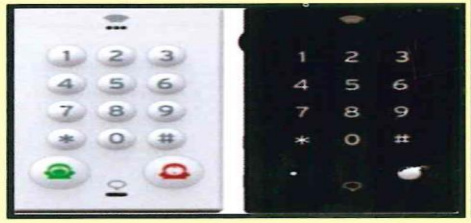
Prinsip 1: Pembahagian *(Segmentation)*

- Membahagikan objek kepada bahagian-bahagian tertentu mengikut fungsi
- Membuat objek yang mudah dipasang atau diasingkan
- Meningkatkan tahap pengasingan atau segmentasi



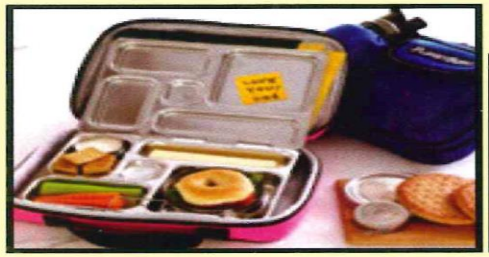
Prinsip 2: Pengekstrakan *(Extraction)*

- Memisahkan atau mengambil sebahagian daripada fungsi objek yang diperlukan sahaja



Prinsip 3: Kualiti Tempatan *(Local Quality)*

- Mengubah struktur objek atau persekitaran luar (atau pengaruh luar) daripada seragam kepada tidak seragam
- Menjadikan setiap bahagian objek berperanan mengikut fungsinya
- Menjadikan setiap bahagian objek dilengkapi dengan fungsi yang berbeza dan berguna



Prinsip 4: Ketidaksamaan *(Asymmetry)*

- Mengubah bentuk sesuatu objek daripada simetri (sama) kepada asimetri (tidak sama)
- Sekiranya objek tidak sama, tingkatkan tahap ketidaksamaan pada objek berkenaan

Prinsip 5 : Gabungan (Merging)

- Mengabungkan beberapa komponen yang pelbagai fungsi dalam satu produk
- Menyatukan sesuatu sistem yang rawak kepada satu sistem

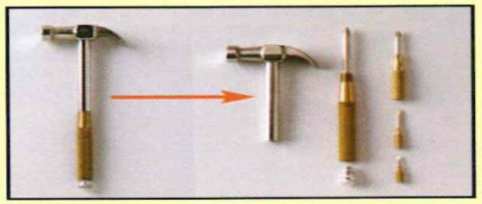
Prinsip 6 : Pelbagai Fungsi (Universality)

- Menyesuaikan sesuatu sistem dengan pelbagai persekitaran
- Menjadikan sesuatu sistem boleh digunapakai untuk pelbagai kegunaan
- Menambahkan lagi fungsi kepada sistem yang dah sediada

Prinsip 7: *Nested Doll*

- Menempatkan beberapa objek di dalam satu kategori objek yang sama dalam saiz yang berbeza





Prinsip 8: Mengurangkan Berat *(Anti-weight)*

- Menggabungkan objek dengan objek lain yang boleh diangkat
- Mengurangkan berat sesuatu objek dengan kaedah-kaedah seperti aerodinamik, hidrodinamik, keapungan dan daya lain yang berkaitan


Prinsip 9: Pencegahan Awal *(Preliminary Anti-action)*

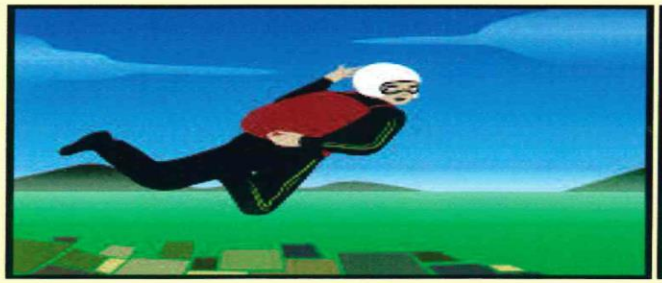
- Langkah pencegahan untuk mengelak kesan merbahaya kepada sesuatu proses
- Mewujudkan pencegahan pada peringkat awal untuk mengelakkan daripada kesan yang tidak diingini berlaku

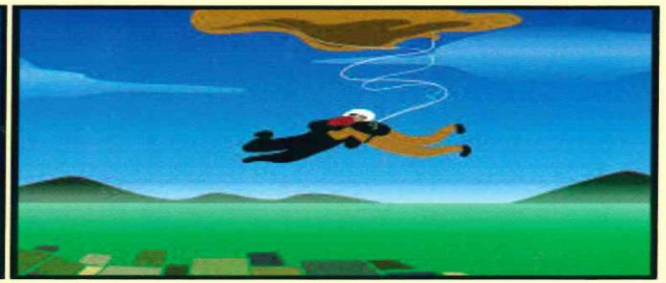

Prinsip 10: Tindakan Awal *(Preliminary Action)*

- Melaksanakan tindakan awal yang diperlukan untuk sesuatu objek secara menyeluruh atau sebahagian
- Meletakkan objek dengan fungsi tertentu terlebih dahulu sebelum ianya boleh digunakan

Prinsip 11: Perlindungan Awal *(Beforehand Cushioning)*

- Persediaan alternatif lain jika berlaku sesuatu kemalangan yang tidak dijangka





Prinsip 12: Potensi yang sama *(Equipotentiality)*

- Memudahkan proses kerja yang tidak memerlukan proses mengangkat atau menurunkan objek

Prinsip 13: Disebaliknya *(The Other Way Round)*

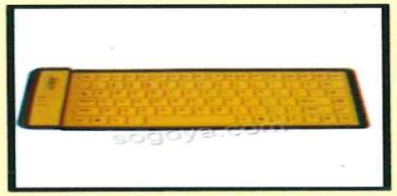
- Melaksanakan tindakan yang bertentangan/ berlawanan, contoh: sejuk kepada panas
- Menjadikan benda yang boleh dialih (atau persekitaran luar) kepada tetap, dan benda yang tetap kepada boleh dialih
- Menghasilkan objek atau proses supaya boleh digunakan pada kedua-dua bahagian


Prinsip 14: Lengkungan *(Curvature)*

- Menggantikan bahagian yang lurus menjadi lengkung, permukaan yang serata menjadi sfera, dan bentuk kiub menjadi bola
- Menggunakan roda,bola,pilin dan kubah
- Menggantikan pengerakkan sebaris menjadi pusingan dan menggunakan daya putaran


Prinsip 15: Dinamik *(Dynamization)*

- Membenarkan ciri-ciri sesuatu objek, persekitaran luar atau proses berubah kepada keadaan lebih yang optimal
- Membahagikan objek kepada bahagian –bahagian yang berupaya bergerak berbanding bahagian lain
- Menjadikan objek yang tidak fleksibel dan tegar kepada objek yang mudah dialih

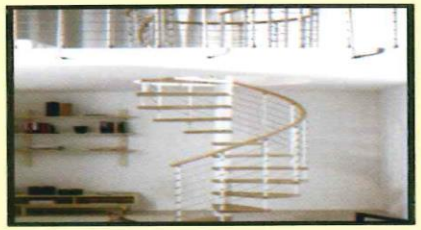




Prinsip 16: Tindakan Separa atau Berlebihan *(Partial Action or Excessive Action)*

- Bagi kaedah yang sukar mencapai penyelesaian 100%, gunakan kaedah yang sama dengan cara ditambah atau dikurangkan supaya dapat menyelesaikan masalah dengan mudah

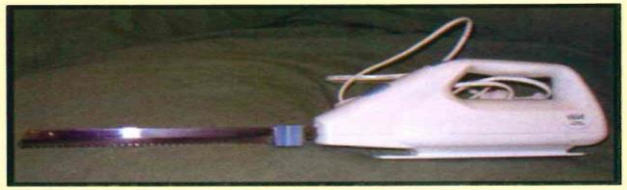
Prinsip 17: Dimensi Lain *(Another Dimension)*

- Peralihan pergerakan dari satu dimensi kepada beberapa dimensi yang lain
- Menggunakan susunan secara bertingkat
- Menukar posisi objek mengikut kesesuaian



Prinsip 18: Getaran Mekanikal *(Mechanical Vibration)*

- Menggunakan objek berayun atau bergetar
- Meningkatkan kekerapan getaran
- Menggunakan frekuensi alunan sesuatu objek
- Menggunakan penggetar piezoelektrik bukan yang mekanikal
- Menggunakan gabungan ultrasonik dan elektromagnet



Prinsip 19: Tindakan Berkala *(Periodic Action)*

- Menggunakan tindakan berkala
- Menukar magnitud atau kekerapan jika sesuatu tindakan telah berkala
- Berhenti seketika diantara tindakan untuk melaksanakan tindakan yang berbeza



Prinsip 20: Tindakan berfaedah yang berterusan *(Continuity of Useful Action)*

- Memaksimumkan kapasiti dan kecekapan sesuatu proses secara berterusan
- Membuang proses yang tidak mempunyai nilai tambah.
- Menggantikan pergerakan 'back-and-forth' dengan pergerakan secara berputar.


Prinsip 21: Langkau *(Skipping)*

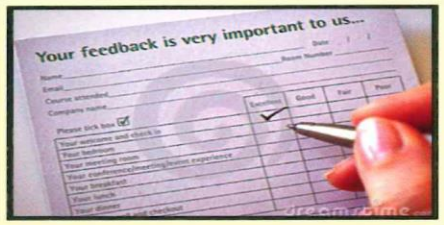
- Melaksanakan operasi yang berbahaya dengan cepat


Prinsip 22: Mengubah keburukan kepada faedah (Convert Harm Into Benefits)

- Menggunakan faktor kerosakan (terutamanya, kesan kemusnahan pada alam sekitar) untuk mendapat kesan positif
- Menghapuskan kerosakan utama dengan menyatukan kerosakan tersebut dengan kerosakan yang lain
- Mengurangkan tindakan yang berbahaya hingga ke tahap tidak membahaya

Prinsip 23: Maklumbalas *(Feedback)*

- Menggunakan maklumbalas untuk meningkatkan kecekapan proses kerja
- Melaksanakan penambahbaikan setelah menerima maklumbalas



Prinsip 24: Perantaraan *(Intermediary / Mediator)*

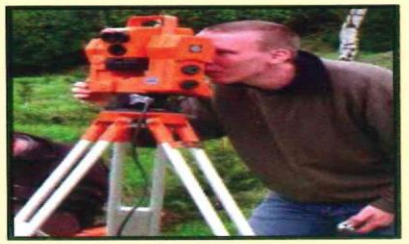
- Menggunakan objek pengantara untuk memindahkan atau melakukan sesuatu proses
- Menggunakan bahan pengantara dengan fungsi tertentu yang mudah dikeluarkan

Prinsip 25: Layan Diri *(Self Service)*

- Sesuatu objek yang beroperasi dengan sendirinya
- Menggunakan bahan buangan untuk fungsi tertentu

Prinsip 26: Menyalin *(Copying)*

- Menggunakan objek yang murah dan mudah sebagai bahan gantian
- Mengantikan objek atau proses dengan imej optikal
- Jika salinan optikal wujud, pindahkan kepada salinan infra-red atau ultraviolet

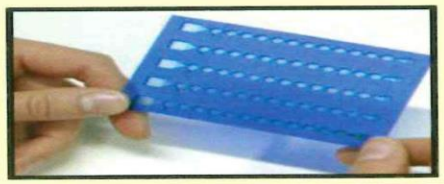


Prinsip 27: Murah/ Pakai Buang/ Tidak Tahan Lama *(Cheap Short Living Objects)*

- Menggantikan objek yang mahal dengan objek murah tanpa menjejaskan kualiti/sifat tertentu seperti ketahanan dan jangka hayat produk/perkhidmatan

Prinsip 28: Penggantian Mekanik *(Mechanical Substituition)*

- Menggantikan kaedah mekanikal dengan pengesan deria (seperti optik, akustik, haba, rasa atau bau)
- Menggunakan elektrik, magnetik dan medan elektromagnetik untuk berinteraksi dengan objek
- Mengubah dari objek statik kepada objek mudah alih, daripada yang tidak berstruktur kepada yang lebih berstruktur
- Menggunakan medan sedia ada dengan sebahagian medan yang diaktifkan (contohnya feromagnetik)



Prinsip 29: Pneumatik atau Hidraulik *(Pneumatics and Hydraulics)*

- Gunakan bahagian gas atau cecair pada sesuatu objek berbanding dengan yang padat (contohnya kembung, mengandungi cecair, kusyen udara,hidrostatik, hidroreaktif)


Prinsip 30: Lapisan Fleksibel Dan Filem Nipis *(Flexible Membrane Or Thin Flims)*

- Gunakan perlindungan fleksibel dan filem nipis selain daripada struktur berbentuk tiga dimensi
- Mengasingkan objek daripada persekitaran luaran menggunakan lapisan fleksibel dan filem nipis


Prinsip 31: Bahan Berongga *(Porous Material)*

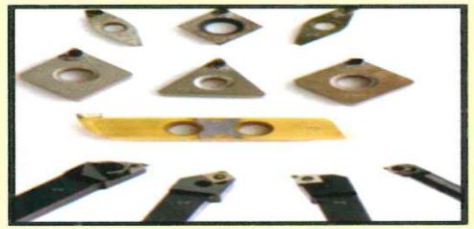
- Jadikan objek berongga atau menambah elemen berongga (memasukkan, menyelaputi, dan sebagainya)
- Jika objek sudah berongga, gunakan ruang tersebut untuk meletakkan barang

Prinsip 32: Ubah Warna *(Color Change)*

- Menukar warna objek atau persekitarannya
- Menukar ketelusan/kelutsinaran objek atau persekitarannya
- Menggunakan bahan tambahan warna untuk melihat sesuatu objek atau proses yang sukar untuk dilihat
- Menukar sifat objek mengikut proses penyerapan atau pembebasan haba

Prinsip 33: Keseragaman *(Homogeneity)*

- Gabungkan objek bersama dengan objek yang mengandungi bahan yang sama (Atau bahan yang mengandungi ciri yang sama)



Prinsip 34: Membuang dan Memulihkan *(Discarding and Recovering)*

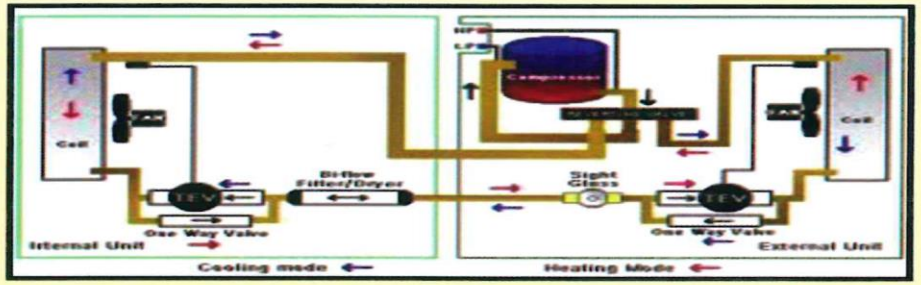
- Objek yang telah digunakan akan dibuang
- Alatan yang telah digunakan dapat digunakan semula

Prinsip 35: Perubahan Parameter *(Parameter Change)*

- Mengubah keadaan fizikal sesuatu objek (contohnya kepada gas, cecair, atau pepejal)
- Tukar kepekatan atau konsisten
- Tukar tahap fleksibiliti
- Menukar kepada parameter lain

Prinsip 36: Peralihan Fasa *(Phase Transitions)*

- Mengaplikasikan fenomena yang terjadi ketika peralihan fasa. (Contoh perubahan kuantiti, penyerapan dan pembebasan haba)

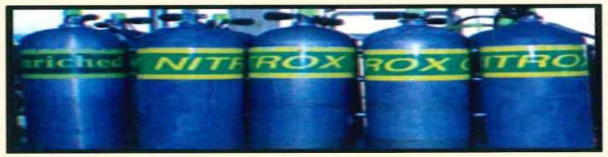


Prinsip 37: Pengembangan Haba *(Thermal Expansive)*

- Menggunakan bahan yang boleh meningkatkan haba
- Jika peningkatan haba sedang digunakan, gunakan beberapa bahan yang mengandungi faktor perkembangan haba yang berbeza


Prinsip 38: Pengoksida Kuat *(Strong Oxidants)*

- Menggantikan udara biasa dengan gas oksigen (Penyelam skuba dengan gas nitrox untuk tempoh menyelam lebih lama)
- Menggantikan udara biasa dengan gas oksigen yang tulen (Memotong besi dengan lebih cepat dengan semburan api oxy-acetylene)



Prinsip 39: Persekitaran Lengai *(Inert Atmosphere)*

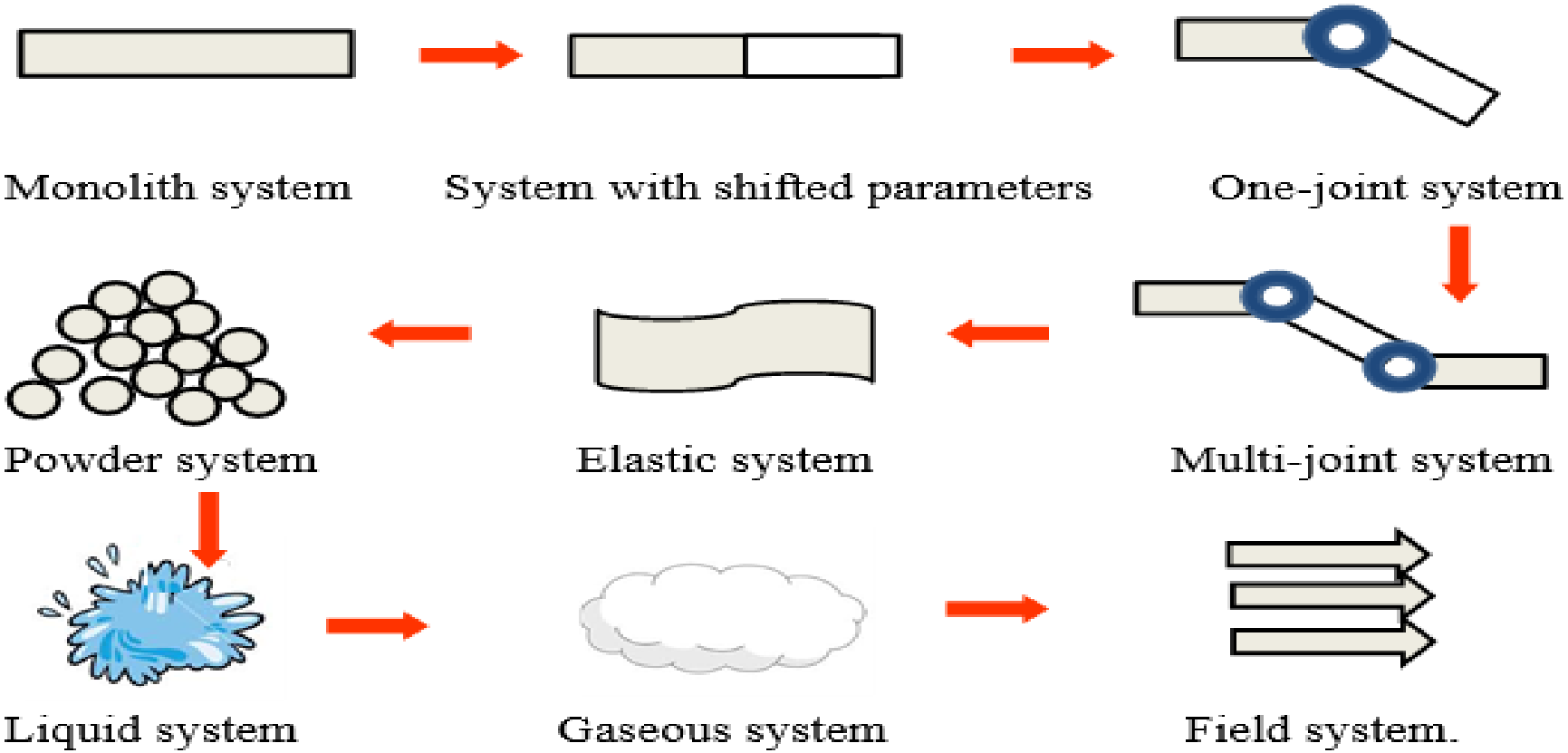
- Menggantikan persekitaran yang normal kepada lengai
- Penambahan bahagian natural atau penambahan lengai kepada sesuatu objek


Prinsip 40: Bahan Komposit *(Composite Materials)*

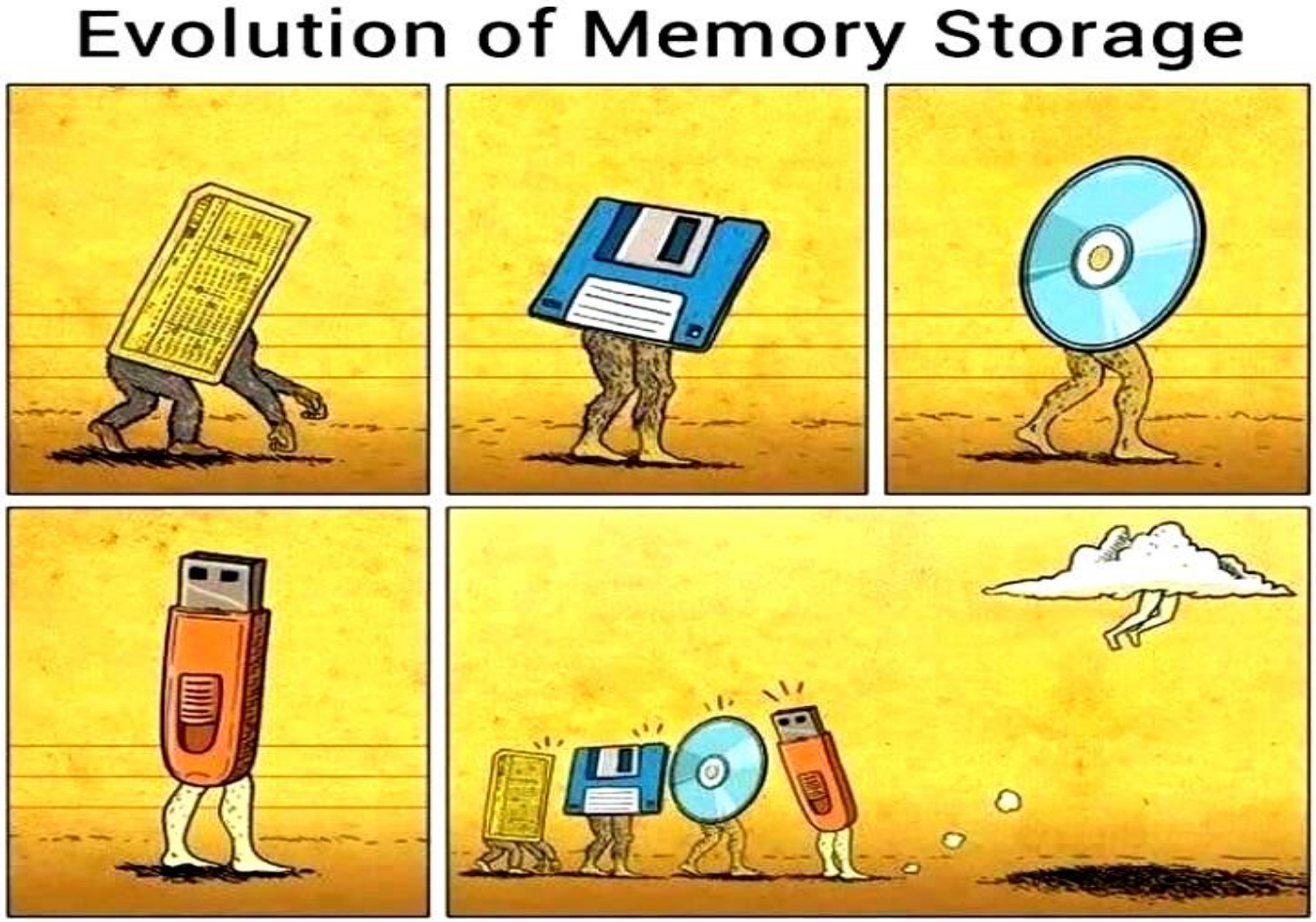
- Menggantikan bahan-bahan homogen (seragam) dengan yang komposit (gabungan)


Trend of Increasing Dynamicity

Increase system controllability by making it more flexible and easily changeable



WEALTH INFORMATION



Technology landscaping, scouting, forecasting & road mapping for innovation

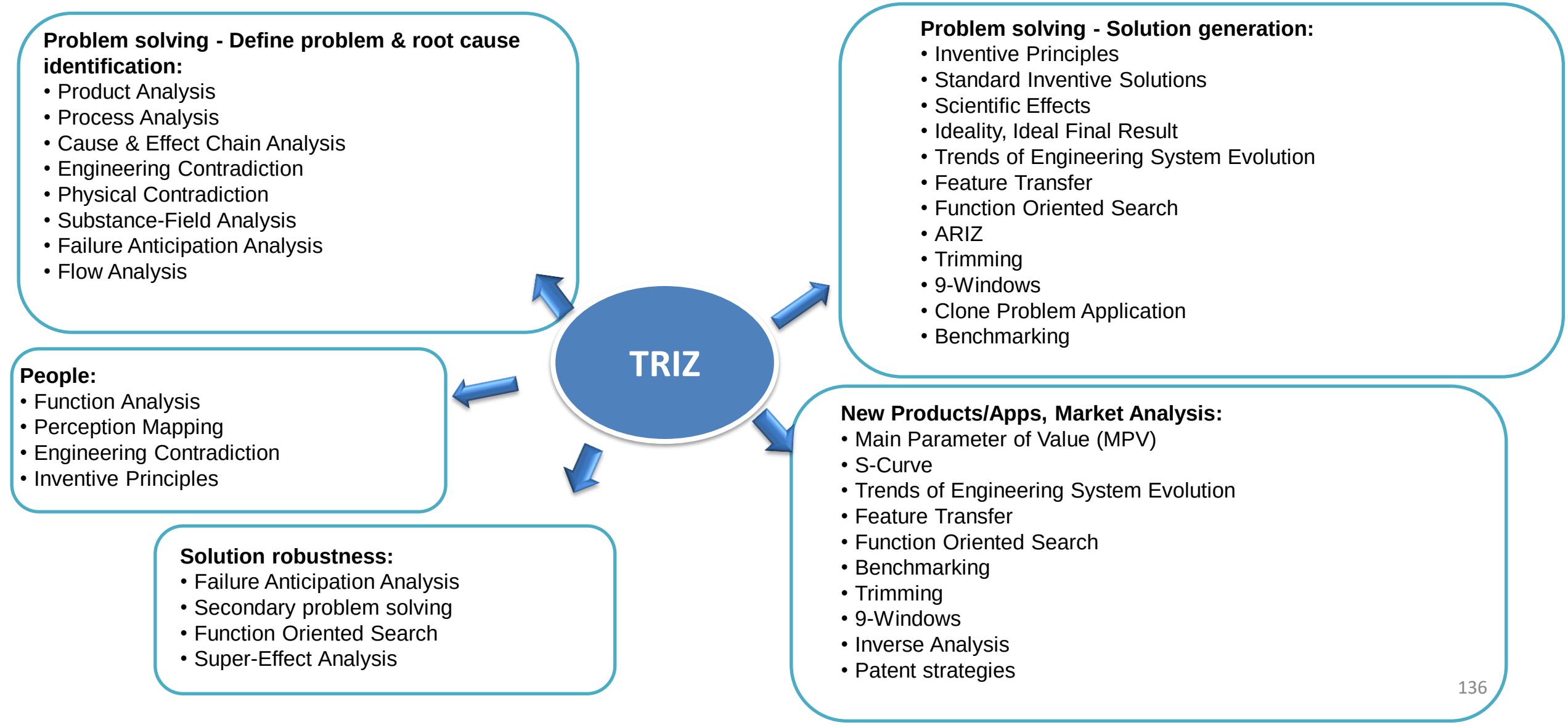
HIGH VALUE INNOVATION

"You can wait a hundred years for enlightenment, or you can solve the problem in 15 minutes with these principles".
Genrich Altshuller

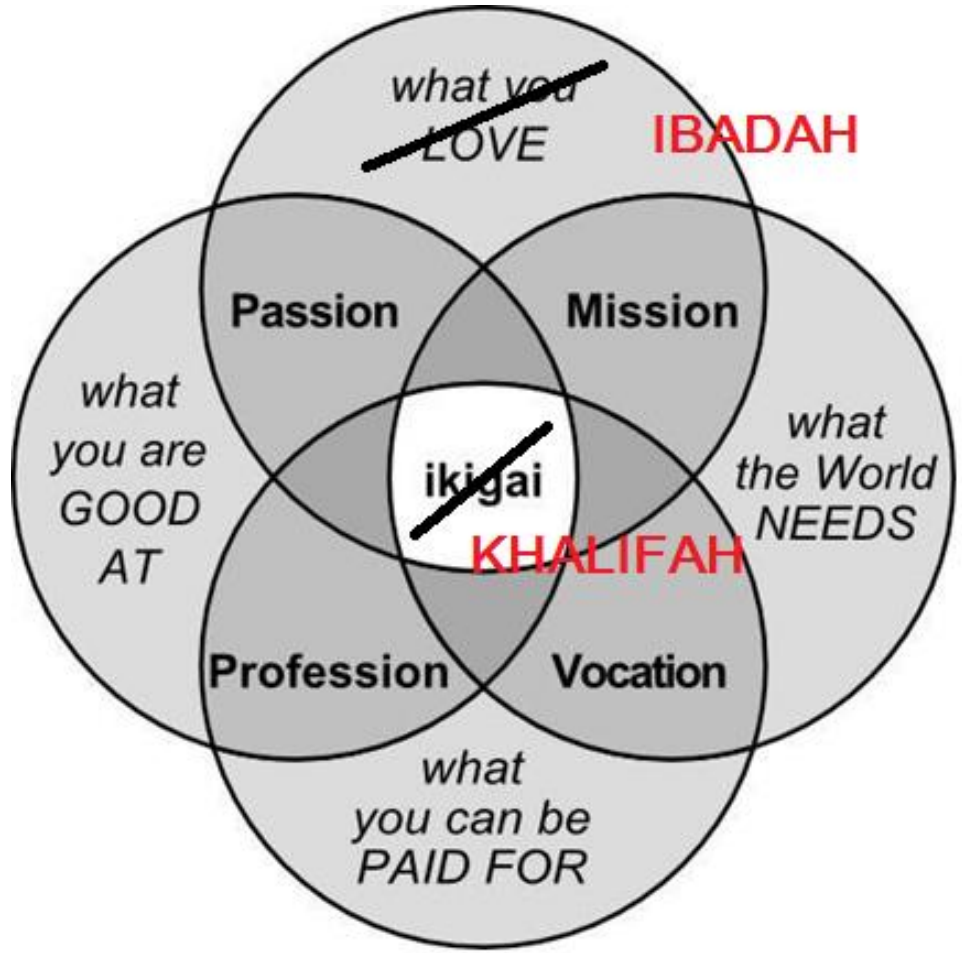
High value problem

High value innovation

WHAT TRIZ CAN DO?




what you LOVE
Passion
Mission
what you are GOOD AT
ikigai
what the World NEEDS
Profession
Vocation
what you can be PAID FOR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Thank You