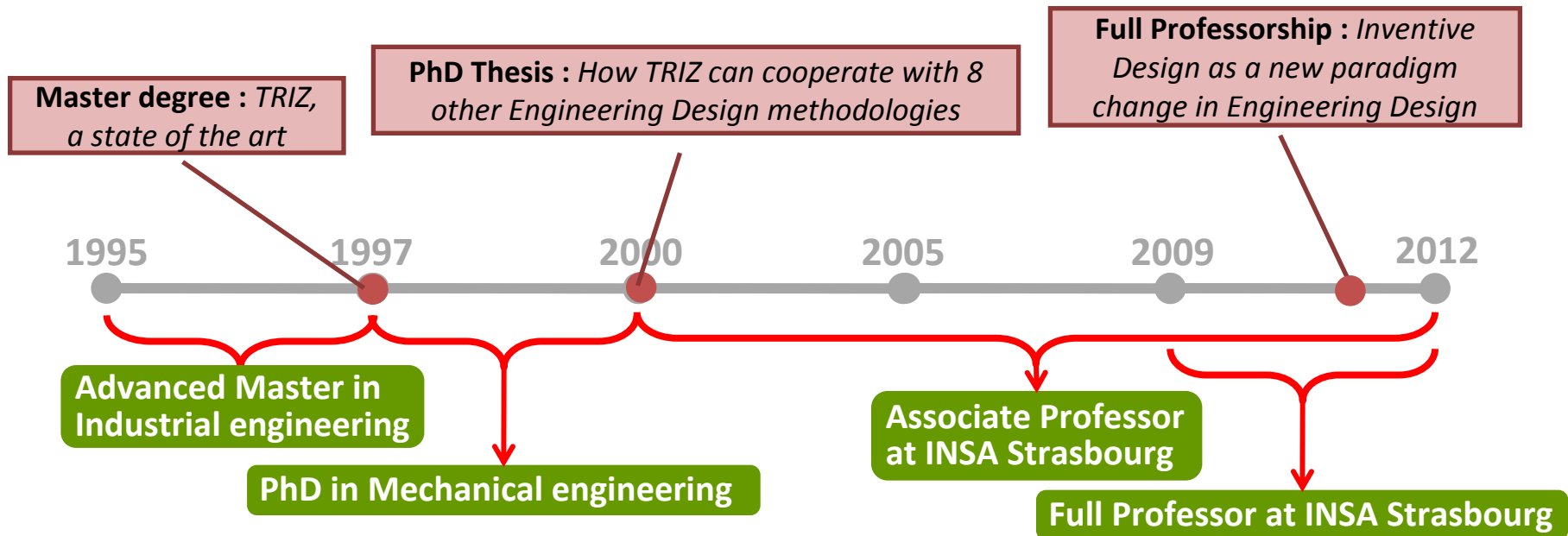




# Keynote : Japan TRIZ Symposium

September 8<sup>th</sup> 2012 – Tokyo – Japan  
Denis Cavallucci, Professor at INSA Strasbourg – France

## How TRIZ can contribute to a paradigm change in R&D practices?





***Outlines  
of the  
Keynote***

**20min**

- Short introduction
- Our Industrial world is in permanent change, which major challenges await R&D departments in future ?
- Summary of TRIZ milestones

**10min**

- The TRIZ Consortium : 3 worldwide large companies unify their efforts
- 5 major drawbacks of TRIZ

**15min**

- Why do we need a "new" software ?
- From IDM major stages to STEPS software
- Major STEPS software interface

**5min**

- Short overview of a real industrial case study

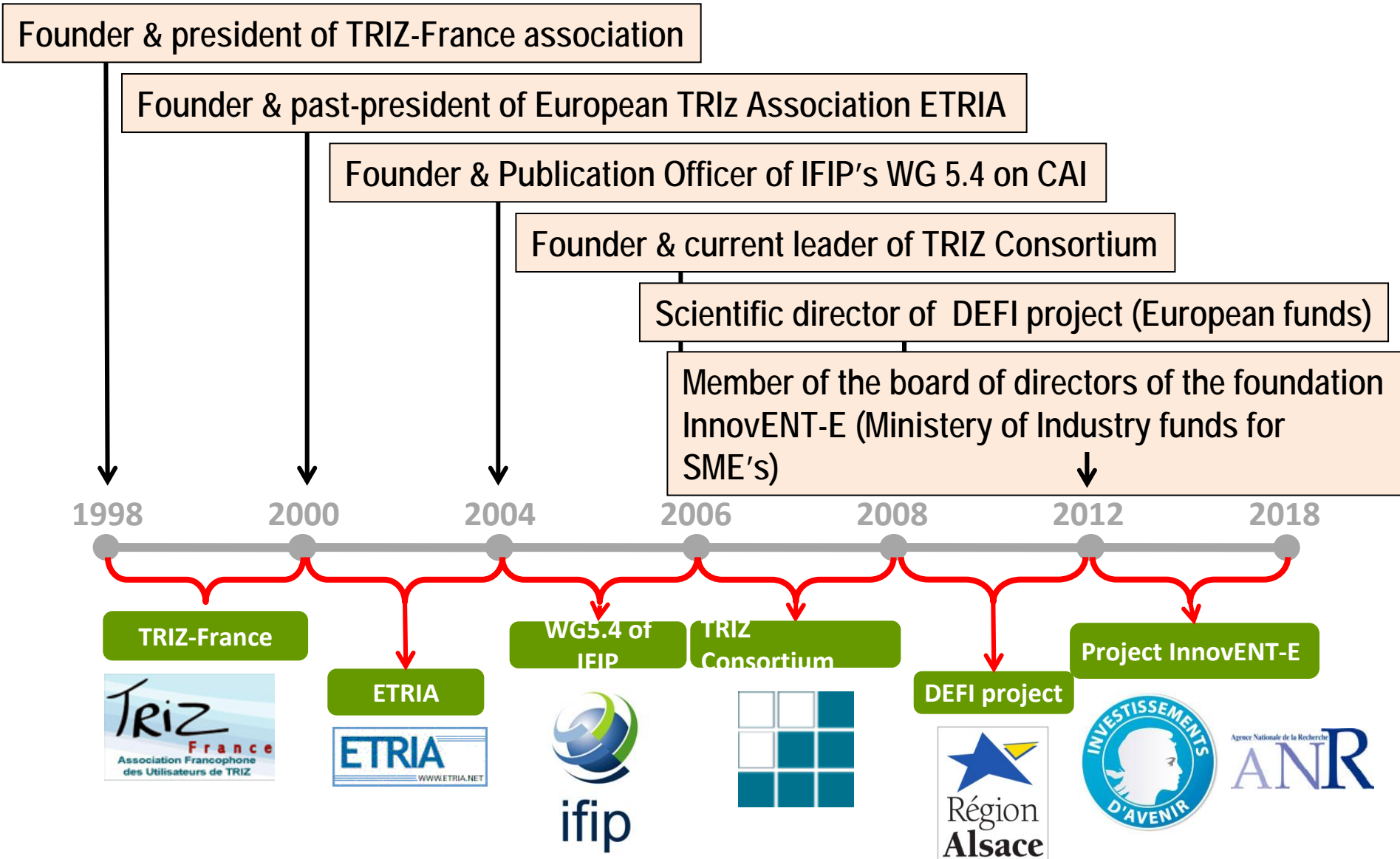
**10min + 20min Q&A**

- Teaching IDM
- Some ongoing research
- Conclusions/Questions

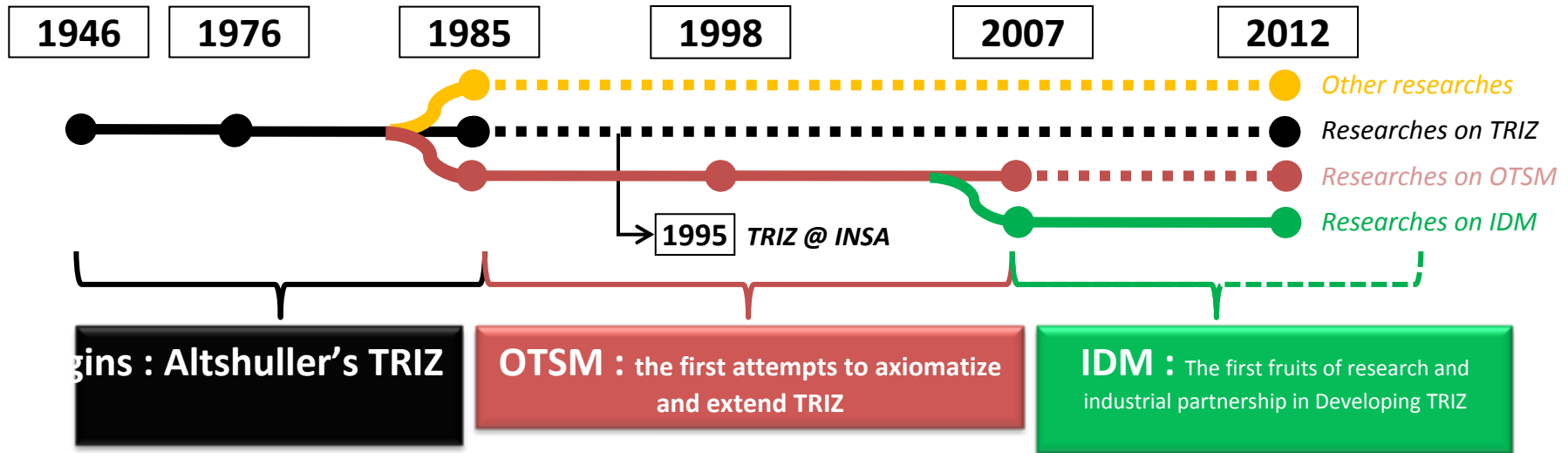


***Short introduction***

↳ My past and current "TRIZ" responsibilities



TRIZ at INSA Strasbourg : from history to now



Fundamentals of TRIZ :

- Notions of contradiction
- Notions of laws
- Methods, tools, techniques
- Meta-knowledge bases



Extensions of TRIZ towards multidisciplinary problematic :

- Notion of problems
- Notion of partial solutions
- Notion of network (PB, CT)
- Towards an axiomatization of TRIZ



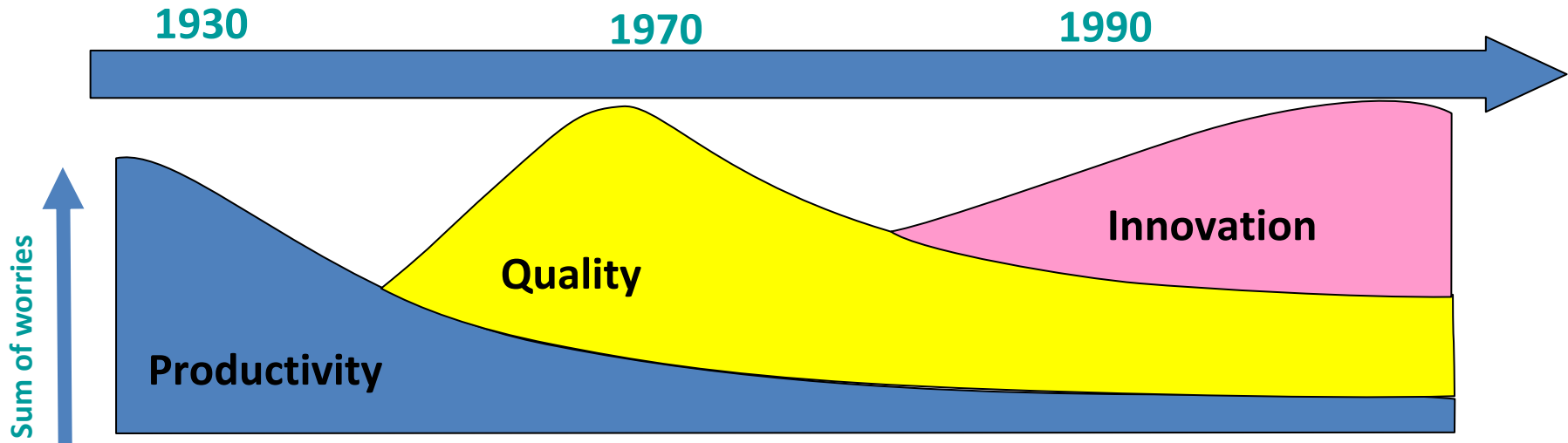
Formalization of TRIZ & OTSM for industry

- Ontology construction, disambiguation of concepts;
- Computerization (STEPS)
- Notion of graphs
- Notions of TRIZ body of knowledge completeness
- Feedback CS → PB graph



***What is  
the current context  
in which we intend  
to contribute***

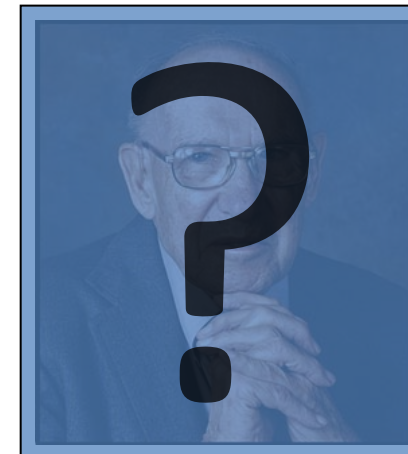
Our Industrial world is in permanent change, which major challenges await R&D departments in future ?



- Answering to demand
- Organize workshops
- Improve productivity rates



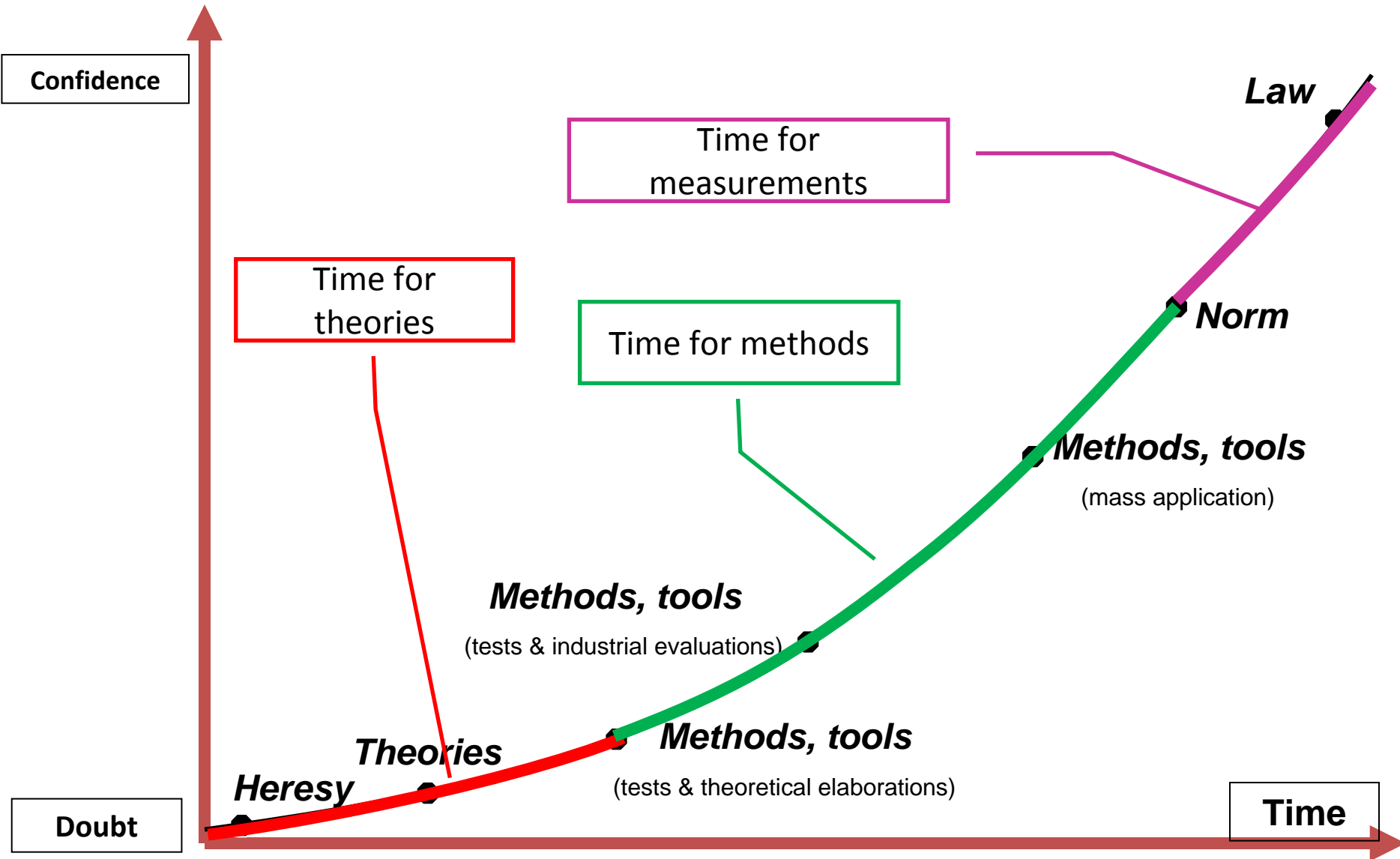
- Be competitive
- Ensure quality
- Optimize organization



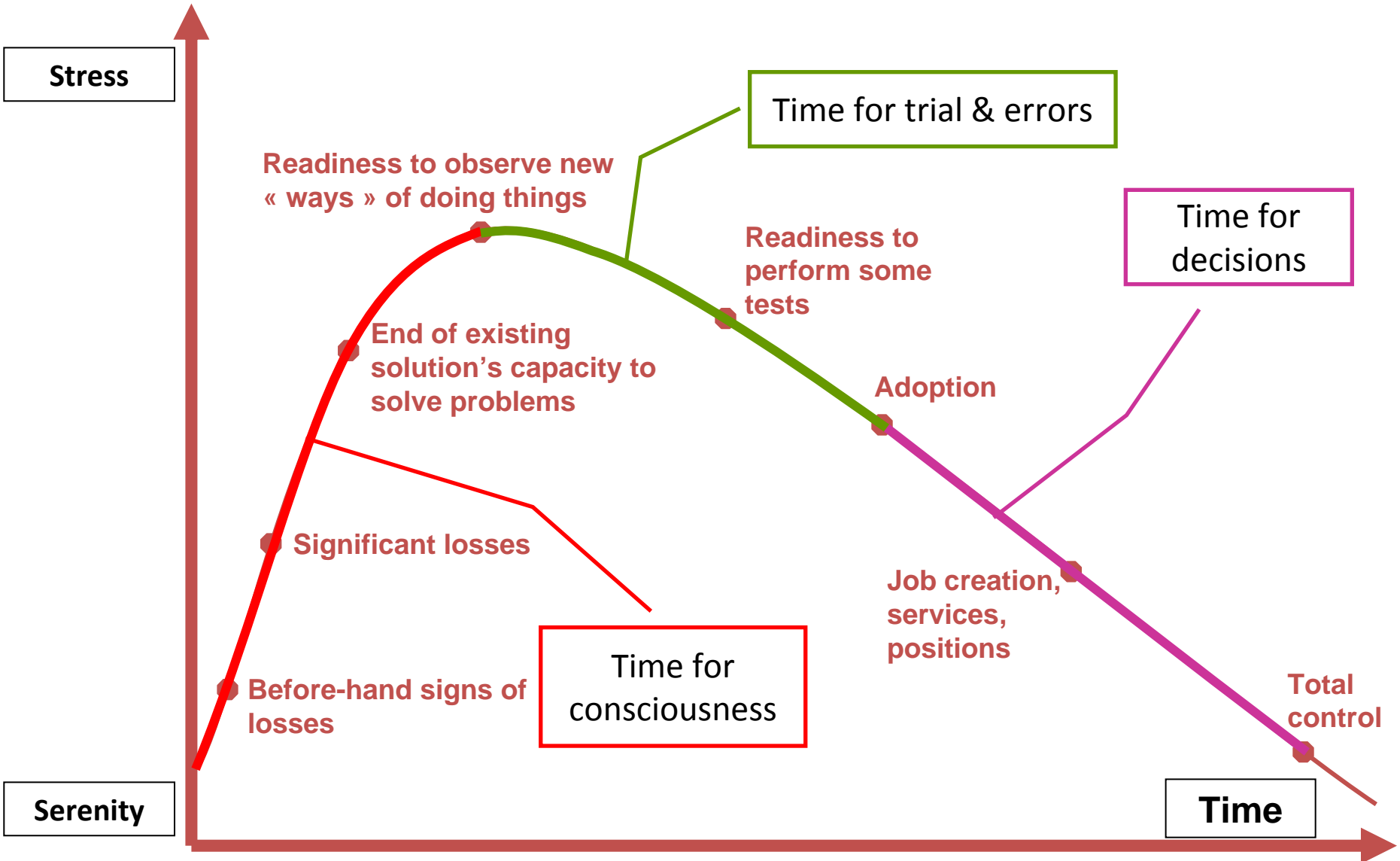
- Organize innovation
- Manage knowledge increasing quantity
- Anticipate product/system's evolutions



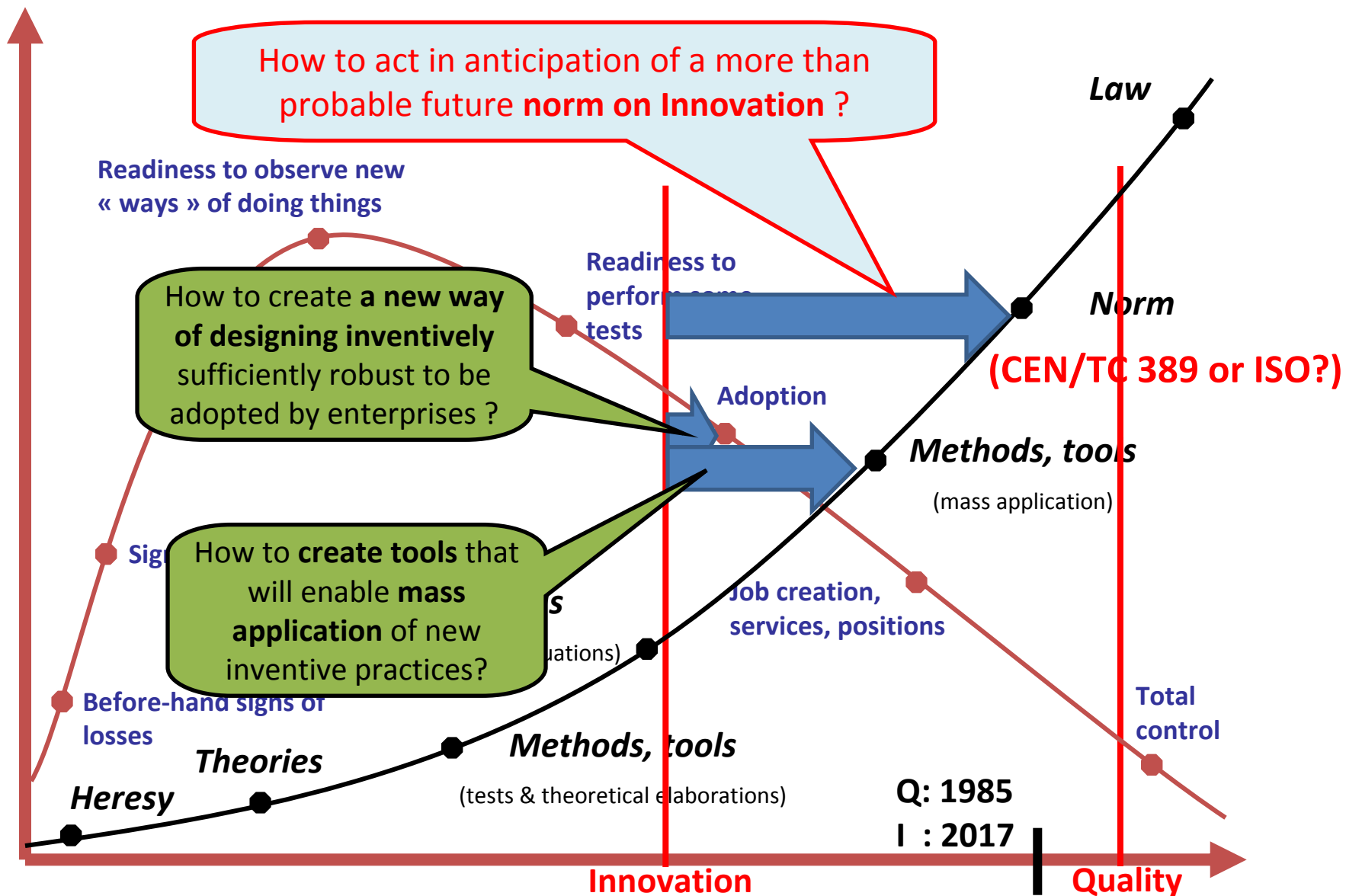
Our Industrial world is in permanent change, which major challenges await R&D departments in future ?



Our Industrial world is in permanent change, which major challenges await R&D departments in future ?



Our Industrial world is in permanent change, which major challenges await R&D departments in future ?





***TRIZ postulates:***  
***A short reminder***  
***about fundamentals***

↳ Short (hopefully different) overview of what TRIZ is

### TRIZ : Key facts

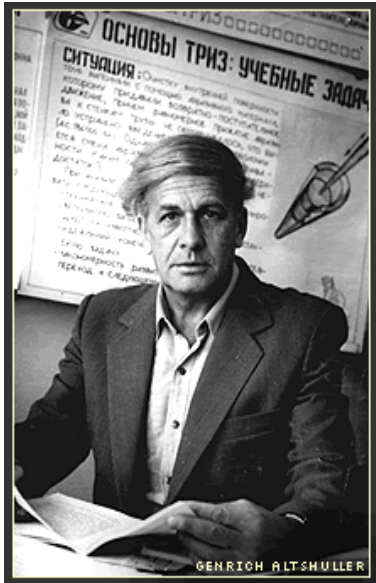
Around 50 years of research (1946-1985) – performed in 300 schools/Laboratories (ex-USSR)  
 Data's : 300 bio of inventors – 400,000 patents – 1500 Technical systems through their history

#### First observations (1956):

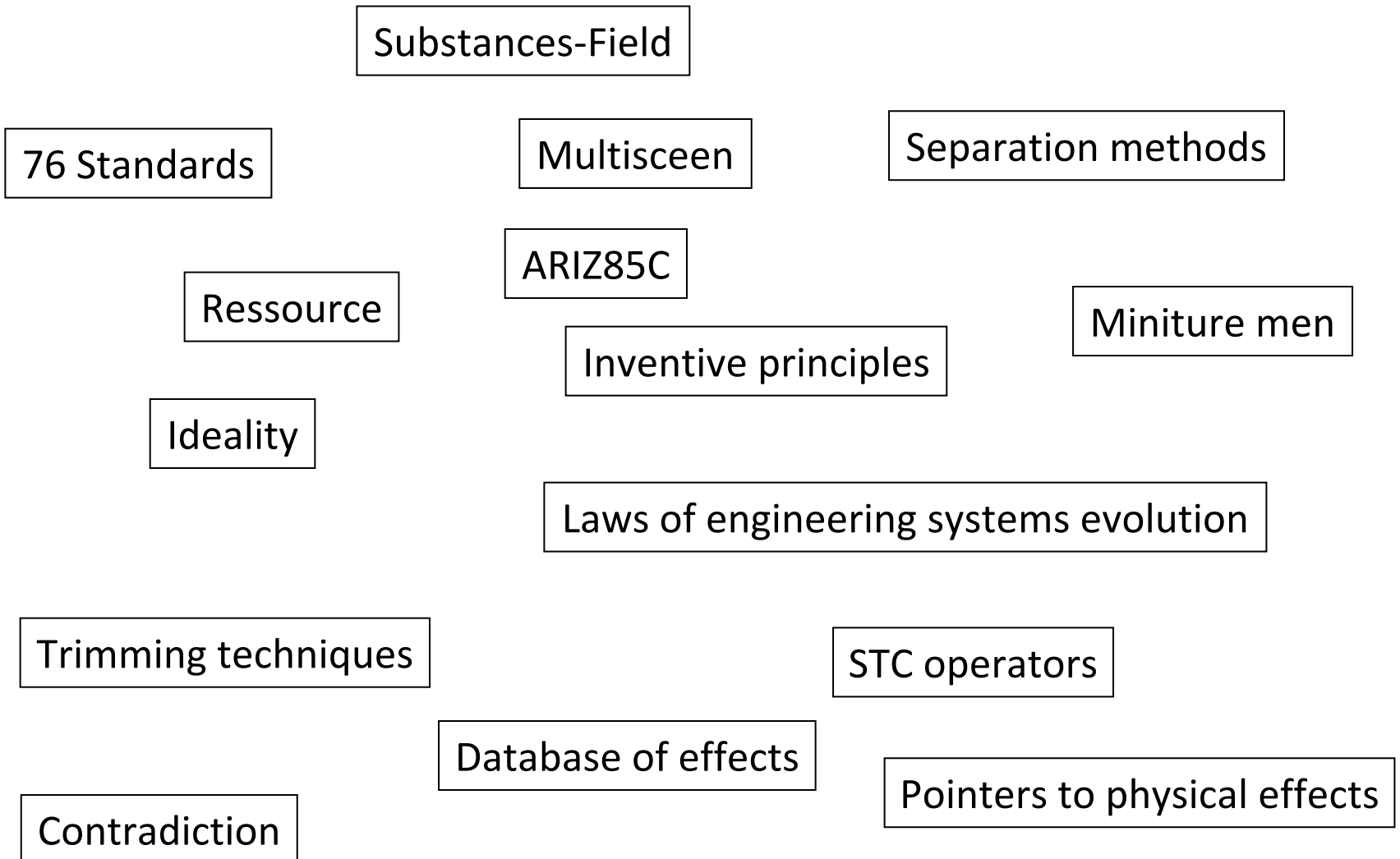
- Inventors react according to similar mechanisms when they invent;
- These mechanisms are independent of their domain of expertise;
- Technical systems are developing in accordance with recurrent trends;
- Every step of these developments resulted in the resolution of one or several contradictions.

#### First hypothesis:

- It is possible to define the laws that govern the evolution of technical systems (help the inventor to anticipate);
- It is possible to construct methods to invent (help the inventor to solve its problems).



↳ Short (hopefully different) overview of what TRIZ is



↳ Short (hopefully different) overview of what TRIZ is

ARIZ85C, Su-field modeling, Miniature men, STC operators

Matrix, Pointers of Effects, Algorithm for choosing inventive standards,...

- 9 laws
- 11 methods for separating physical contradictions
- 40 Inventive Principles
- System of 76 Inventive Standards
- 1200 Effects (Physical, Chemical, Geometrical)

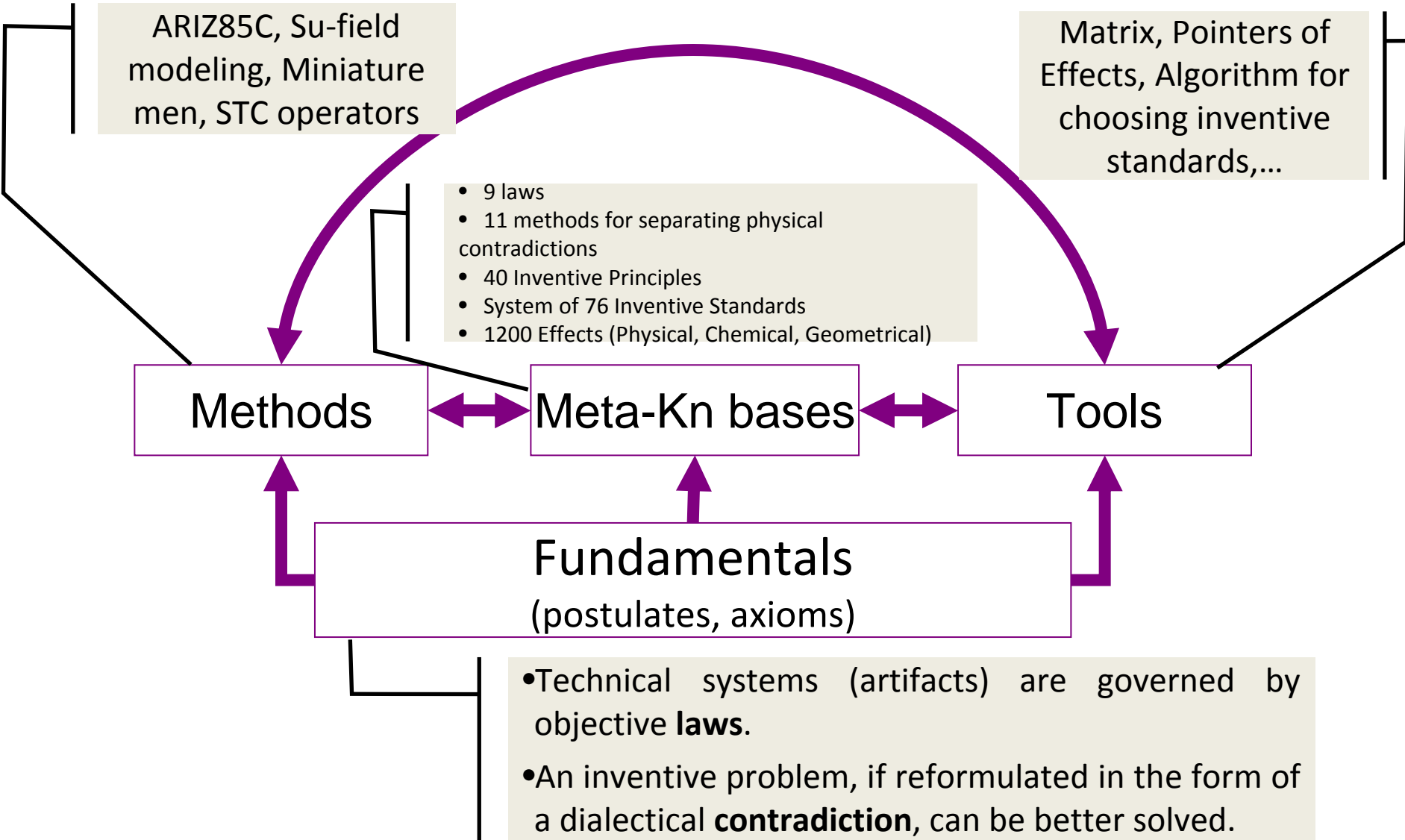
Methods

Meta-Kn bases

Tools

Fundamentals  
(postulates, axioms)

- Technical systems (artifacts) are governed by objective **laws**.
- An inventive problem, if reformulated in the form of a dialectical **contradiction**, can be better solved.



→ Short (hopefully different) overview of what TRIZ is

**An attempt of definition** : Russian acronym of Theory of Inventive Problem Solving. Theory elaborated by Genrich Altshuller stipulating that technical systems are directed by laws governing their evolutions. To evolve from a generation to another, a technical system solves its contradictions, towards its ideality, while minimizing the use of available resources.

**1st Axiom:** The evolution of technical systems is governed by objective laws. These laws are invariants of their evolution.

**Corollary 1.1:** The laws help to locate the state of maturity of the system and to better anticipate its evolutions.


**Corollary 1.2:** A direction of design in accordance with these laws has statistically more chances to appear relevant.

**2nd Axiom:** Any problematic situation can be translated in the elementary form of a contradiction (within the meaning of dialectic).

**Corollary 2.1:** An identified and formulated contradiction becomes an inventive opportunity when its resolution is refusing compromise.

**Corollary 2.2:** Impossibility of formulating a contradiction indicates that what appears as a problem might not be an Inventive Problem.



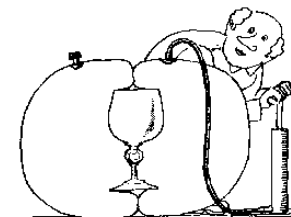
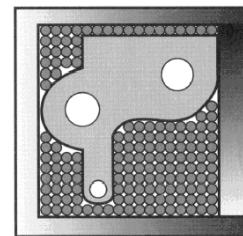
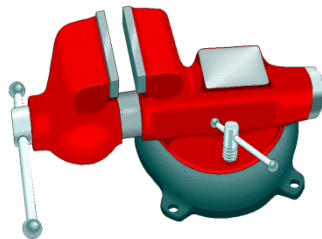


***TRIZ postulates:  
Laws of engineering  
systems evolution***

↳ Short (hopefully different) overview of what TRIZ is

# law 8: Dynamization

In order to improve their performance, rigid systems should become more dynamic. By dynamic we mean: evolve to more flexible and rapidly changing structures, adaptable to changes of working conditions and requirements of the environment.

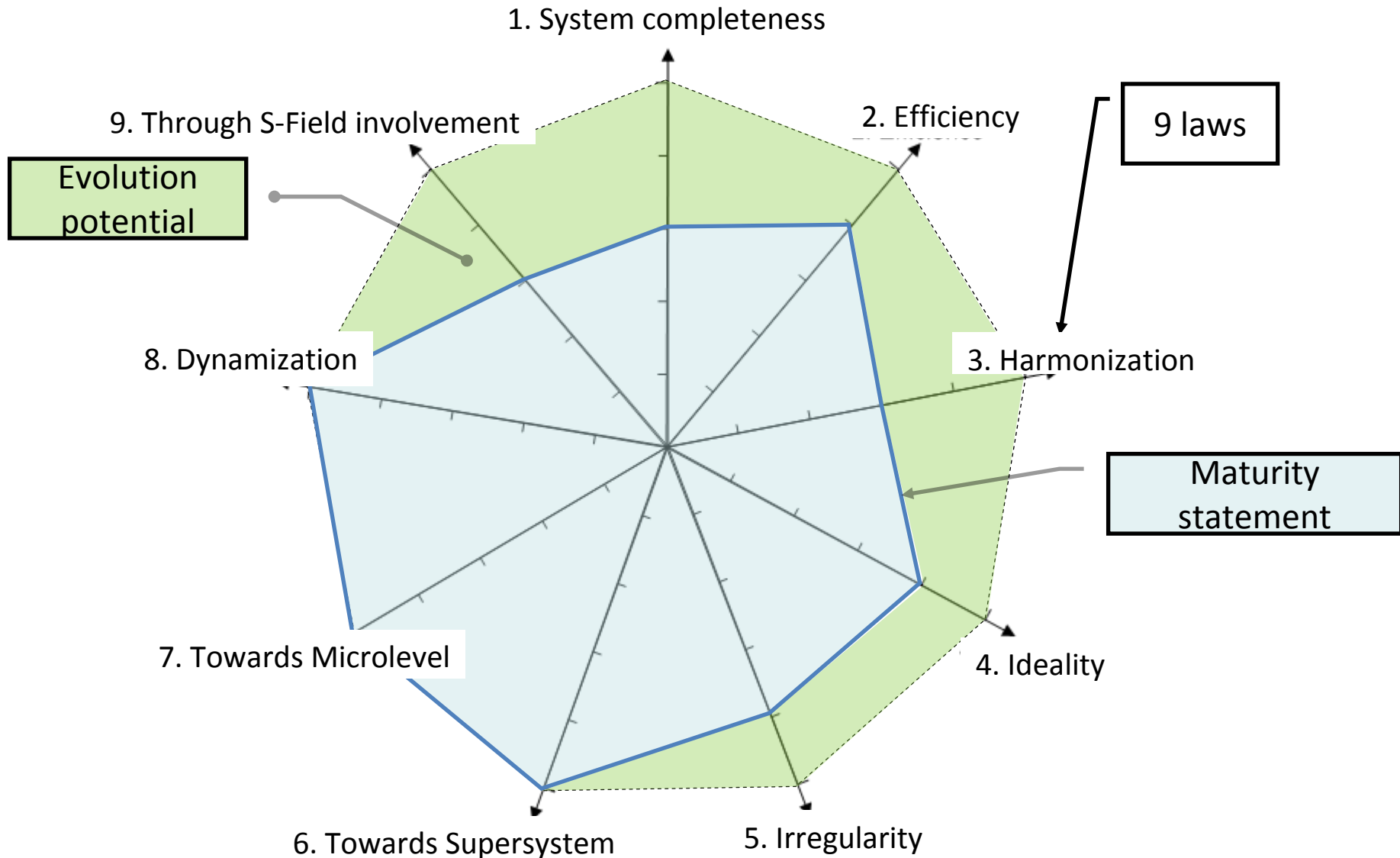


Short (hopefully different) overview of what TRIZ is



↳ Short (hopefully different) overview of what TRIZ is

**9 laws** have been disclosed by TRIZ founders,  
they can be used to discuss the evolution potential of any technical system





***TRIZ postulates  
Contradiction***

↳ Short (hopefully different) overview of what TRIZ is





## Contradictions typologies

**AC (administrative):** I wish [my table resists to heavy loads] but I don't know how !

**TC (technical):** If I improve [mechanical resistance] of [my table] then [transportability] gets worse !

**PC (physical):** The [thickness] of the [platen] must be [thick] for having a satisfactory [mechanical resistance] and [thin] for a satisfactory [transportability].



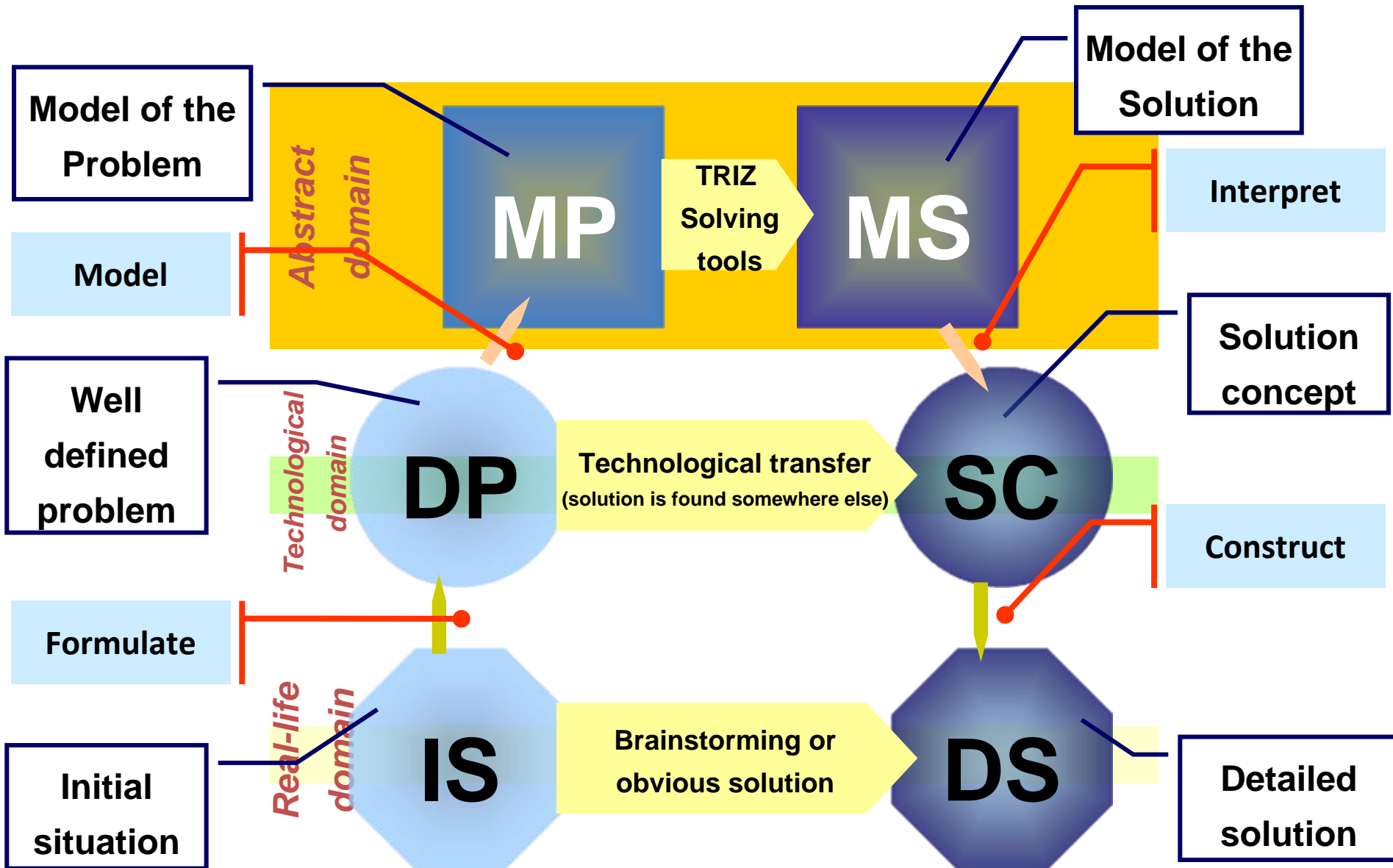
	Thickness	
	thick	thin
Mechanical resistance		
transportability		



***TRIZ***

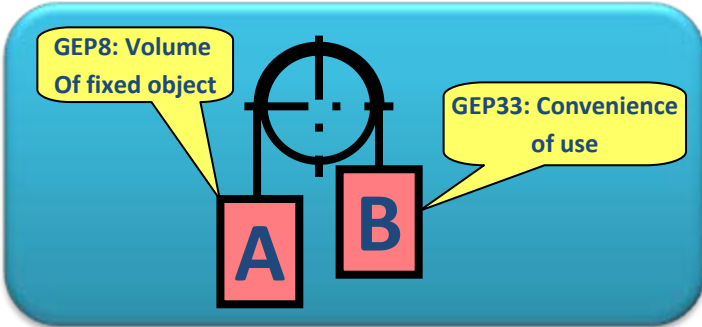
***when observed as a method***

↳ Short (hopefully different) overview of what TRIZ is



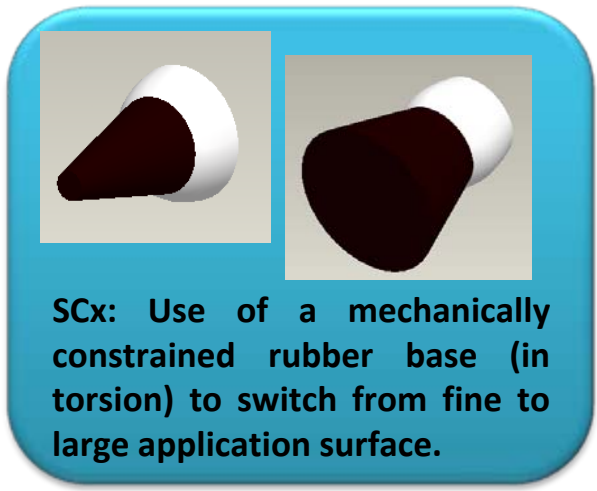
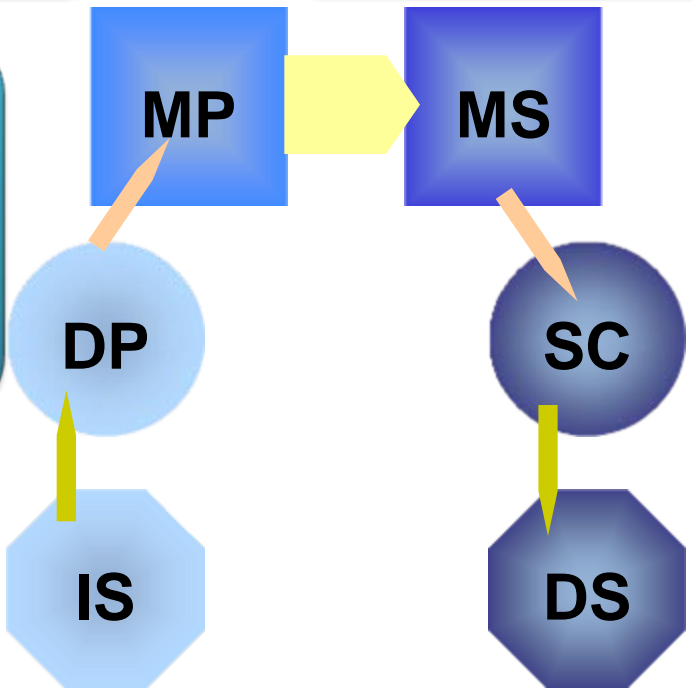
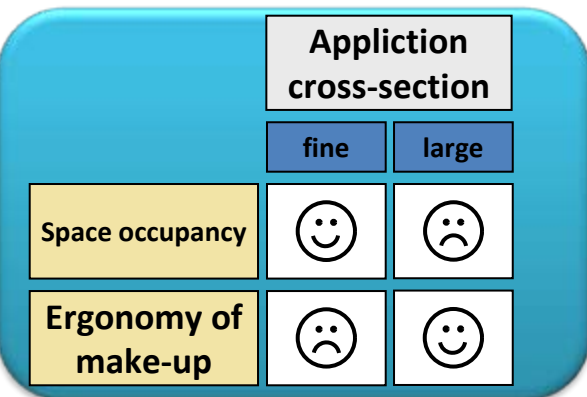


Short (hopefully different) overview of what TRIZ is



Paramètre à améliorer (PE1)	Paramètre qui se dégrade (PE2)										
	Poids d'un objet mobile	Poids d'un objet immobile	Longueur d'un objet mobile	Longueur d'un objet immobile	Surface d'un objet mobile	Surface d'un objet immobile	Volume d'un objet mobile	Volume d'un objet immobile	Vitesse	Force	Transition, pression
1 Poids d'un objet mobile	1	1	1	1	1	1	1	1	1	1	1
2 Poids d'un objet immobile	1	1	1	1	1	1	1	1	1	1	1
3 Longueur d'un objet mobile	1	1	1	1	1	1	1	1	1	1	1
4 Longueur d'un objet immobile	1	1	1	1	1	1	1	1	1	1	1
5 Surface d'un objet mobile	1	1	1	1	1	1	1	1	1	1	1
6 Surface d'un objet immobile	1	1	1	1	1	1	1	1	1	1	1
7 Volume d'un objet mobile	1	1	1	1	1	1	1	1	1	1	1
8 Volume d'un objet immobile	1	1	1	1	1	1	1	1	1	1	1
9 Vitesse	1	1	1	1	1	1	1	1	1	1	1





- 30. Flexible membrane, thin films
  - a. Replace existing objects with flexible membranes.
- 15. Dynamism
  - b. Separate an objet into several ones movable between each others.



→ Short (hopefully different) overview of what TRIZ is



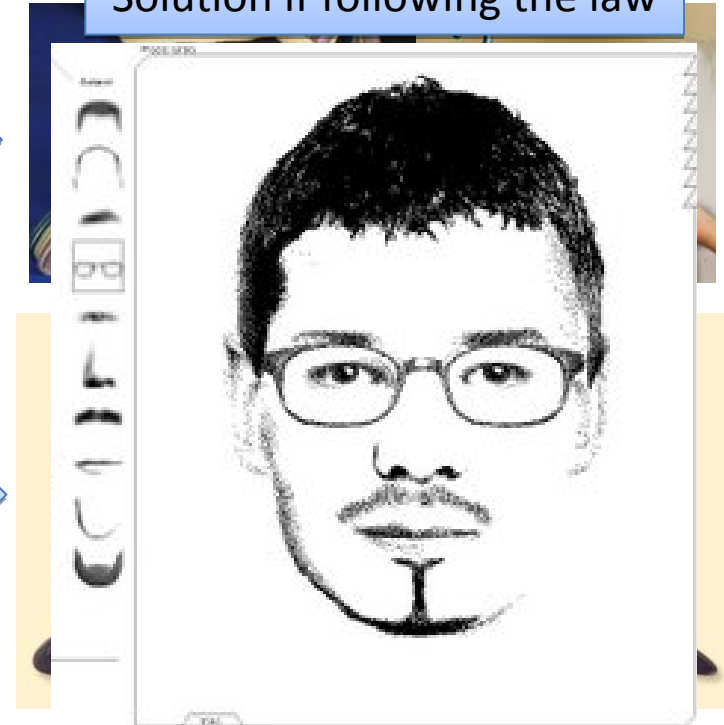
Arms

	Lenght	
	Long	Short
Shirt stability		
Easyness of hanging		

Law 8 : Dynamization

Law 3 : Harmonization

Draw a portrait (face) of the Solution if following the law



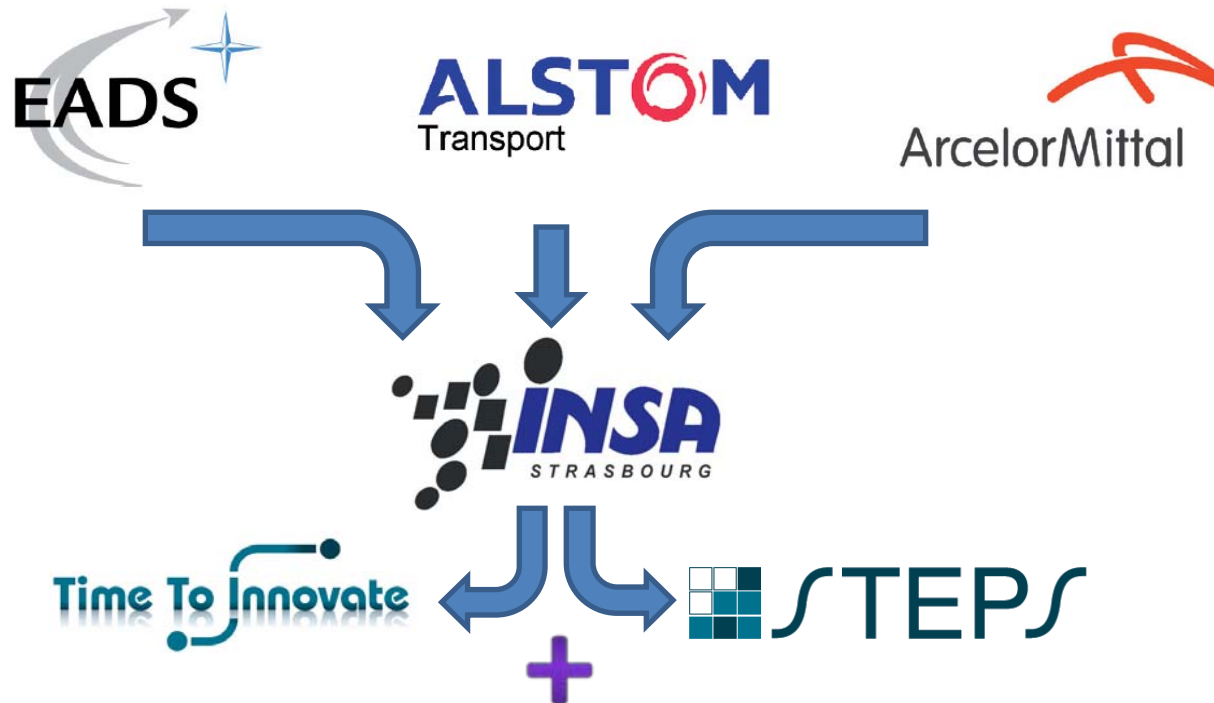


# ***The TRIZ Consortium***

***3 Large scale companies  
interested in TRIZ***

***Decided to unify efforts***

↳ The origins of IDM methodology



## Life Long Learning : IDM

«Inventive Design Method based on TRIZ and its associated software STEPS»

3 weeks training plus a professional project mentored by experts



## A network of experts trained

Assisting IDM-TRIZ diffusion in companies worldwide



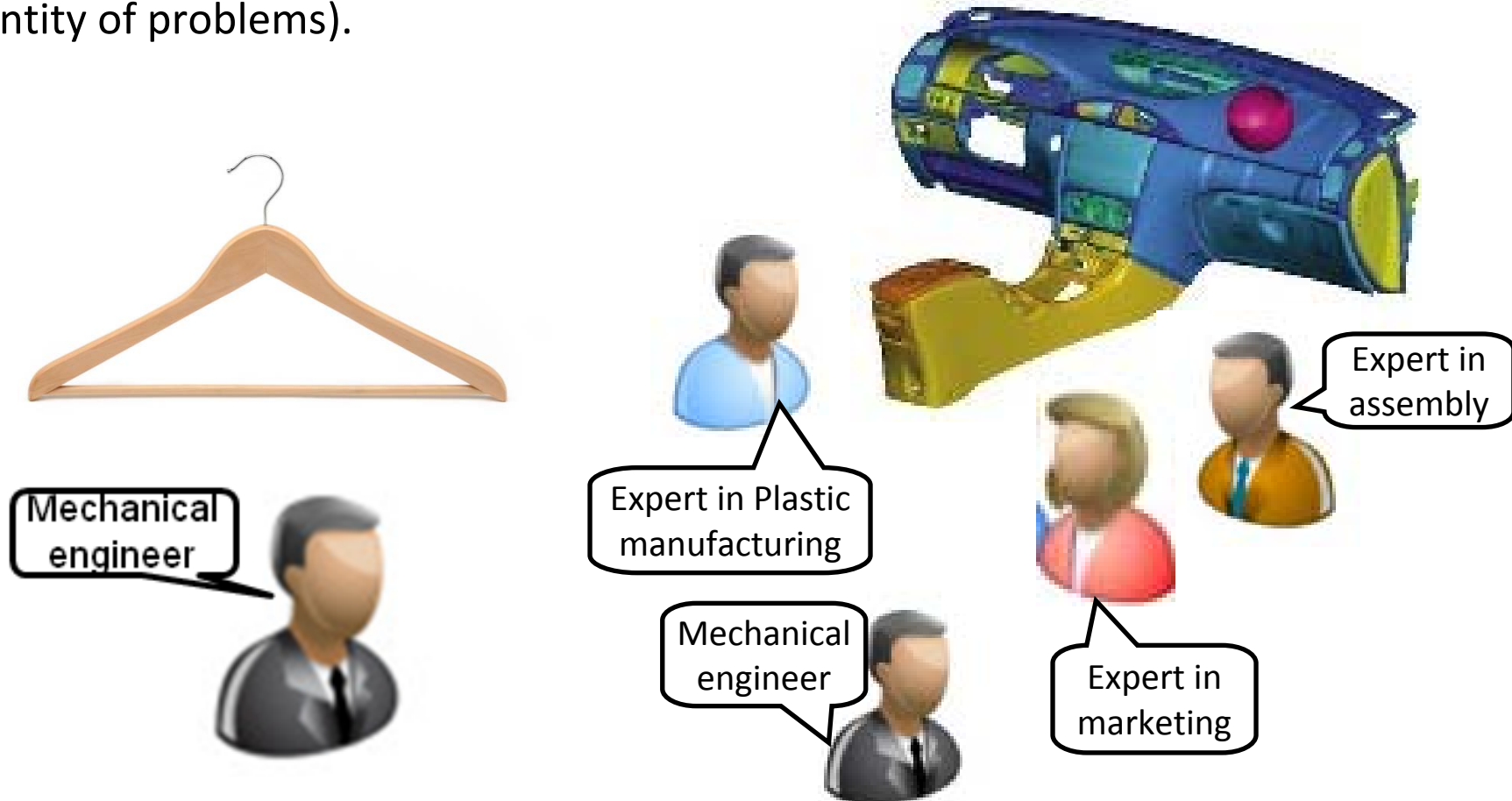


*Understanding  
TRIZ limitations  
In industrial context*

↳ 5 major drawbacks of TRIZ

## About initial and exhaustive investigations :

- TRIZ is not designed to investigate complex initial situations (gathering thoroughly all knowledge necessary and known to document/understand the diversity and the quantity of problems).







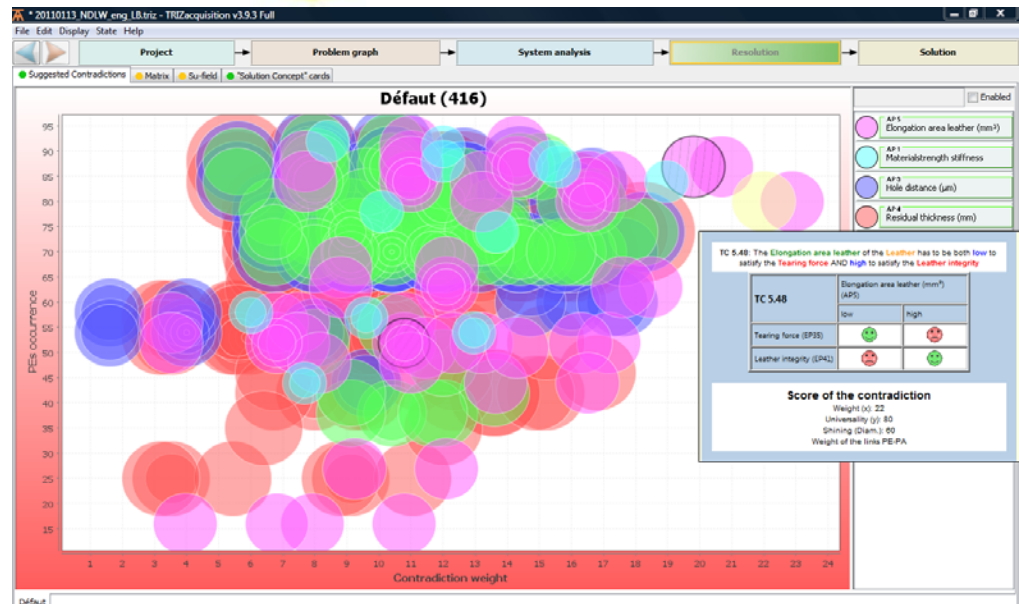
↳ 5 major drawbacks of TRIZ

## About contradiction's quantity... and choice :

- TRIZ is designed for solving a single contradiction. How to disclose, represent and chose the most appropriate one since contradictions quantity increase exponentially with system's complexity ?



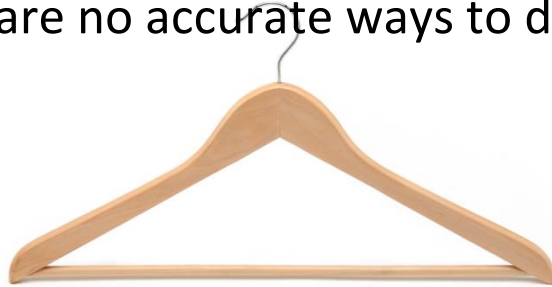
		Arm's length	
		long	short
stability			
ease of placing clothes on			



↳ 5 major drawbacks of TRIZ

## About a methodology to disclose a contradiction :

- There are no accurate ways to disclose appropriately a contradiction.



As you know, I'm a TRIZ expert, therefore I know the truth...  
The contradiction is...



Let  $i=2q-1$  or  $i=2q$  and  $M \in \mathcal{R}^{2m \times k}$  be the matrix of influences  
 $M_{ij}=1$  means that  $AP_q$  has a positive influence on  $EP_j$   
 and  $M_{ij}=-1$  means that  $AP_q$  has a negative influence on  $EP_j$

Moreover

$\forall i, m \mid i=2*m$ , if  $M_{i,j} = 1$  then  $M_{i+1,j} = -1$  and if  $M_{i,j} = -1$  then  $M_{i+1,j} = 1$  else  $M_{i,j} = \infty$

Figure 6 shows a possible matrix of influences.

$$\begin{array}{c}
 AP_1 \\
 \vdots \\
 AP_m
 \end{array}
 \begin{array}{c}
 \frac{Va_1}{Va_1} \\
 \dots \\
 \frac{Va_m}{Va_m}
 \end{array}
 \begin{array}{c}
 1 \\
 2 \\
 \dots \\
 2m-1 \\
 2m
 \end{array}
 \begin{pmatrix}
 1 & -1 & \dots & \infty & \dots & \infty \\
 -1 & 1 & \dots & \infty & \dots & \infty \\
 \dots & \dots & \dots & \dots & \dots & \dots \\
 \infty & \infty & \dots & 1 & \dots & -1 \\
 \infty & \infty & \dots & -1 & \dots & 1
 \end{pmatrix}$$

Figure 6: Matrix representing the influences between the APs and the EPs



↳ 5 major drawbacks of TRIZ

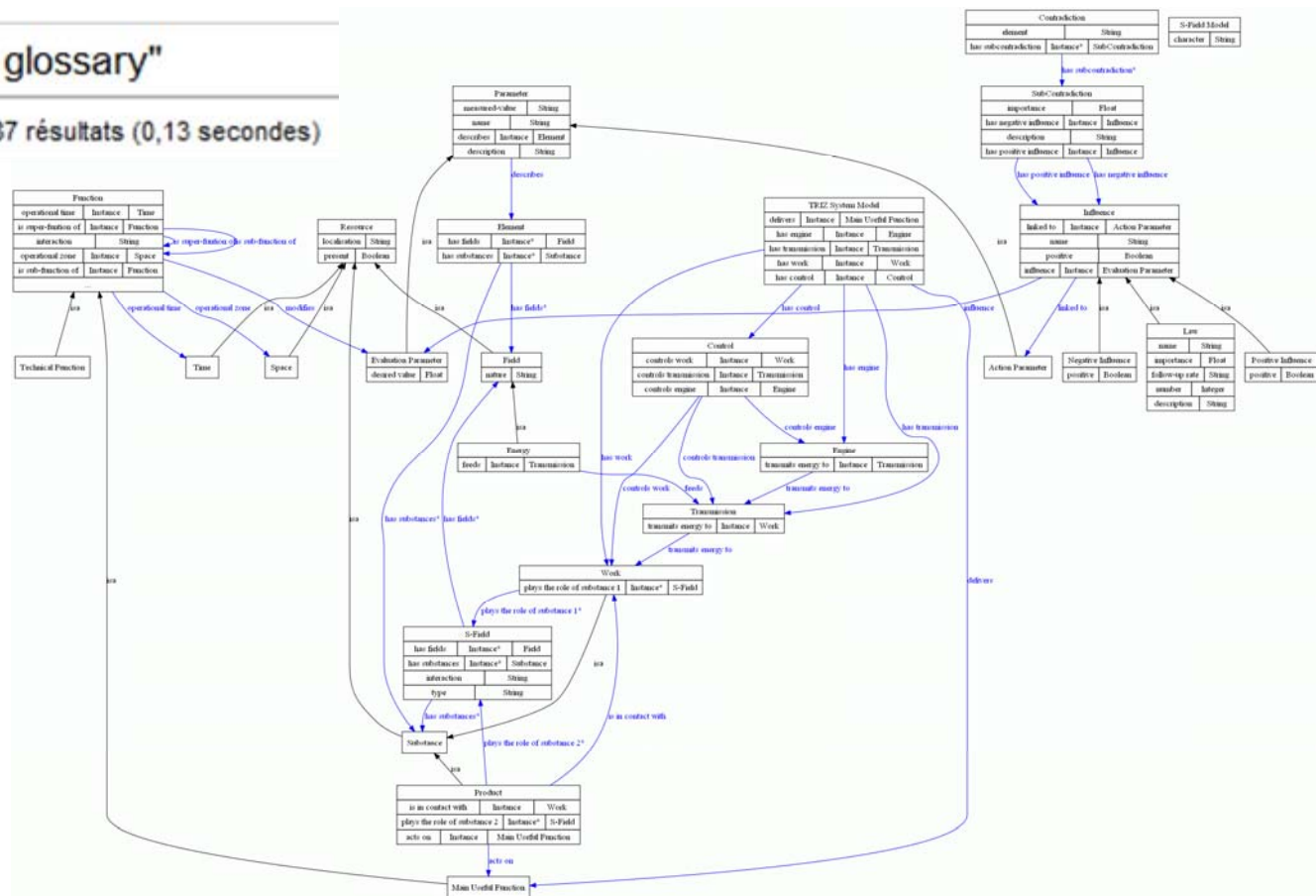
## About TRIZ corpus consistency :

- Are you aware of any “glossary” or “ontology” of TRIZ components ? There are no logical links/coherence between TRIZ components.



"TRIZ glossary"

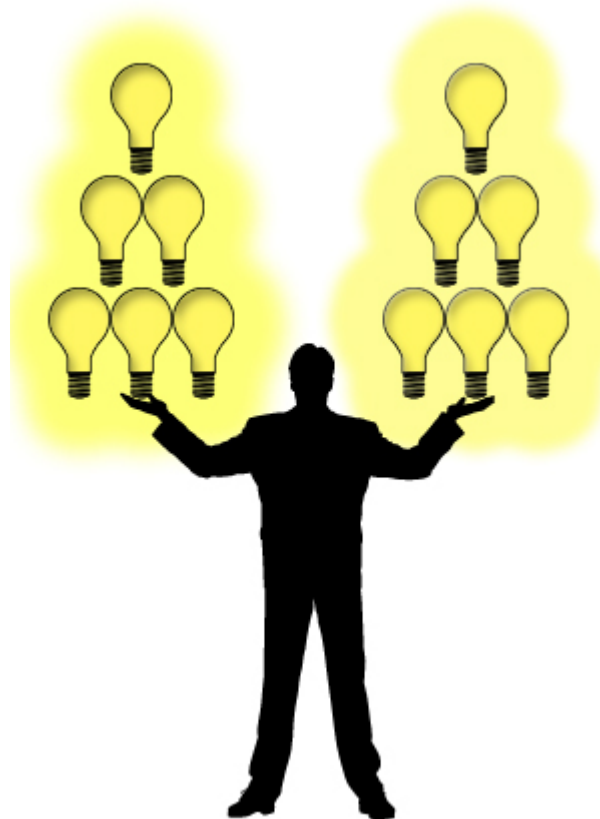
Environ 87 résultats (0,13 secondes)




↳ 5 major drawbacks of TRIZ

## Where is TRIZ's best solution ?

- There are no means in TRIZ to help the designer to decide, among a set of Solution concepts being all inventive, which one is the one to choose.





*There is a need  
to efficiently deploy  
IDM methodology*

*The industrial partners proposed :*

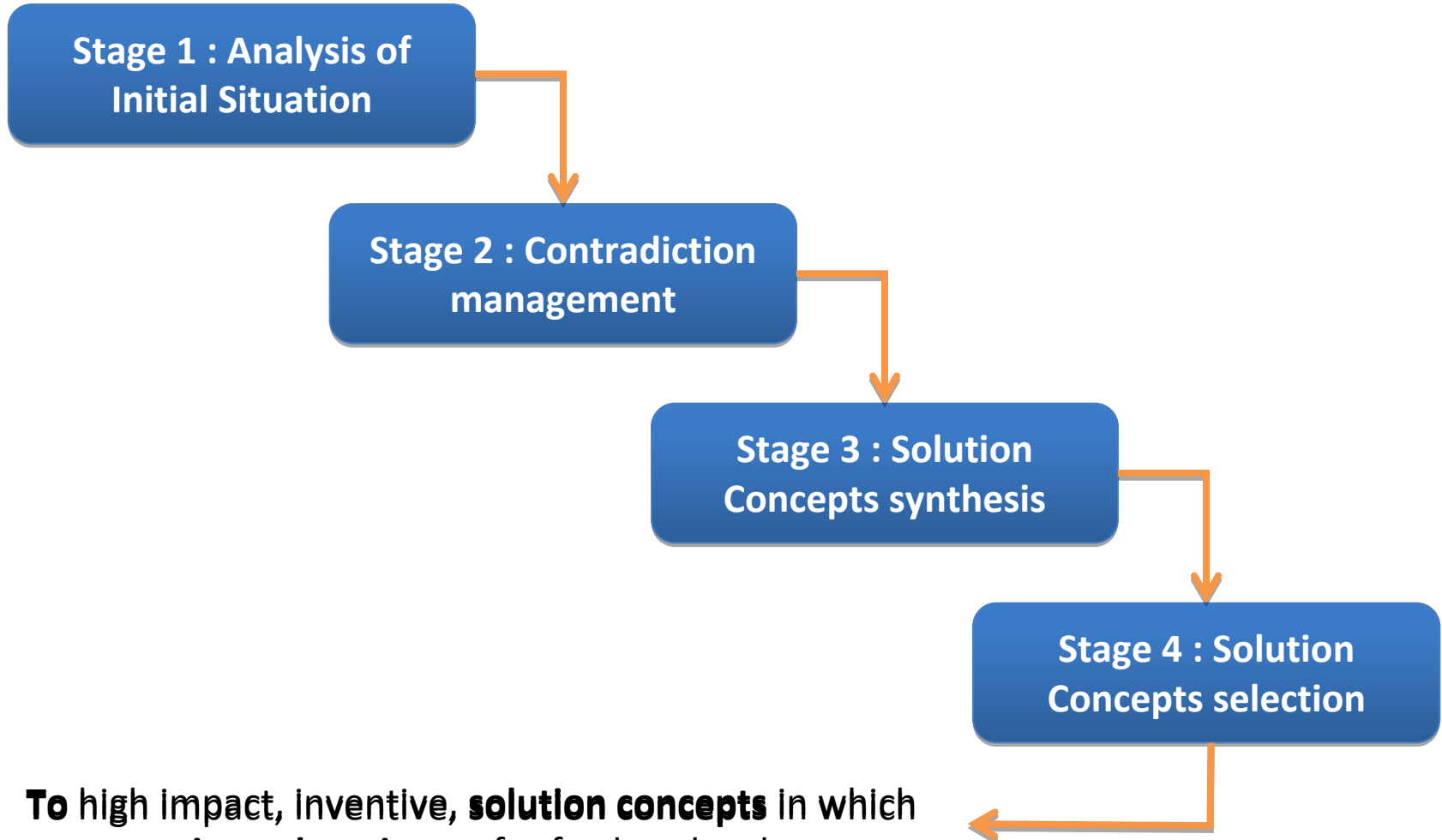
*To build a new software !*

↳ Why do we need a software ?

A first statement in which industrial and academic partners agreed on : There is a need for a software :

- To assist the animator in conducting inventive activities (to structure, to organize study data's);
- To relieve users of tedious tasks;
- To ensure minimal (robustness) consistency of the approach;
- To permit the sharing of practices inside a community;
- To install a spiral of constant evolution in the development of the software through research.

↳ IDM's 4 major Sages



**To high impact, inventive, solution concepts** in which **company is ready to invest** for further developments

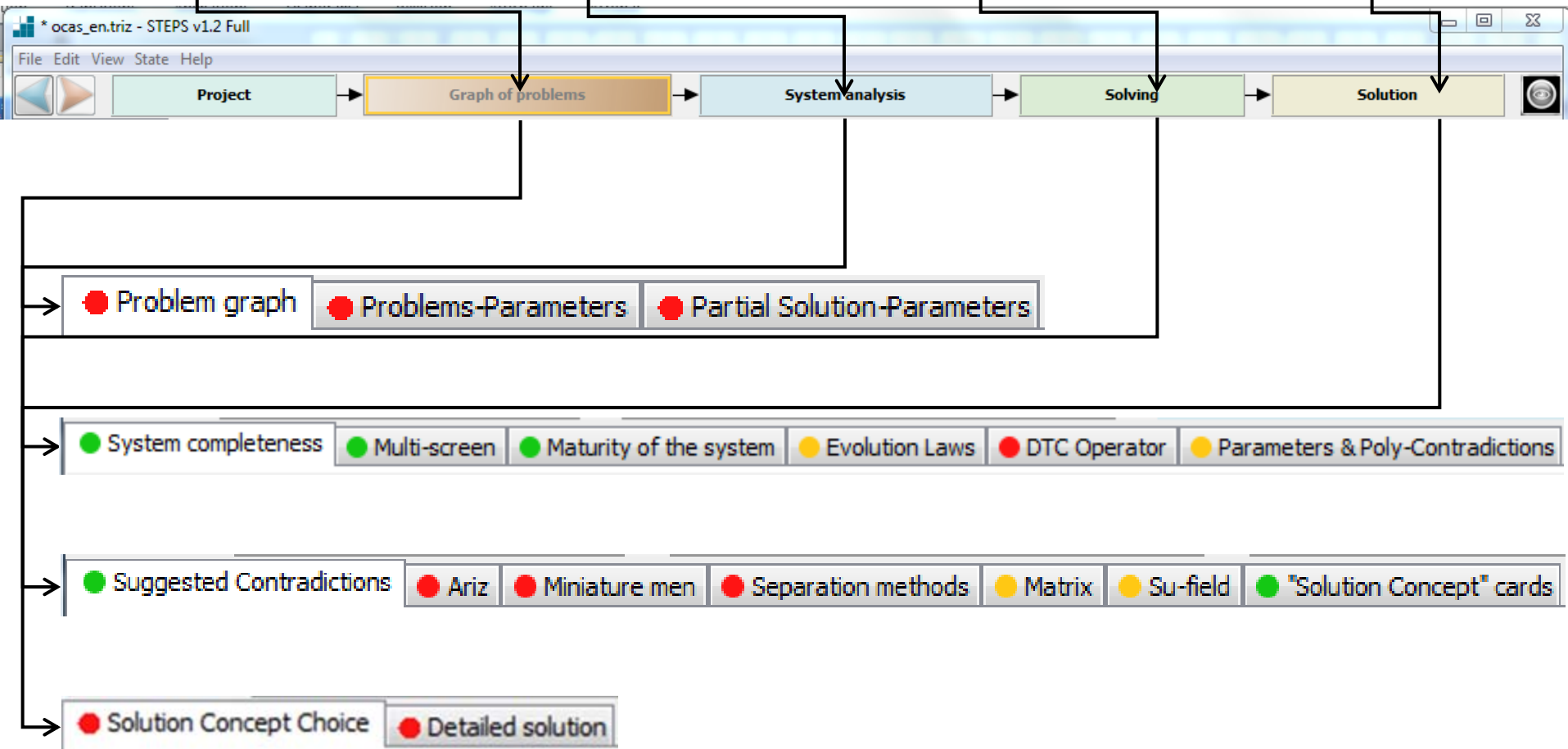
Starting with an Initial situation

Step 1 : Analysis of Initial Situation

Step 2 : Contradictions management

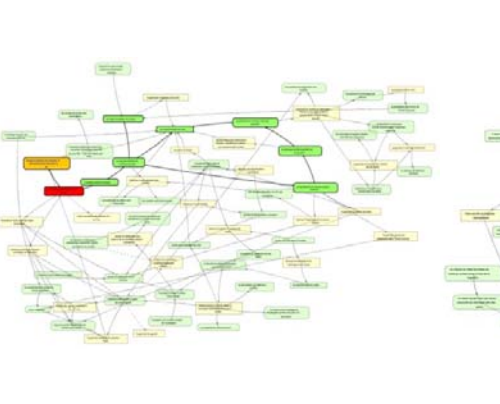
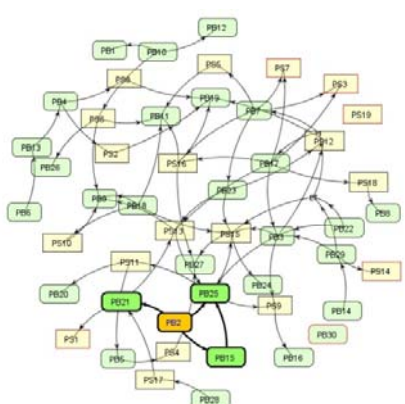
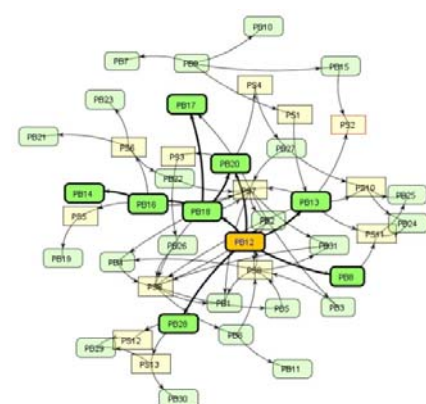
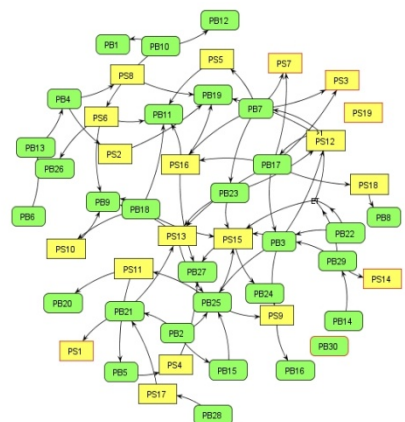
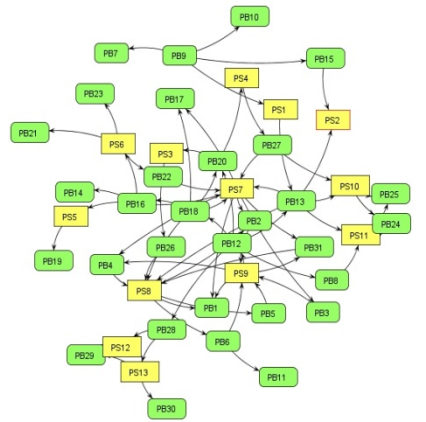
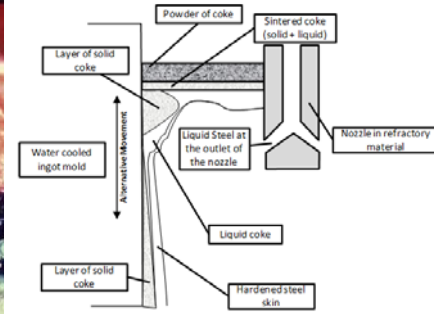
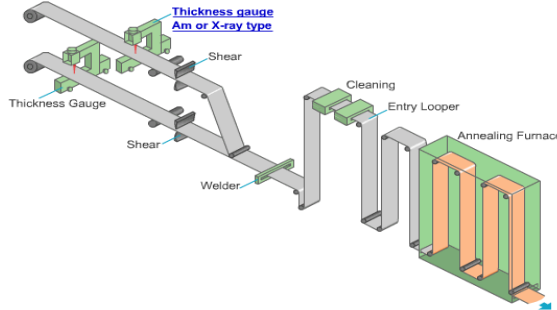
Step 3 : Solution Concepts synthesis

Step 4 : Solution Concepts selection



Starting with an Initial situation

Managing populations of contradictions



# Starting with an Initial situation

## Managing populations of contradictions

arcelor2-TFC2011.triz - STEPS v1.2\_demo Full

File Edit Display State Help

Project → Problem graph → System analysis → Resolution → Solution

● Problem graph ● Problems-Parameters ● Partial Solution-Parameters

Navigation:

Multiple creation Version: graphe\_v3 Add

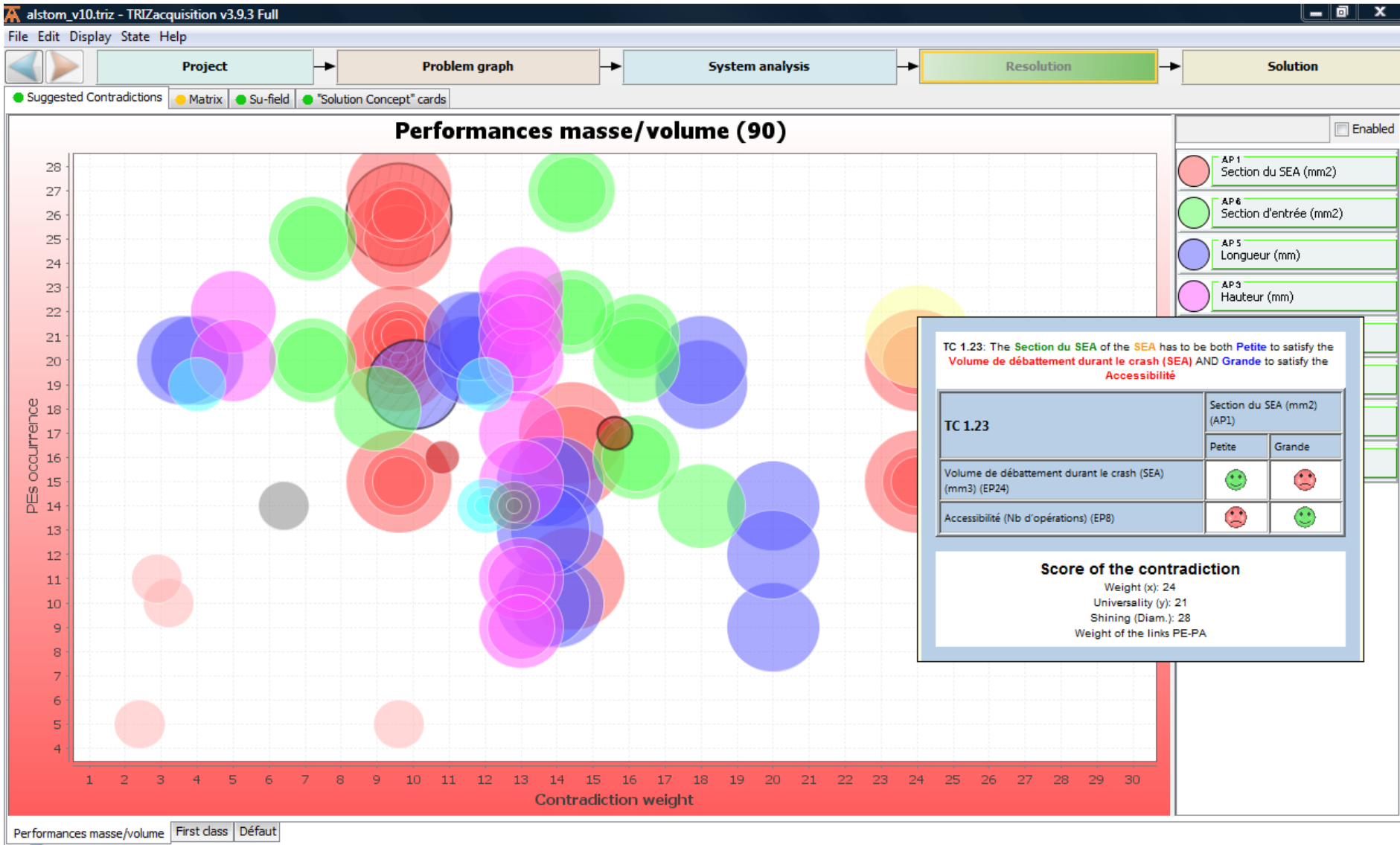
Category list

- Liquid metal is tearing off coke
- Solid slug in slag skin is trapping particles
- Diminution of carbon rate is rising slug's importance
- Bubbles are agitating the interface steel-coke
- Les bulles d'argon modifient l'écoulement du métal dans la lingotière
- Les réactions métal-laitier diminuent la tension interfaciale
- La busette se bouche
- Une modification de l'immersion de la busette induit des fluctuations de vitesses e...
- Le type d'écoulement généré est modifié
- L'acier colle aux parois de la lingotière

Links: PB14



- Starting with an Initial situation
- Managing populations of contradictions



Fully operated TRIZ techniques

### The Matrix

Principles Percentage

1	10%
2	10%
3	10%
4	10%
5	10%
6	10%
7	10%
8	10%
9	10%
10	10%
11	10%
12	10%
13	10%
14	10%
15	10%

Separation Methods

- 1 - In space
- 2 - In time

### Su-Field

Types

F1	S1
F1	S2
F1	S3
F1	S4
F1	S5
F1	S6
F1	S7
F1	S8
F1	S9
F1	S10
F1	S11
F1	S12
F1	S13
F1	S14
F1	S15

### ARIZ85C

1.1 - The contradiction

TC 0.0: The action parameter of the Element has to be at the same time  $va$  to satisfy the Parameter to be improved AND  $va\_barre$  to satisfy the Degrading parameter

action parameter (AP0)	
$va$	$va\_barre$
Parameter to be improved (EP0)	☺ ☹
Degrading parameter (EP0)	☹ ☺

1.2 - Define the object and the tool

Tool: \_\_\_\_\_

Main Useful Function: \_\_\_\_\_

Object: \_\_\_\_\_

1.3 & 1.4 - CT 1: action parameter  $va$

Tool → Parameter to be improved → Object

Object → Degrading parameter → Tool

1.6 - Formulation of the problem model

Intensified conflict: \_\_\_\_\_

Required output: \_\_\_\_\_

1.7 - Solving by su-field

Can the problem be solved using the inventive standards? Yes No

### Miniature Men

2.1 - Define the operational zone

Z1 Z2 Z3

Define z1 Define z2 Define z3

Define t1 Define t3 Define t2

The contradiction: TC 0.0

Create a « Solution Concept » Card

### Separation methods

2.2 - Define the separation method

Note the common area to Z1 and Z2 in which  $va$  and  $va\_barre$  are incompatible: Z3: potential operational zone

Note the resource elements which can potentially enable to Z1 or Z2 to take on an opposite value to the currently taken on:

Create a « Solution Concept » Card

→ STEPS's Solution Concept cards

## A Solution Concept tree is built

(each branch is a solution concept card)

alstom\_v10.triz - TRIZacquisition v3.9.3 Full

File Edit Display State Help

Project → Problem graph → System analysis → Resolution → Solution

● Suggested Contradictions ● Matrix ● Su-field ● "Solution Concept" cards

Fiches concept de solution

- SEA
  - Soufflet
    - (1.1.1.1) Soufflet qui s'étend 2
    - (1.1.1.2) Soufflet qui s'étend 3
    - (1.1.1.3) Soufflet qui s'étend
    - (1.1.1.4) Soufflet multi-hélices
  - Longueur fixe
    - Effort axial
      - (1.1.2.1.1) Chaussette et tube composite
      - (1.1.2.1.2) Low technology
      - (1.1.2.1.3) Chassis utile au guidage
      - (1.1.2.1.4) NIDA repris au fond
  - Matériaux différents
    - (1.1.2.2.1) Pièces en mousse (alu ou acier)
    - (1.1.2.2.2) Faire le tiroir en forgeage
  - Segmentation
    - (1.1.2.3.1) Tiroir multi-pièces en usinage
    - (1.1.2.3.2) Tiroir multi-pièce en écrasement
    - (1.1.2.3.3) Diviser le tiroir en deux
    - (1.1.2.3.4) Chappe-couteau
  - Autres principes d'absorption
    - (1.1.2.4.1) rendre périodique l'écrasement
  - Section d'entrée
    - (1.1.3.1) Paroi frontale segmentée
  - divers
    - (1.2.1) Ecrasement hélicoïde
    - (1.2) essai

**Code**  
SC 1.1.2.1.3

**Label**  
Chassis utile au guidage

**Law**  
Intégralité des parties      Conductibilité énergétique      Idéauté

**Hypothesis(s)**

**Contradiction**

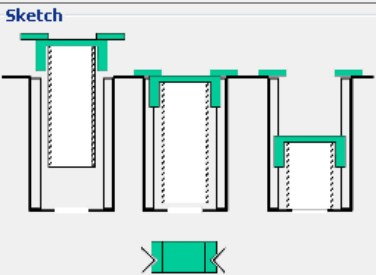
TC 1.1: The Section du SEA of the SEA has to be both Petite to satisfy the Temps des cycles de fabrication AND Grande to satisfy the Commodité de remorquage

TC 1.1	Section du SEA (mm2) (AP1)	
	Petite	Grande
Temps des cycles de fabrication (Jours) (EP14)	😊	😞
Commodité de remorquage (EP5)	😞	😊

**Principe**  
19. Periodic action

a) Instead continuous action use pulse actions.  
b) Vary periodicity according the conditions.  
c) Use pauses between impulses to perform some other action

**Sketch**



**Notes**

**Description**

Le chassis guide et donc élimine l'utilité des barres. Pour maintenir le SEA, les parois intérieures du chassis sont tapissées d'une mousse rigide.

**Your contradiction is separable**  
in time

**Resource(s)**  
Force d'impact

**Advantage(s)**  
Moins de pièces

**Drawback(s)**  
Difficultés de montage

**Risk(s)**

**Documentation**



***Conducting an industrial case :  
summary***

Summary of a case study

Day 1

Day 2

Day 3

Day 4

Day 5

Day 6

Day 7

Day 8

Day 9

Day 10

Flexible schedule consisting in 10 sessions face to face and an equivalent amount of work "off sessions" by both INSA study leader and Company team members (based on a complex case situation)

## Problem Statement phase

Phase consisting in drawing a problem statement through a problem graph and known partial solutions

## Data's gathering and Contradiction analysis

Phase consisting in entering into the detailed problem description through a key problem and disclosing all its related contradictions

## Contradictions treatment

Phase consisting in engaging several contradictions (the most relevant ones) into a solving phase using TRIZ techniques. Solution concepts are drawn in this phase.

Phase consisting in engaging R&D means to characterize technologically and qualitatively the solution concept's feasibility

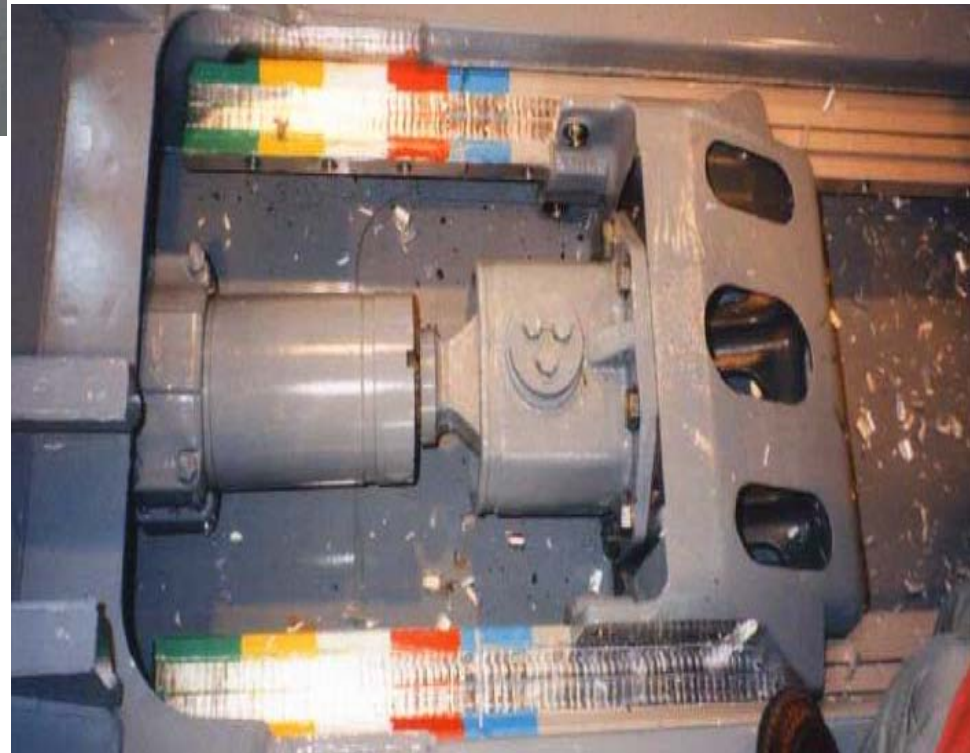
Phase consisting in analyzing Solution Concepts and choosing a reduced set of them for further calculations based on the Problem network shrinkage they provoke

## Solution Concepts analysis

## Calculations & validations of the chosen solution Concepts

↳ Summary of a case study

## Crash retention in High speed trains



Summary of a case study

Case study in high speed train industry : Crash absorbing system

Competing arena in high speed train market



Problematic : How to efficiently absorb energy in crash situations?



Analysis of competition and state of the art of expert knowledge on the topic  
All people knowledge and doc. (patents, articles) are studied



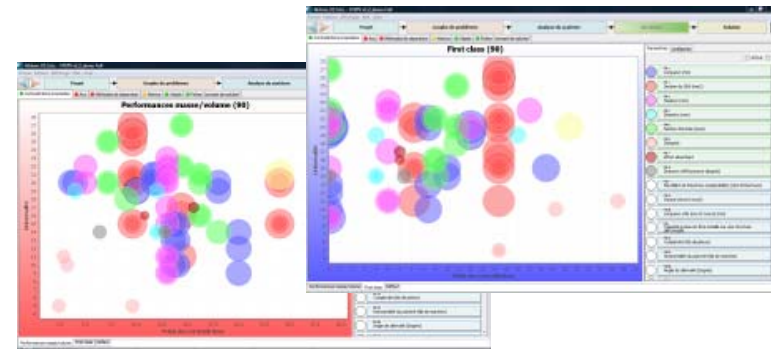
Construction of a problem graph



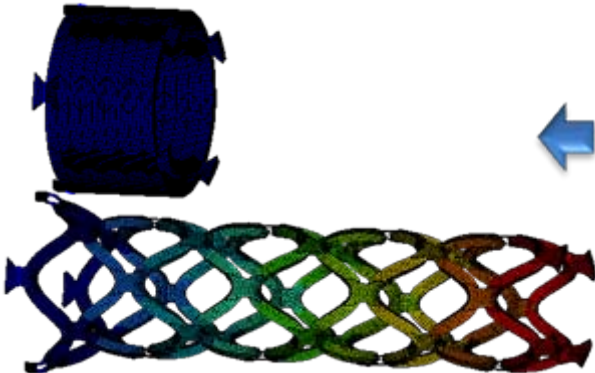
Interpreting the graph : define the core problem



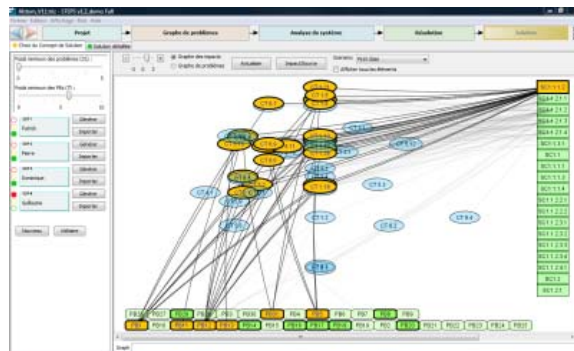
Contradiction extraction & management



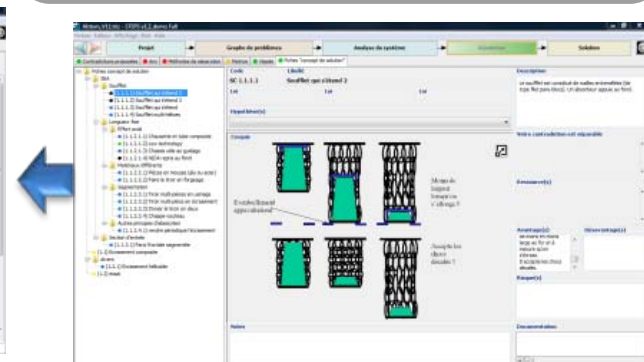
Towards calculation and 3D modelling of the solution concept for validation



Use of Pugh's matrixes for automatic ranking of solution concepts



Use of TRIZ techniques for building solution concept





***Teaching IDM  
to engineers  
in life-long learning***





An official full version of STEPS software is necessary all along the training process

→ Teaching IDM

## IDM experts

(3 w + 1 w on a mentored professional project)



Basic TRIZ



Advanced TRIZ



Management of complex situations



Case study + mentoring



All classical components of TRIZ are studied in a comprehensive course with industrial exercises and team working + public presentation of the work (35 hours/5 days)

Advanced techniques of TRIZ are applied (Su-Field ; ARIZ) on industrial situations with a mentoring and team working + public presentation of the work (35 hours/5 days)

IDM (extensions of TRIZ towards complex and multidisciplinary situations) are studied and applied on a professional basis in a real industrial project. A mentoring on the project is provided by a IDM-Expert and specific abilities of animating a team are provided through the exercise (2 x 35 Hours / 70 Hours)



***Some limitations of  
in which we are currently  
conducting research  
(ongoing PhD)***

→ Conclusions

**Limit N° 1 of our work :** Team working for “human-built” problem graph is too long and not 100% accurate



Achille Souilli's PhD

**Limit N° 2 of our work :** For a permanently evolving coherence of our work and error-free concepts manipulations, using computers is necessary.



Wei Yan's PhD

**Limit N° 3 of our work :** There are still no means of measuring Inventive Efficiency in R&D teams (besides simply counting invested funds or patents), therefore how can we monitor the effects of IDM adoption ?



Ali Taheri's PhD

**Limit N° 4 of our work :** Solution Concepts are always “hard to believe” especially by expert since they are outside what they classically admit as possible.

Thongchai  
Chinkatham's PhD

## Year

- 2012 (77) >
- 2011 (217) >
- 2010 (125) >
- 2009 (86) >
- 2008 (79) >

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## Author Name

- Tan, R. (61) >
- Cavallucci, D. (22) >
- Cascini, G. (19) >
- Cao, G. (18) >
- Rousselot, F. (15) >

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## Subject Area

- Engineering (581) >
- Computer Science (208) >
- Business, Management and Accounting (108) >
- Decision Sciences (67) >
- Mathematics (59) >

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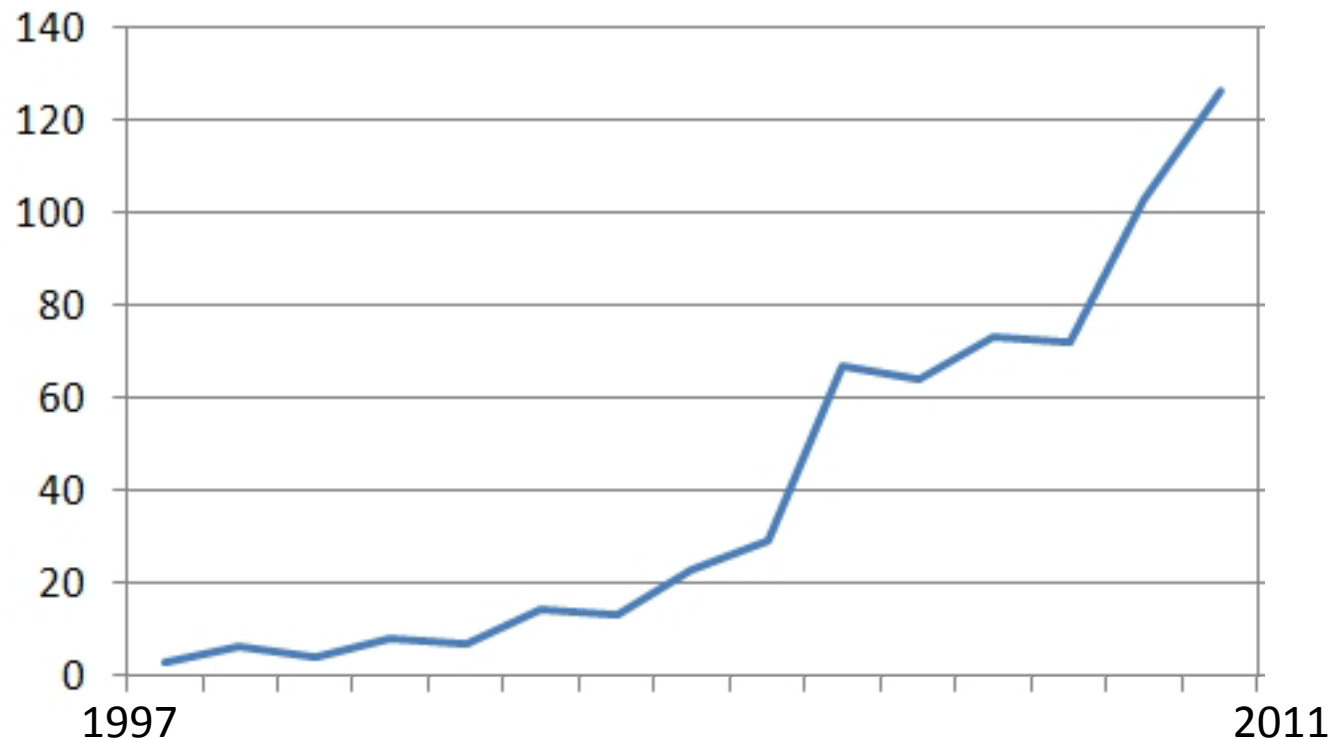
## Document Type

- Conference Paper (497) >
- Article (299) >
- Conference Review (12) >
- Review (11) >
- Article in Press (6) >

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 Conclusions

Quantity of scientific papers per years being published and using the keyword TRIZ in the title or the abstract



## What are we heading towards :

- **Research** : building new knowledge through partnership always keeping in mind its usefulness for society (industry) ;
- **Education** : train people at all levels with academic excellence in mind;
- **Expertise** : create a network of experts, able to practice, teach assist industry with IDM-TRIZ model;
- For all these 3 directions, our software **STEPS** is at the crossroads :
  - **Educating** more efficiently, more rapidly using STEPS;
  - Trying our new **research findings** using proto-STEPS for research and **tests**;
  - **Practicing** IDM-TRIZ in industry through a growing community of practice using STEPS as a **methodological guideline**.



Thank you for your  
attention !  
Time for questions now