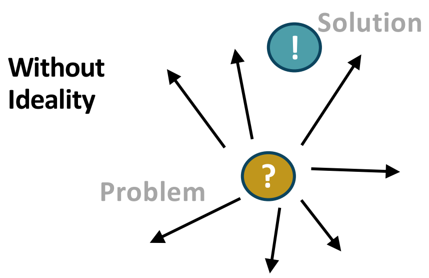
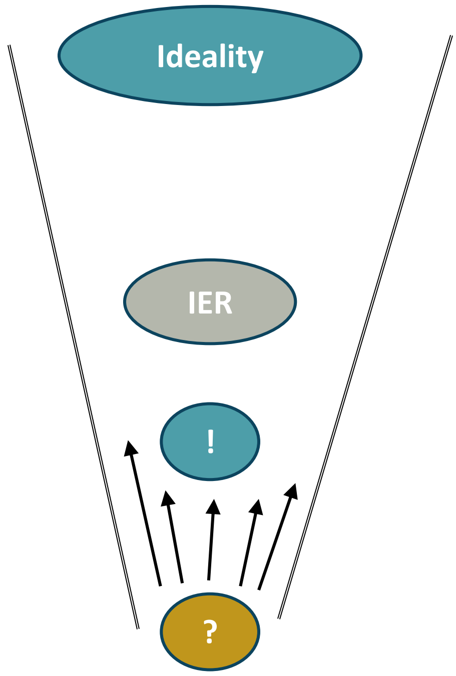
Ideality & Ideal End Result (IER)

$$\text{Ideality} = \frac{\Sigma \text{ Useful functions and effects}}{\Sigma \text{ costs} + \Sigma \text{ harmful effects}}$$

Ideality shows the direction of the best solution.
(It can also be different for those involved!)



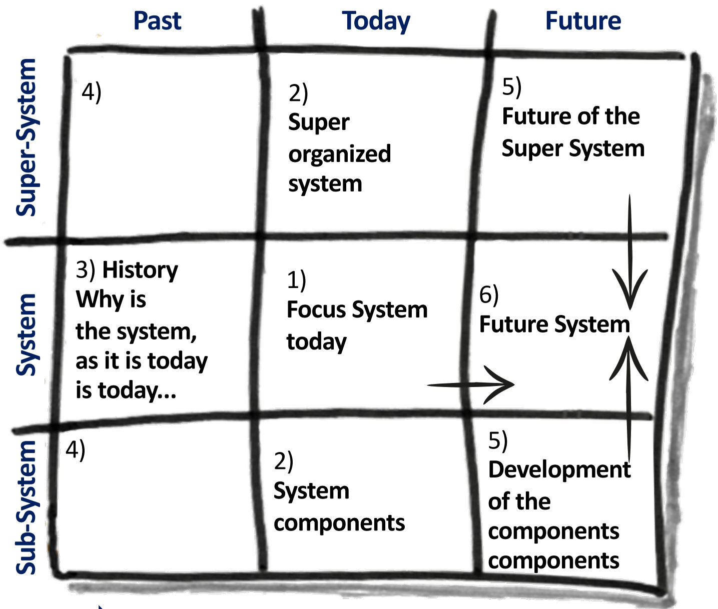


Focus on new development
The ideal machine fulfills the function completely without existing itself and without harmful side effects.

Focus on improvement:
Ideal **E**nd Result:
The model of the best solution to an inventive problem. The IER solves the problem completely with minimal system changes, without affecting the system properties using the available resources.

System Operator “9-Screen Approach”

The simplest form of the system operator is the 9-field model.
It is also known as “talented thinking”.



Derivation of questions and ideas

Columns:

- The middle column shows the current time.
- The first column shows the past.
- The right-hand column shows the future.

Past and future must be defined more precisely!

Rows:

- The middle row shows the system under consideration (define boundaries!)
- The top row shows the supersystem, the environment in which our system is embedded.
- The bottom line shows the subsystem with the individual components of the system.

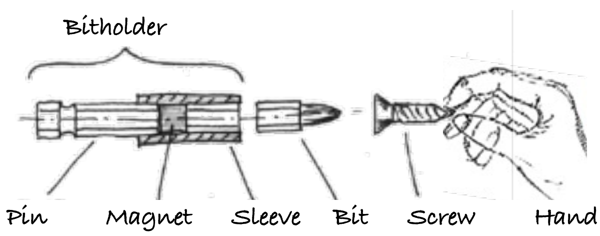
Rows and columns can be expanded depending on the level of observation and the objective. For example, the system operator can be used for generation planning.

Problem-oriented 9-field thinking

“Understanding the problem, Solve challenges.”

In “Problem-oriented 9-field thinking”, the middle column shows the time at which a problem occurs.
The first column shows the time immediately before the problem occurs.
The right-hand column shows the time after the problem has occurred.

	BEFORE	Moment of the problem	**AFTER**
Supersystem	How can the supersystem prevent the problem from occurring? **Screw receives a coating**	How can the supersystem solve the problem at the time of the problem? **Screwdriver generates vibrations** **Second hand catches the bit** **Hold the screwdriver straight before removing it.**	What can the super system do to achieve the goal after all? **Helper picks up the bit and hands it over**
System	How can the system prevent the problem from occurring? **Bit is coated so that it slides out of the profile.**	How can the system solve the problem itself when it occurs? **A bit holder with a very strong magnet or locking mechanism is used.**	How can the system solve the problem after the time of the problem? ?
Subsystem	How can the sub-system prevent the problem from occurring? **Bit holder generates additional holding force and maintains it**	How can the system solve the problem itself at the time of occurrence? **Bit holder has a tight fit**	What can the sub-system do to achieve the goal after all? **What can the sub-system do to achieve the goal after all?**



Derived questions are then e.g:
What can the supersystem do to prevent the problem from occurring in the first place?
What can the subsystem components do to minimize the effects of the error?
And so on.

Developed by Oliver Gerundt and Jochen Wessner 2019

Resource Analysis

TRIZ Consulting Group

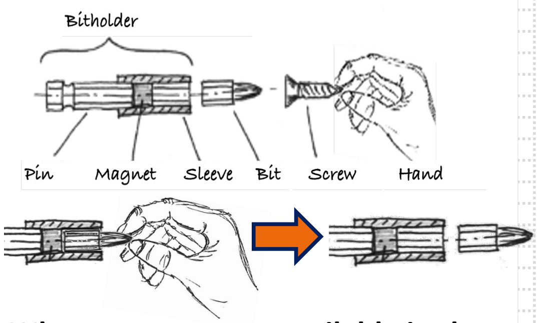
Scanning of all existing resources in the system itself and in the higher-level system, as well as possible additional resources. What can these resources contribute to solving the problem? solve the problem? Resources are used in all other tools to solve the problem.

What resources are available in the system and super system?

- **Material** (e.g. solids, liquids, gases, plasma, environment, waste,...)
- **Spatial** (e.g. spaces, cavity, empty space, nesting, other dimension, vertical/horizontal arrangement,...)
- **Functional** (e.g. useful, harmful, secondary functions,...)
- **Temporally** (e.g. before, during, after the action, clocked, continuous, parallelization, at the customer, ...)
- **Field-shaped** (e.g. mechanical, thermal, electrical, magnetic, chemical, flow, GPS, WLAN...)
- **Information** (e.g. sensors, status change, temporary info, colors, data...)

What can these resources contribute to solving the problem?

Example:



What resources are available in the system?
Which ones are accessible?

	Resource	What can the resource contribute to the solution?
Spatial	Cordless screwdriver Box Furniture	Which screwdriver shapes? Box with additional function? What screwdriving waste is actually available?
Material	Pin Magnet Sleeve Box plastic housing	Switchable electromagnet Plastic injection-molded part offers freedom for additional functional surfaces etc.
Field Shaped	Magnetic force Current Torque Speed WLAN, GPS...	Influencing / changing magnetic fields Can the bit be jammed by the torque? Integration into smart home network?
Temporally	Operating time (screws) Operating time (accessories) Storage time	Integration into smart home network?
Functional	Change process Build-up process	Lock the bit additionally when changing
Information	Instructions Assembly instructions Internet / Forum Other users	Research whether there are DIY solutions.

Input: Environment analysis, system and super system → Resource Analysis → Output: Solution approaches Trimming (new function carriers)

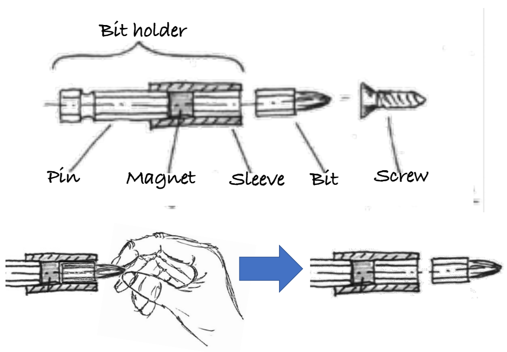
Developed by Oliver Gerundt and Jochen Wessner 2019

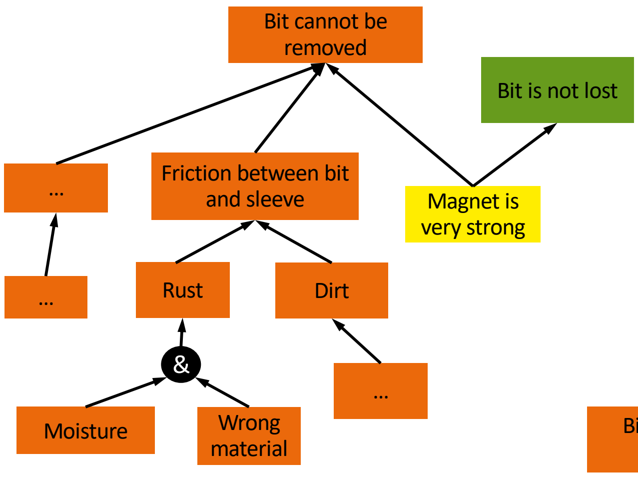
Root-Conflict-Analysis, RCA+

Possible starting points are:

- negative Effects
- Poorly controlled/controllable functionalities
- insufficient functions

Starting point: **Negative Effect**

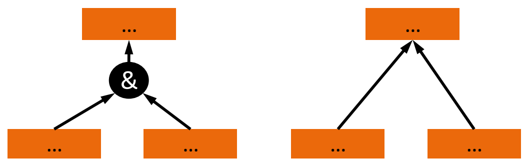




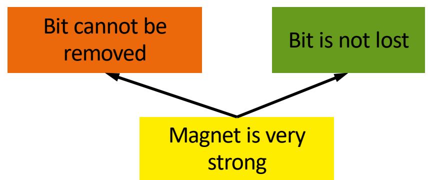
„What causes this effect to occur? “

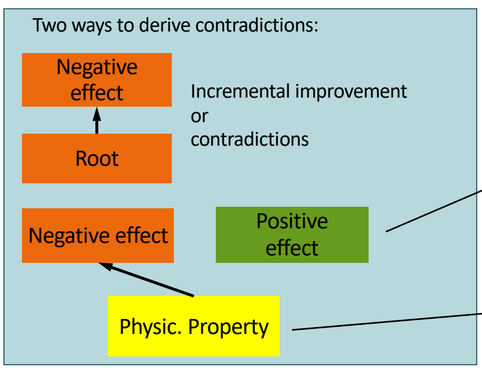
Avoid “why ”*, as misinterpretation is possible. Better:
A: Noun-verb-object (nail splits wood)
B: Property/parameter + “too” (temperature too high)
C: Change of a poperty/state
(water freezes too slowly)
D: Radical change (ice melts)
E: Absence (missing support)
*) “Why are you going shopping?”
a: “What for?” “... to buy bread.”
b: Cause = “...because I'm hungry.”
Tip: Proceed step by step, do not jump to the most distant cause!

Negative: Cause should be completely eliminated	Effect
Positive: Positive aspect of a negative cause	Effect
Combined positive & negative: positive and negative aspects: typical contradiction	Effect
Non-changeable root cause: outside the company's own sphere of influence	Effect



AND or OR operation





If Magnet is very strong
Then the bit is not lost
But it is difficult to remove

The magnet should be strong so that the bit is not lost
AND
The magnet should be weak so that it is easy to change.

Source: Koltze/ Souchkov: Systematic Innovation; 2nd edition

Developed by Oliver Gerundt and Jochen Wessner 2019

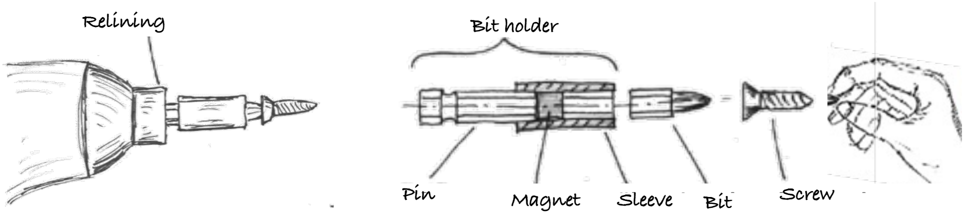
Function Analysis for Products

TRIZ Consulting Group

Scenario:

Company Wiho would like to improve its screwdriving systems.

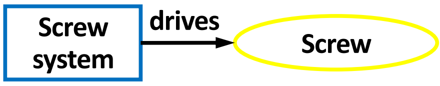
As there is great cost pressure in this market, a 'value analysis' is to be carried out to ensure that work is carried out on the right issues. The first step is a functional analysis.



"A function is an action that a component performs in order to change a parameter on another component or to keep it active."

Step 1: Main Function

What is the main function? **What is the target component?**



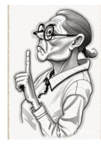
Step 2: Component Analysis

Target Component: Screw

Main Function: Screw System drives Screw

System components:	Supersystem components:
Bit	Screw
Sleeve	Relining
Magnet	Hand
Pin	

"Components are parts with mass and fields."



Step 3: Interaction analysis

Case: Screwing process	Relining	Pin	Magnet	Sleeve	Bit	Screw	Hand
Relining		X	O	O	O	O	O
Pin	X		X	X	O	O	O
Magnet	O	X		X	X	O	O
Sleeve	O	X	X		X	O	O
Bit	O	O	X	X		X	O
Screw	O	O	O	O	X		X
Hand	O	O	O	O	O	X	

Which components are in contact with the others, touch each other?

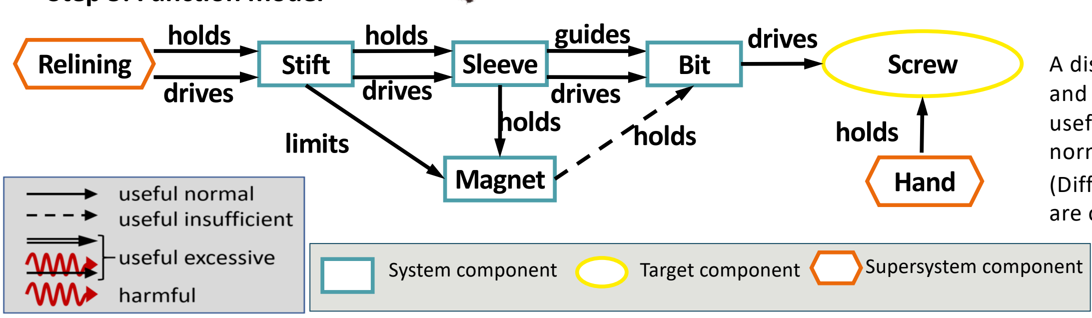
Jedes Kreuz in der Interaktionsanalyse entspricht mindestens einer Funktion.

Step 4: Functional analysis (tabular)

component (function carrier)	Action (Verb)	Target (Object of the Function)	Category (U=useful, H=harmful)	Perform. level (I=insufficient, E=excessive, N=normal)	Comment
Relining	holds	Pin	U	N	
Relining	drives	Pin	U	N	
Pin	limits	Magnet	U	N	
Pin	holds	Sleeve	U	N	
Pin	drives	Sleeve	U	N	
Magnet	holds	Bit	U	I	
Sleeve	holds	Magnet	U	N	
Sleeve	guides	Bit	U	N	
Sleeve	drives	Bit	U	N	
Bit	drives	Screw	U	N	
Hand	holds	Screw	U	N	

Category	**U** useful	**H** harmful
Performance Level	**N** normal **I** insufficient **E** excessive	---

Step 5: Function model



A distinction is made between useful and harmful functions, whereby the useful functions are classified as normal, insufficient and excessive. (Difference to VDI: in VDI 2222 there are only useful functions)

Input: System information → **FA** → **Output:** Understanding the problem Analysis, questions, contradictions

Developed by Oliver Gerundt and Jochen Wessner 2019

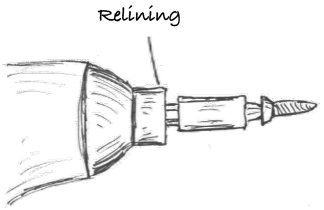
Value Analysis

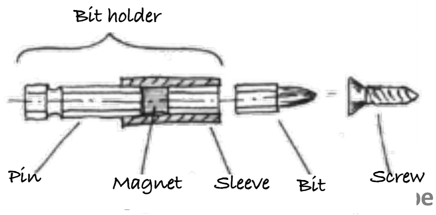
TRIZ Consulting Group

Scenario:

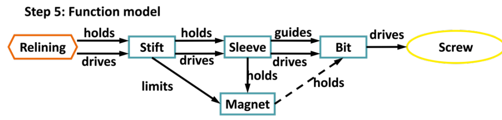
Company Wiho would like to improve its screwdriving systems.

As there is great cost pressure in this market, a 'value analysis' is to be carried out to ensure that work is carried out on the right issues. The first step is a functional analysis.

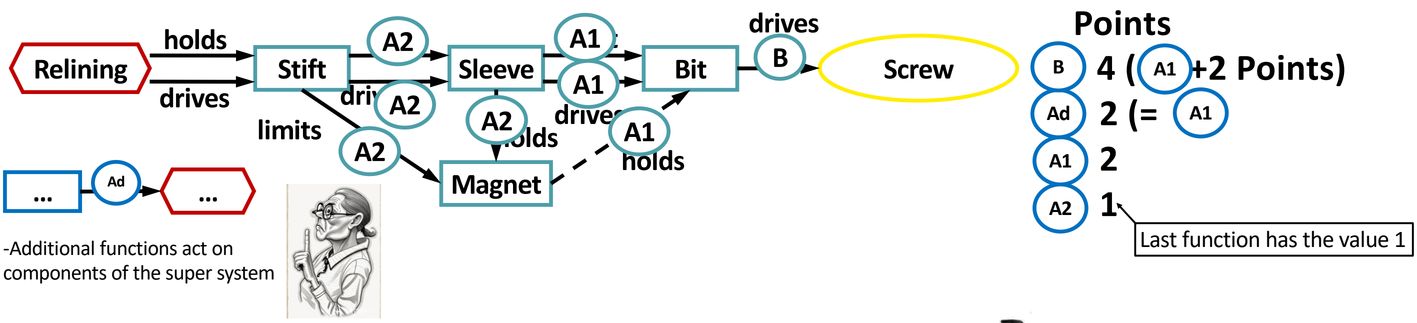




Step 1 to 5:
See functional analysis
Starting point value analysis:
Graphical function model



Step 6: Values

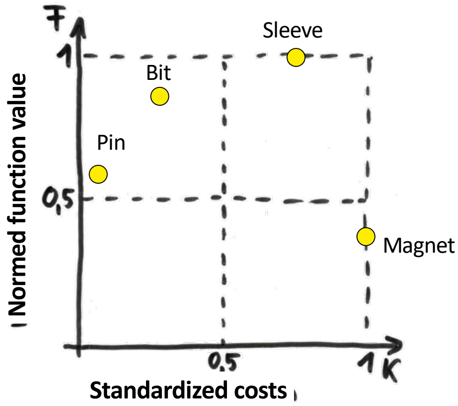


-Additional functions act on components of the super system

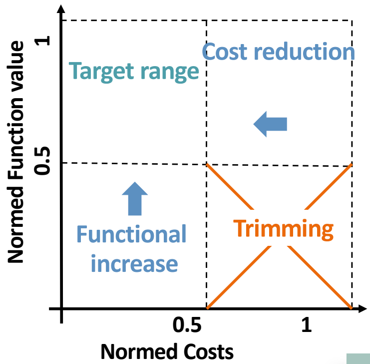
Step 7: Table of values

Component	Function-Classes	S Value	Normed Function Value	S Cost (Mat, Value Creation)	Normed Costs
Bit	B	4 (Max-Value)	0,8 (4/5)	0,50€	0,25
Sleeve	2xA1+A2	5	1,0 (5/5)	1,50€	0,75
Magnet	A1	2	0,4 (2/5)	2,00€	1,0
Pin	3xA2	3	0,6 (3/5)	0,20€	0,1

All functions that are executed by system components are assigned a value. Functions of super system components and harmful functions are not assigned a value. Note the direction of the arrow!



Step 8: Value diagram



Step 9: Derivation of questions

Derivation of tasks and questions depending on the position in the diagram:

- Which component should be trimmed?
- How can the costs of AB be reduced?
- How can the functionality of XY be increased?

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Trimming on the Product

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Function-carrier → Action → Object of the Function

Trimming is a method of improving a technical system by eliminating individual components by...

... removing the function completely. (Rule A)

~~Function-carrier~~ ~~Action~~ ~~Object of the Function~~

... the object of the function executes the function itself. (Rule B)

~~Function-carrier~~ Action ↺ Object of the Function

... another component performs the useful function. (Rule C)

~~Function-carrier~~ / New Function-carrier → Action → Object of the Function

For rule C there are there are 4 guidelines!

1: The new function holder is already performing an identical or similar function on this object.

Functions-carrier → Action A → Object of the Function; Component → Action A* ⟩ ~~Functions-carrier~~ → Action A → Object of the Function; New Functions-carrier → Action A*

2: The new function holder is already performing an identical or similar function on another object.

Functions-carrier → Action A → Object of the Function; Component → Action A* → Object of the Function ⟩ ~~Functions-carrier~~ → Aktion A → Object of the Function; New Functions-carrier → Aktion A* → Object of the Function

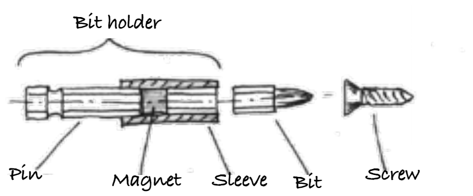
3: The new function holder is already performing some function on this object.

Functions-carrier → Action A → Object of the Function; Component → Interaction ⟩ ~~Functions-carrier~~ → Action A → Object of the Function; New Functions-carrier → Interaction

4: The new function holder has the resources to perform the function.

Functions-carrier → Action A → Object of the Function; Component ⟩ ~~Functions-carrier~~ → Action A → Object of the Function; New Functions-carrier

Example:



The component to be trimmed is selected on the basis of the functional analysis...

Step 5: Function model

Relining –holds→ Stift –holds→ Sleeve –guides→ Bit –drives→ Screw; Stift –drives→ Relining; Sleeve –drives→ Stift; Bit –drives→ Sleeve; ~~Magnet~~ (~~holds~~, ~~attracts~~) holds Bit

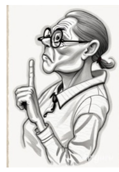
... and created a trim model.

Relining –holds→ Stift –holds→ Sleeve –guides→ Bit –drives→ Screw; drives; drives; drives; holds

A trim model is an initially fictitious model of the system in which one or more components have been removed. The task is now to ensure that the system functions without this component. If these problems can be solved, the model can be implemented.

Idea: Rule B: The bit is magnetized and holds itself.

“Possibility of using the resources identified!”



- Creation of a functional model, ideally with 'value-analytical consideration‘
- Decision on components to be trimmed
  - “Reduce costs” goal Expensive components are eliminated
  - “Problem elimination” objective Components with harmful, excessive or inadequate functions are trimmed
  - “Value enhancement” objective Expensive components with few functions are trimmed
  - Goal “patent avoidance” Trimming of one or more components to create a new system.
  - “New product” objective Trimming of components to create a new system.
  - Target “disruptive new product” Radical trimming of key components or several components.
- Create a trimming model using the trimming rules and guidelines.
- Formulate the task to be solved.

Input: Functional model → Trimming → Output: Abstract Solutions

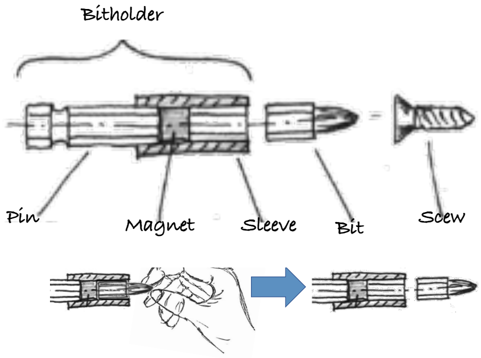
Developed by Oliver Gerundt and Jochen Wessner 2019

Technical Contradiction & 40IP

TRIZ Consulting Group

The need for improvement creates a contradiction:
“something should get better, but something else gets worse”

The problem:
The hand has difficulty gripping the bit when changing it.
If a strong magnet is installed, the bit is difficult to
pulled out
be pulled out. A weak magnet means that the bit
can be lost.
Typical solution: lazy compromise
TRIZ solution: Improvement without making something else worse!
What should be improved? (Attention: not HOW!)



Formulation of the contradiction
In that form
If: **the Magnet is very strong** *(Feature)*
Then: **the bit is held reliably** (positive effect)
But: **it cannot simply be removed** (negative effect)

Inversion of the contradiction
by exchanging IF and BUT
If: **the Magnet is weak**
Then: **the bit can be removed easily**
But: **it is not held reliably**

Deciding which contradiction is stronger
⍰ Matrix is not symmetrical

OK ?

Transition from two different, specific parameters to two abstract parameters - Generalization of the problem for a general solution with the contradiction matrix

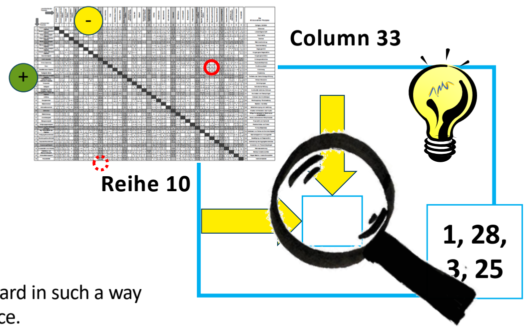
	Concrete parameter	Abstract Parameter
Improving parameters +	Holding force	Strength, intensity
Worsening parameters -	Extraction force	User friendliness

1, 28, 3, 25

	Concrete parameter	Abstract Parameter
Improving parameters +	Extraction force	User friendliness
Worsening parameters -	Holding force	Strength, intensity

28, 13, 35

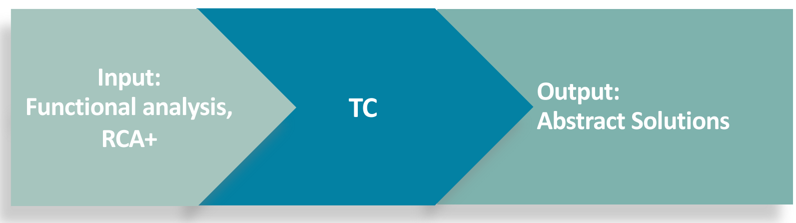
The matrix is not symmetrical!
Inverting the contradiction leads to differen[t]
principles!



Principles of the contradiction matrix by G. Altschuller

1 Segmentation
28 Replacement of the mech. system
3 Local quality
25 Self-help

IDEA 1 (from IP3, local properties):
The sleeve is divided into two parts. A movable part can be pushed forward in such a way
forward in such a way that it can clamp the screw and thus hold it in place.
IDEA 2 (from IP15, adaptation):
In addition to the 'guide bit' function, the sleeve also has the function of
'Guide magnetic flux', which is achieved by locally changing the magnetic properties of the
sleeve.
properties of the sleeve.
IDEA 3 (from IP25, self-sufficiency):
A recess is integrated in the handle and a coil is integrated parallel to it. If one-handed
work is required, the screw is inserted into the recess before the screwing process and
magnetized.
and magnetized. The screw then holds onto the bit “by itself”.



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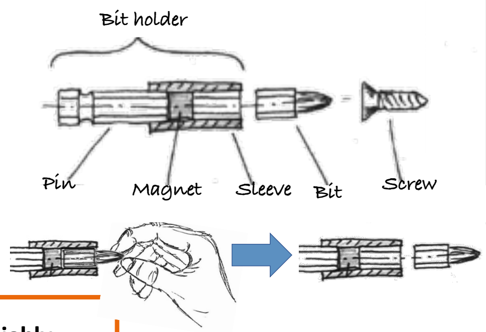
Physical contradiction & Separation principles

TRIZ Consulting Group

The need for improvement creates a contradiction:
"On the one hand, I want to do something this way because....,
on the other hand, I want to do it differently because...."

The problem:
The hand has a hard time gripping the bit when changing it.
If a strong magnet is installed, the bit cannot be lost; if a weak magnet is installed, the bit can be changed easily.

Typical solution: lazy compromise
TRIZ solution: Both are possible



Formulation of the physical contradiction in the following form:

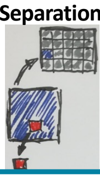
The magnet should be strong enough to hold the bit reliably
AND
the magnet should be weak so that the bit can be changed easily.

Step	Method	Possible innovation principles (Source: 1) Litvin 1993 and 2) Koltze 2017)
1. Step	Separation in space 1)+2)	#1 decomposition, division, #2 separation, #3 local properties, #7 nesting, #4 asymmetry, #17 higher dimension
2. Step	Separation in time1)+2)	#15 Adaptation, #34 Elimination & Regeneration, #10 Advance Action, #9 Adv. counteraction, #11 preventive action
3. Step	Separation in relationship 1)	#40 composite material, #31 porous materials, #32 color and transparency, #3 local properties, #19 periodic effect, #17 higher dimension
4. Step	Separation in structure 2)	#1 Disassembly/disassembly, #2 Separation, #5 Coupling, #18 Utilization of mechanical vibrations, #19 Periodic effect, #40 Application of composite materials
5. Step	Separation through system transition1)	#1 decomposition, separation, #5 unification, #33 uniformity and homogeneity, #12 equipotential principle
6. Step	Separation by change of condition 2)	#35 Change of phys. and chem. Properties, #36 Application of phase transitions, #38 strong oxidizing agents, #39 inert medium/ inert atmosphere
7. Step	satisfaction 1)	#36 Application of phase transitions, #37 Thermal expansion, #28 Replacement of mech. operating principles, #35 Change in physical state, #38 Strong oxidizing agent, #39 Inert medium/inert atmosphere
8. Step	Bypass 1)	#25 Self-supply and self-service, #6 Multi-purpose use, #13 Function reversal

Separation in space

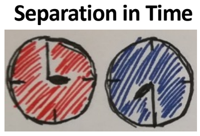
"Can the room be used or can the machine be divided?"

Separation through System Transition



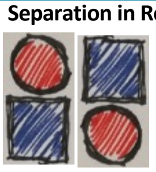
"Can the function be moved to the upper or lower system?"

Separation in Time



"How can the time before, after, and in parallel be used?"

Separation in Relationship

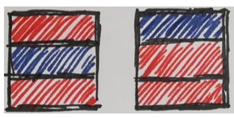


"How can the interaction be changed?"

Separation by Bypass

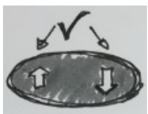
"How can the problem be circumvented?"

Separation in Structure



"How can the structure be changed?"

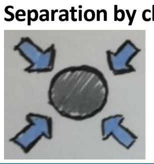
Separation by Satisfaction



"How can you do justice to both?"

The question for everyone is: "What can the resources contribute to the solution?"

Separation by change of Conditions



"How can the environmental conditions be changed?"

Input: Physical Contradiction → Separation Principle → Output: Separation as abstract solution

Developed by Oliver Gerundt and Jochen Wessner 2019

Smart-Little-People/ Nano-Dwarfs

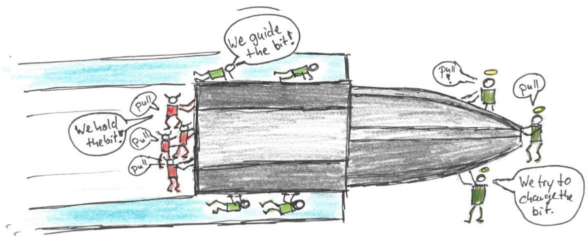
TRIZ Consulting Group

Technique for problem modeling and creative solution finding

- Smart Little People are nano-sized, active figures that can perform a wide variety of tasks.

1. Use many nano-gnomes; they can appear and disappear.
2. Because they have no mass, they can move at will. They can also make themselves infinitely heavy, deform, twist, etc.
3. Model all situations, before and during the problem, as well as the desired situation.
4. Model possible solutions with gnomes and transfer the solution.
5. Model everything possible with the gnomes (including the environment).
6. Make many models.
7. Use and build analogies.
8. The gnomes can do anything!

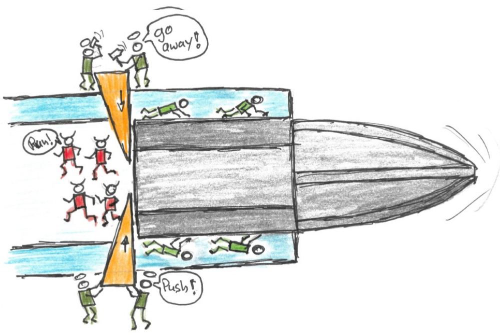
Step 1:
Problem analysis



The "good guys" are supposed to pull out the bit. The leading dwarves are holding the bit. But the "bad guys" don't want to release it...

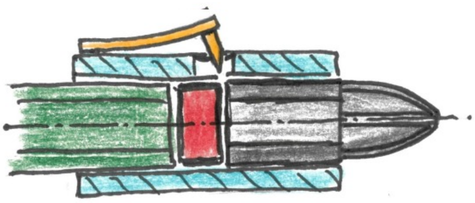
Step 2:

30 / 5.000
Develop an abstract solution

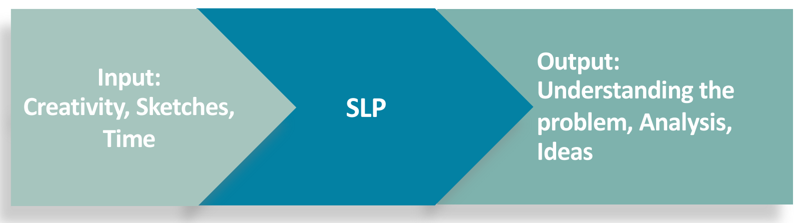


The "good guys" now come up with the idea of driving a wedge between the Bit and the "bad guys." The bad guys take off. They could have been lured away by an attractive temptation...

Step 3:
Transfer solution



In the real solution you could use a spring-loaded wedge that is pressed between the magnet and the bit.



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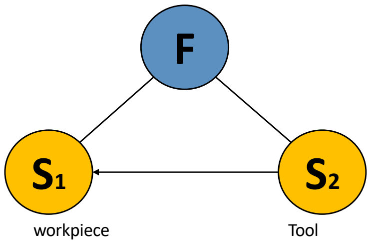
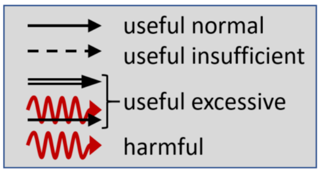
Substance-Field-Analysis & 76 Standard solutions

Structure of a substance-field model*:
2 substances
1 field
"Tool" acts on "Workpiece"



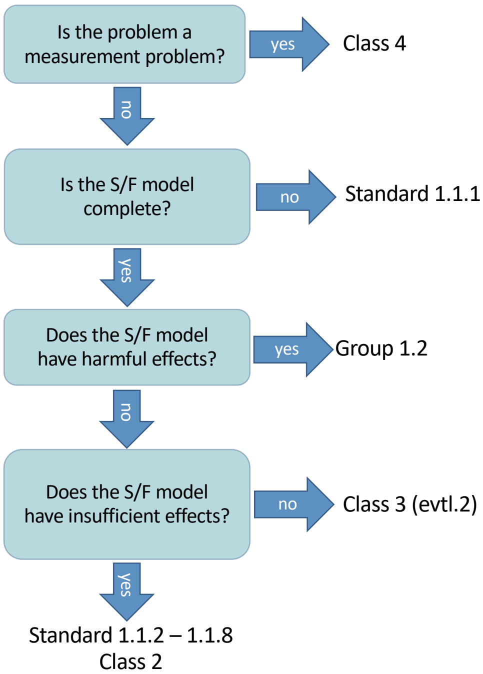


Possible fields are :
Mechanical
Acustical (Vibrations)
Thermal
Chemical
Electrical
Magnetic
Intermolecular
Biological
Mnemonic: **„MAThChEMIB“**

Process
Step 1: Create the substance-field model of the problem
Step 2: Select possible solutions from the 76 standard solutions
Step 3: Create the substance-field model of the solution
Step 4: Apply the abstract solution to the concrete problem
The standard solutions are selected according to the following diagram:

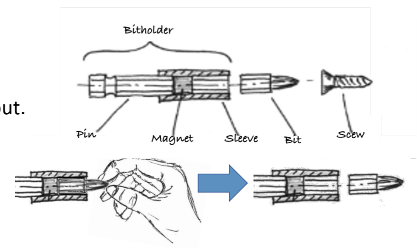
Materials are components, products, objects, machines, etc. (no fields)

*) Exceptions: measurement models

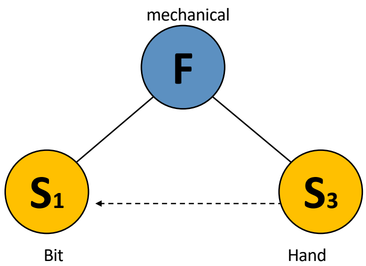


Example:

The problem:
It's difficult for your hand to grip the bit when changing it.
If a strong magnet is installed, the bit can be difficult to pull out.



Step 1: Substance-field model of the problem

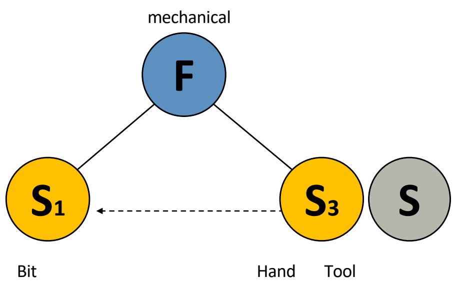


Step 2: Selection of possible standard solutions

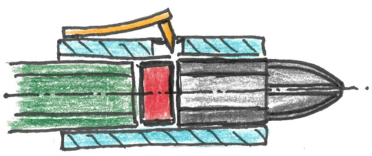
Here groups 1.1.2-1.1.8 + class 2

Step 3: Substance-field model of the solution

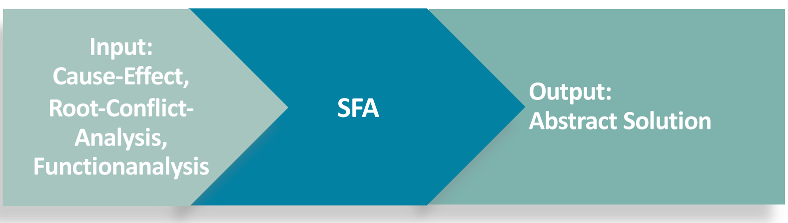
here: 1.1.3



Step 4: Transfer of the solution



The “tool” is installed on the sleeve and helps to push out the bit.



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Substance-Field-Analysis & 76 Standard solutions

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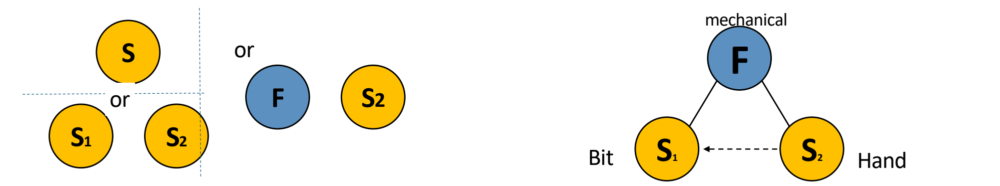
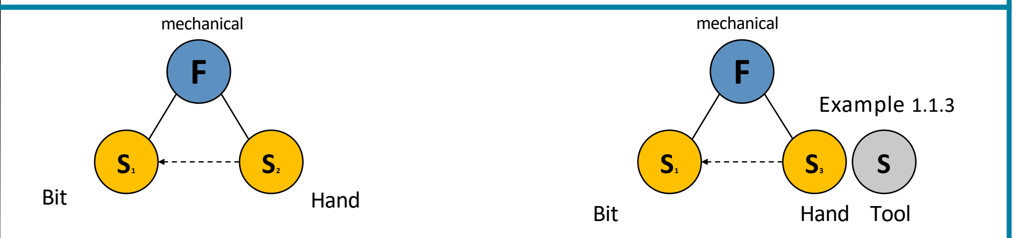
Problem — **one possible solution**

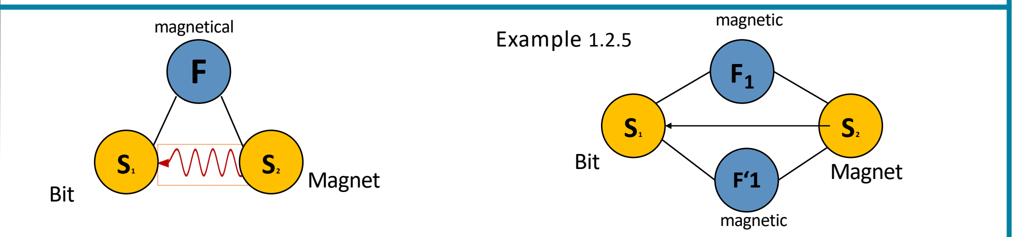
Standard 1.1.1



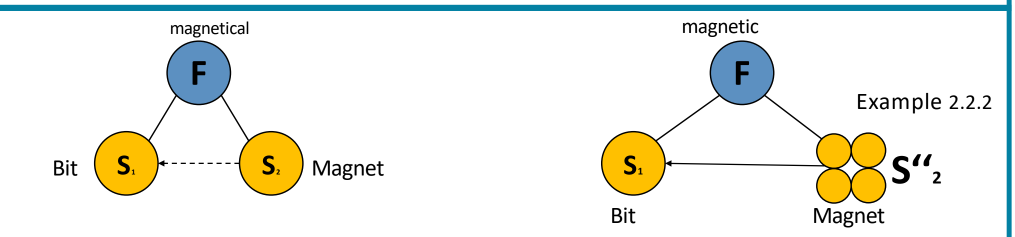
Standard 1.1.2 – 1.1.8



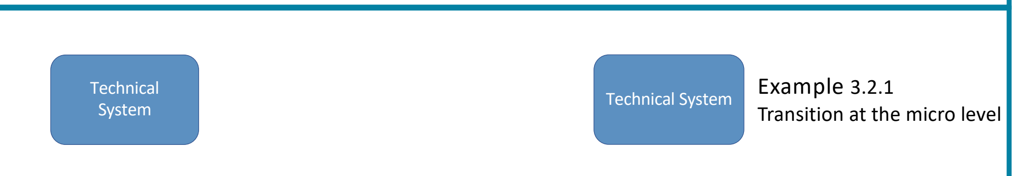
Group 1.2
Decomposition of S/F models



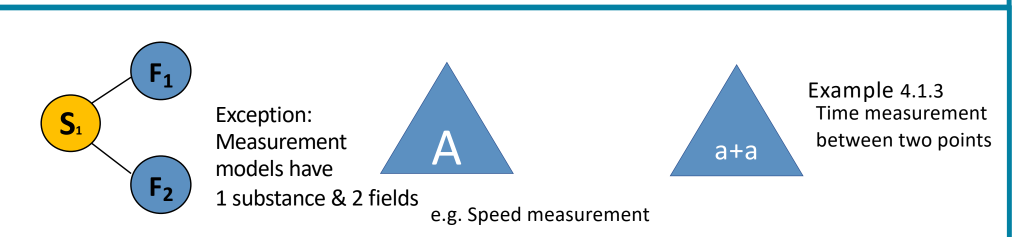
Class 2



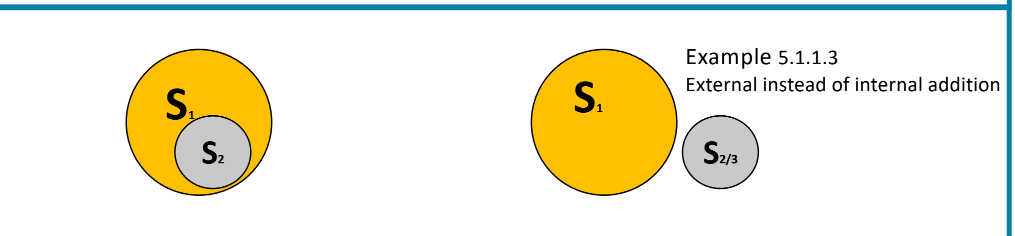
Class 3
Long-term development



Class 4
Measurement problems



Class 5



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