POLITECNICO DI MILANO

TRIZ & Innovazione sistematica:
strumenti e metodi per l'innovazione in azienda

Gaetano Cascini
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Politecnico di Milano

- Established in 1863
- Organized in 16 departments (devoted to research) and a network of 9 Schools of Engineering, Architecture and Industrial Design spread over 7 campuses over the Lombardy region
- Approximately 40,000 students (the largest institution in Italy for Engineering, Architecture and Industrial Design)
- Ranked as one of the most outstanding European technical universities

alintec Innovazione Sistematica

Polit. di Milano – KAEMaRT group

www.kaemart.it

- **KAEMaRT** (Knowledge Aided Engineering, Manufacturing and Related Technologies)
- Established and coordinated by Prof. Umberto Cugini since 1979
- 2 Full Professors, 2 Associate Professors, 3 Research Assistants, 4 Research Fellows, 12 PhD Students with background in Computer Science, Physics, Engineering and Industrial Design (more than 200 fellows since the origins)
- Mission: to investigate **new solutions for industrial applications** and to develop **innovative methods, tools** and prototypes
- The group is involved in courses at the Faculties of Industrial Engineering, Industrial Design and Management and Production Engineering.


Gaetano Cascini – short resume

- 1999 : PhD in Machine Design
- 1999 – 2008 : Assistant Professor at University of Florence
- 2008 – now : Associate Professor at Politecnico di Milano
- Past:
  - 2003-2005 : Founder and first President of Apeiron, the Italian TRIZ Association
  - 2005-2009 : Vice-Chair of the IFIP 5.4 Working Group (Computer-Aided Innovation)
  - 2006-2009 : President of the European TRIZ Association
  - 2007-2009 : Member of the MA TRIZ Presidium
- Currently:
  - Member of the ETRIA Executive Board
  - Chair of the "Computer-Aided Innovation" workgroup and Communication Officer of the TC-5 Committee (Computer Applications in Technology) of IFIP (International Federation for Information Processing)
  - Author of 80+ papers presented at International Conferences and published in authoritative Journals
  - Author of 8 patents (assignees University of Florence, Whirlpool Europe, Bracco Imaging, Logli srl, SCAM srl, Meccaniche Fiorentine)

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Centro di Competenza per l'Innovazione Sistematica

Soggetti aderenti al Centro di competenza:
- Alintec
- Area Science Park Trieste
- Politecnico di Milano
- Università degli Studi di Bergamo
- Università degli Studi di Firenze
- Ceris-Cnr di Torino
- PIN Scrl Servizi didattici e scientifici per l'università di Firenze

Innovazione Sistematica
www.innovazionesistematica.it

- Training and coaching for TRIZ introduction in industry:
  - ABB SACE - 2 case studies + Training + 4 pilot projects
  - Alenia Aermacchi - Training + 2 case studies
  - Alluflon - Moneta - Training & Coaching
  - Bracco Imaging - 1 pilot project (3 Patent Applications)
  - Coster Group - Training
  - Enel - 2 Training activities
  - Philip Morris Intertaba - Training
  - Intier Motrol - Training
  - John Bean Technologies - Training
  - Procomac - Training + 1 Extended Technology Forecasting + 2 case studies
  - SACMI - Training + 2 pilot projects
  - Tecniplast - Advanced Training & Coaching
  - Whirlpool - 1 pilot project (1 Patent)
  - Zoppas Industries - Training

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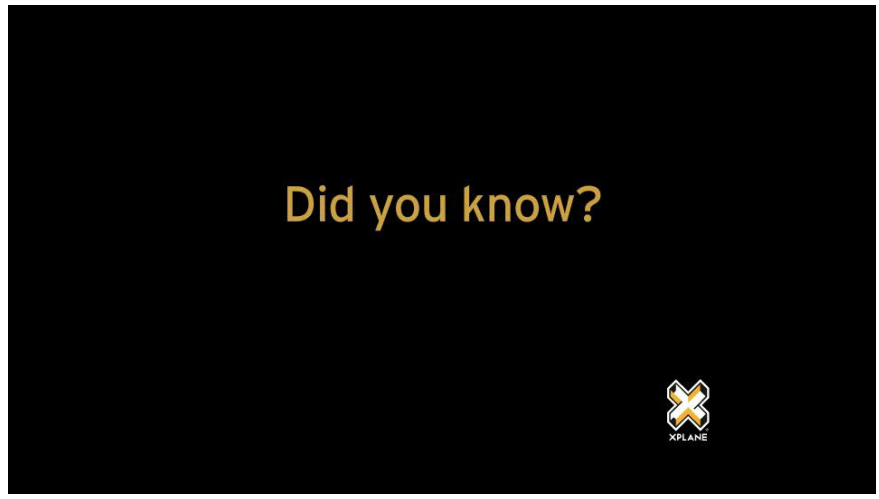
Program & Goal

- Goal:
  - (*TRIZ newcomers*) To understand what TRIZ and Systematic Innovation are. Get awareness of TRIZ tools and techniques. Appreciate strategic and operational applications of TRIZ.
  - (*TRIZ practitioners*) Share TRIZ experiences and approach.

- Program:
  - Background
  - TRIZ Origins
  - TRIZ Postulates and Key Concepts
  - TRIZ Applications
  - TRIZ in Industry
  - Warnings & Suggestions

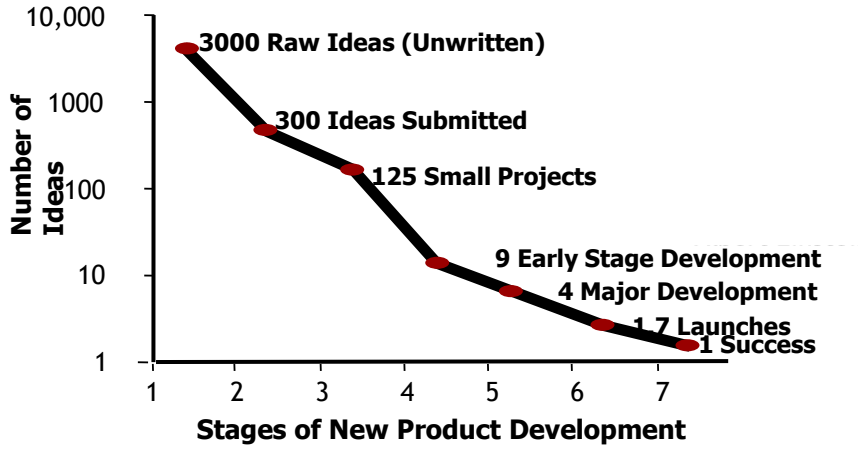
Background

- Shift Happens!!
  - licensed by Karl Fisch, Scott McLeod, and XPLANE under a Creative Commons Attribution Non-Commercial Share-Alike license



Background

- From raw ideas to success products



Source: G. Stevens and J. Burley, "3000 Raw Ideas = 1 Commercial Success!" *Research•Technology Management,* 40(3): 16-27, May-June, 1997.

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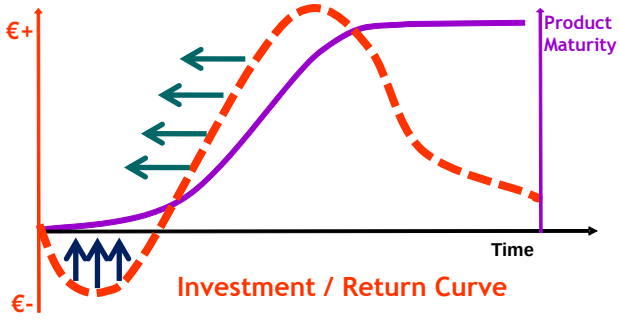
Problem Solving: Main Goals & Obstacles

- Goal: Improve the efficiency of Innovation Processes
  - Reduce or eliminate waste of resources (time, money…) for useless trials and errors
  - Develop one valuable solution is much better than many ideas to be validated
  - Manage complexity of modern systems



Investment / Return Curve

- Obstacles:
  - Psychological Inertia
  - Trial & Error: lack of a structured approach
  - Design conflicts

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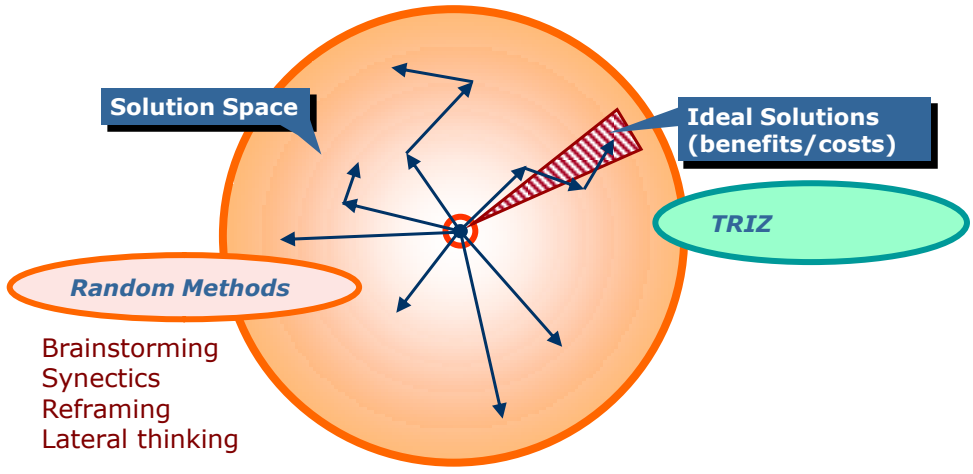
Psychological Inertia ➔ Trial & Error

"You've got to kiss a lot of frogs before you find your princess..."

"It is difficult to find a black cat in a dark room especially when the cat is not there."



Brainstorming
Synectics
Reframing
Lateral thinking
…

Lack of a structured approach: not everywhere

Primary school

Problem: How to distribute 50 cherries between 3 kids?

Should your kids solve the problem by "intuition" and/or by "experience"??!!

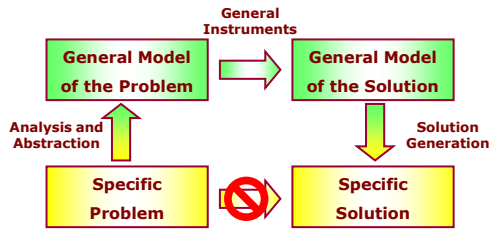
Lack of a structured approach: not everywhere

Type of Problem: arithmetic

Model of the problem: 50:3

Tool: division

Model of the solution: 16,666…



Solution: distribute 16 cherries to each kid

Lack of a structured approach: not everywhere

High School:

What does it happen by mixing Sulfuric Acid with Calcium Hydroxide ?

What would you suggest?
Let's try and see?!?

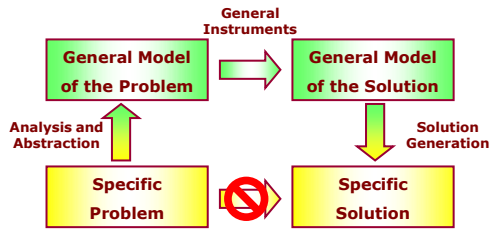
Lack of a structured approach: not everywhere

Type of problem: chemical

Model of the problem: $H_2SO_4 + Ca(OH)_2$

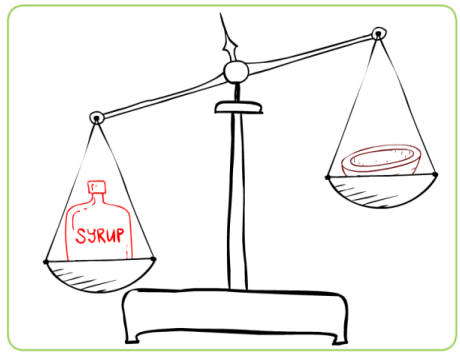
Tool: laws of chemistry, oxide-reduction

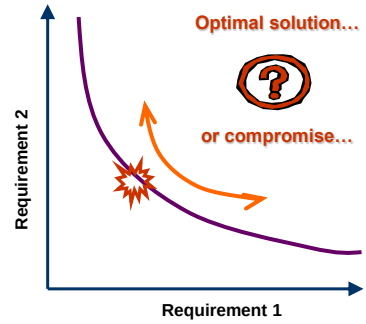
Model of the solution: $CaSO_4 + 2\ H_2O$



Solution:
Calcium Sulfate + Water

Design Conflicts





POLITECNICO DI MILANO

TRIZ
Theory of Inventive Problem Solving

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Теория Решения Изобретательских Задач
Theory of Inventive Problem Solving

Genrich Altshuller
(1926-1998)

Analysis of hundreds of thousands inventive solutions

- 99% of inventions use already known solution principle
- Less than 1% are really pioneering inventions
- Breakthrough solutions emerge from resolving contradictions
- Inventors and strong thinkers use patterns
- Creative problem solving patterns are universal
- Creative ideas can be produced in a systematic way

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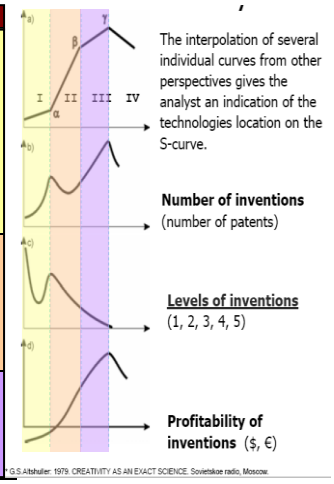
Теория Решения Изобретательских Задач
Theory of Inventive Problem Solving

- The architecture of TRIZ is based on:
  - Three Postulates:
    - Postulate of Objective Laws of Systems Evolution
    - Postulate of Contradiction
    - Postulate of Specific Situation
  - Main models:
    - Models of the problem solving process
      - *Hill model (abstraction-embodiment)*
      - *Tongs model (from current situation to ideality, barriers identification)*
      - *Funnel model*
    - Description of systems, problems, solutions
      - *ENV model*
      - *Model of function*
      - *Substance-Field Model*
      - *Model of contradiction*
    - "System operator" (multi-screen approach)
      - *Round about problems*
      - *Resources search*
  - Instruments:
    - ARIZ (Algorithm of Inventive Problem Solving), main instrument of Classical TRIZ for Non-Typical Problems, which integrate all others TRIZ instruments
    - System of Inventive Standard Solutions
    - Pointers to Physical, Chemical, Geometrical Effects

Postulate 1

Laws of Engineering Systems Evolution

Laws of Technical System Evolution		
1	Law of System Completeness Corollary: Controllability Trend of elimination of human involvement from systems Trend of increasing dynamicity	Static
2	Law of "energy conductivity" of a system	Static
3	Law of harmonizing the rhythms of parts of the system	Static
4	Law of increasing ideality	Kinematics
5	Law of uneven development of the parts of a system	Kinematics
6	Law of transition to a super-system Trend Mono-Bi-Poly	Kinematics
7	Law of Transition from macro to micro level	Dynamics
8	Law of increasing Su-Field inyteractions	Dynamics

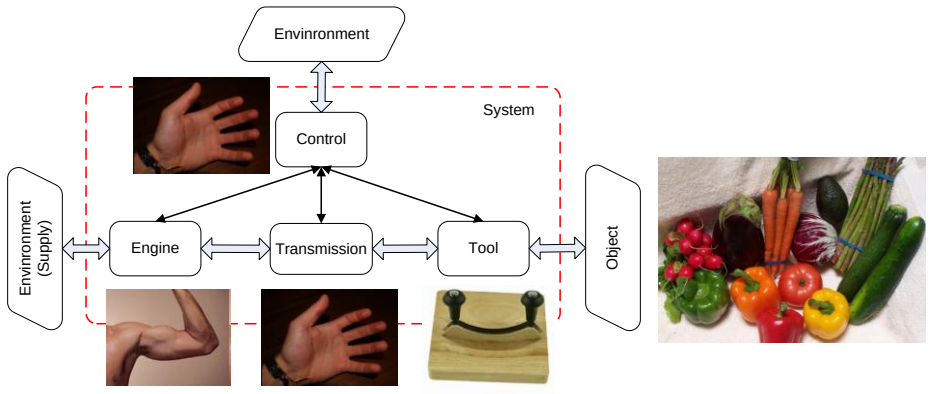


- Conclusions for practice:
  - Good solutions are developed in accordance with the objective laws of system evolution

Postulate 1

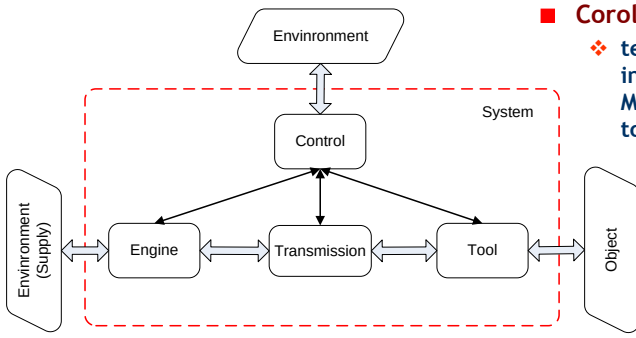
1. Law of System Completeness

In order to deliver its function, a Technical System must include, internally or externally (e.g., through the contribution of a human operator), four elements:
- a Tool, which is the working element delivering the function of the TS, i.e., exerting a certain effect on its object;
- an Engine, i.e., the element providing the energy necessary to produce the expected effect of the function;
- a Transmission, i.e., the element transmitting energy from the Engine to the Tool;
- a Control, i.e., an element governing at least one of the previous elements.



Postulate 1

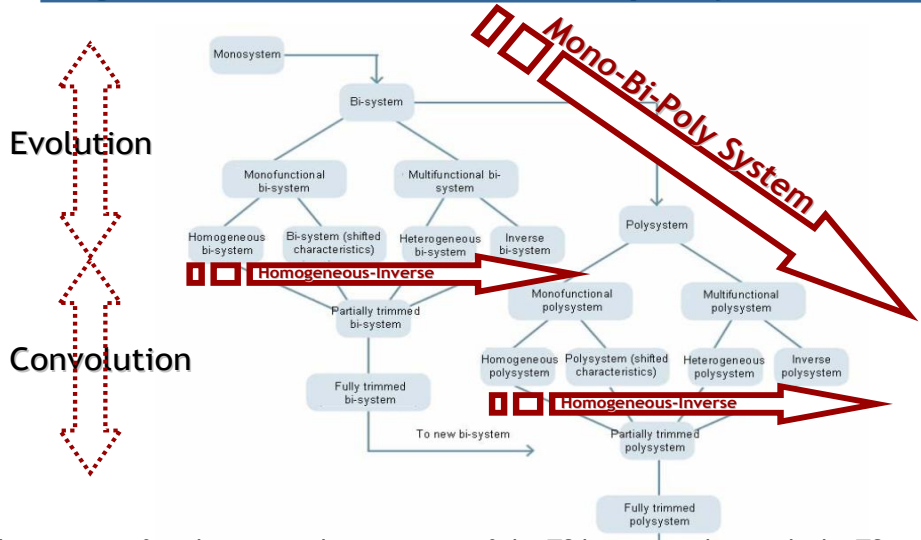
1. Law of System Completeness (corollary)



- **Corollary:**
  - technical systems evolve by integrating all the elements of the Minimal Technical System in order to reduce human involvement

Postulate 1

E.g. Law #6: Transition to Supersystem

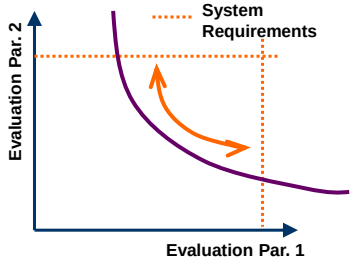


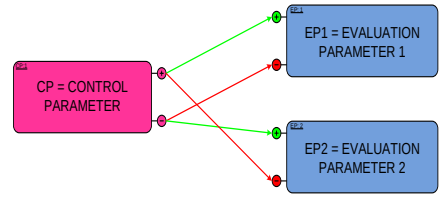
- In the process of evolution, as the resources of the TS become exhausted, the TS merges with other systems and continues its development as a part of supersystem.

Postulate 2

Contradictions

- System evolution implies the resolution of contradictions, i.e. **conflicts** between a system and its environment or between the components of the system itself





- Conclusions for practice:
  - To solve a problem we should first discover underlying contradictions
  - To achieve maximum benefits, contradictions should be resolved, not compromised
  - Overcoming contradictions is a driving force behind technology evolution. Resolving contradictions instead of compromising or optimizing, results in breakthrough solutions

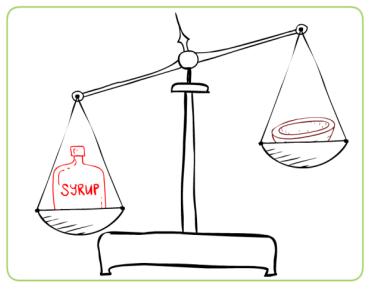
Postulate 2

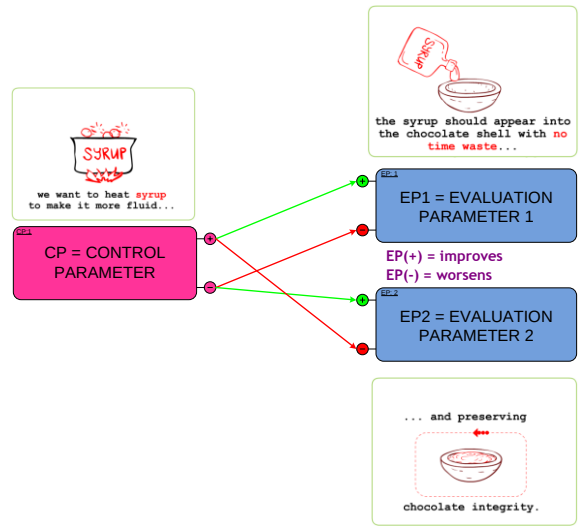
Contradictions

Contradictions

"Technical" Contd:
TC1: EP1(+) - EP2(-)
TC2: EP2(+) - EP1(-)

"Physical" Contd:
CP = V ➔ EP1(+) - EP2(-)
CP = anti-V ➔ EP1(+) - EP2(-)





Postulate 2

Contradictions

Problems from different domains, sharing the same contradiction, can be solved by means of the same solving principles

Contradictions

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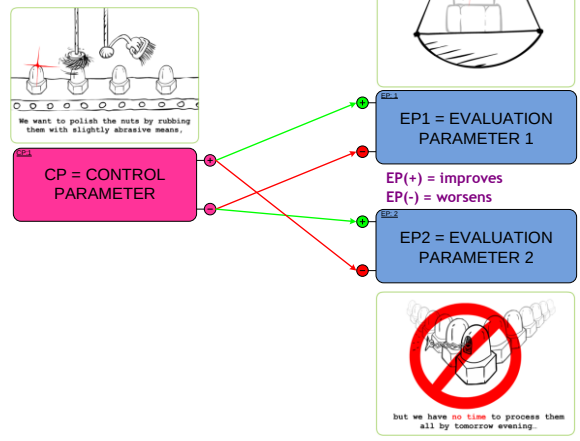


Postulate 3

Specific situation - Resources

- Each stage of evolution of a system takes place in a specific environment (context, situation) which influences the evolution (transformation) of the system and provide specific resources

Energy Resources:
- Energy in the system
- Energy from the supersystem
- Potential energy
- Dissipated energy

Spatial Resources:
- Empty space, encapsulating
- Other dimensions
- Shape
- Size (1D, 2D, 3D)

Information Resources:
- Inherent properties
- Mobile information
- Temporary information
- Redundant information

Time Resources:
- Parallel working
- Preliminary action/counteraction
- Reworking
- Frequency of action

Material Resources:
- Waste flow
- Cheap materials
- Substance characteristics
- Void

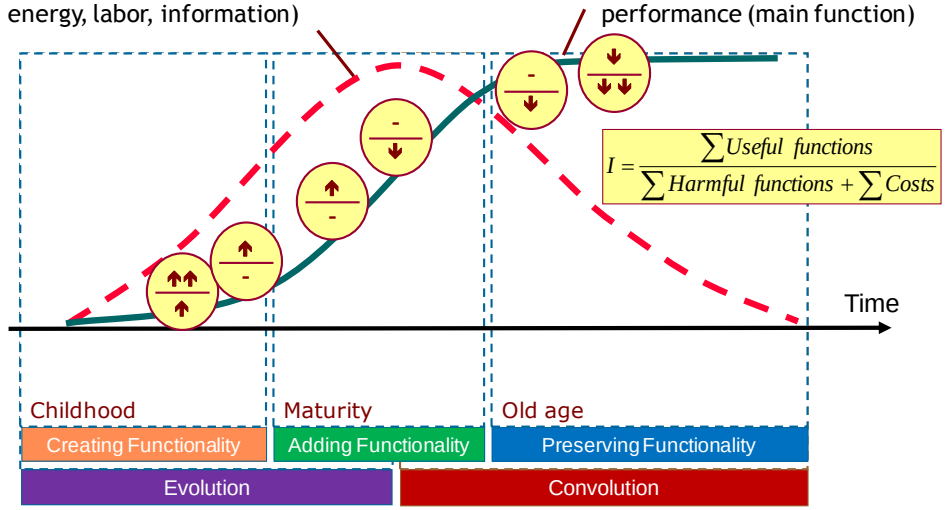
- Conclusions for practice:
  - Good solutions must (first of all) take into account the resources available in the specific situation

Postulate 3

Trend of Ideality increase and consumption of resources

Wave of Evolution: Expenses to create value and deliver functionality (material, energy, labor, information)

S-Curve of Evolution: Degree of the system's performance (main function)



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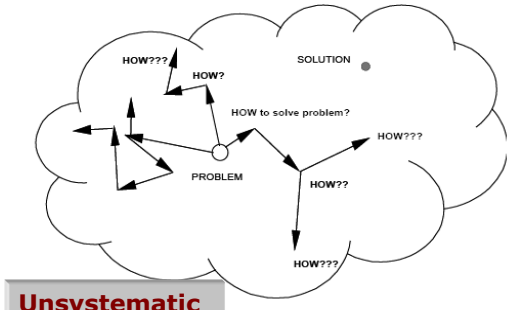
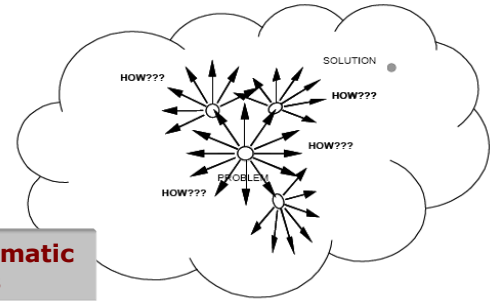
Conventional "Conceptual" Problems solving approaches



Unsystematic Trials



Systematic Trials

Source: http://www.triz-journal.com/archives/2002/12/d/04.pdf

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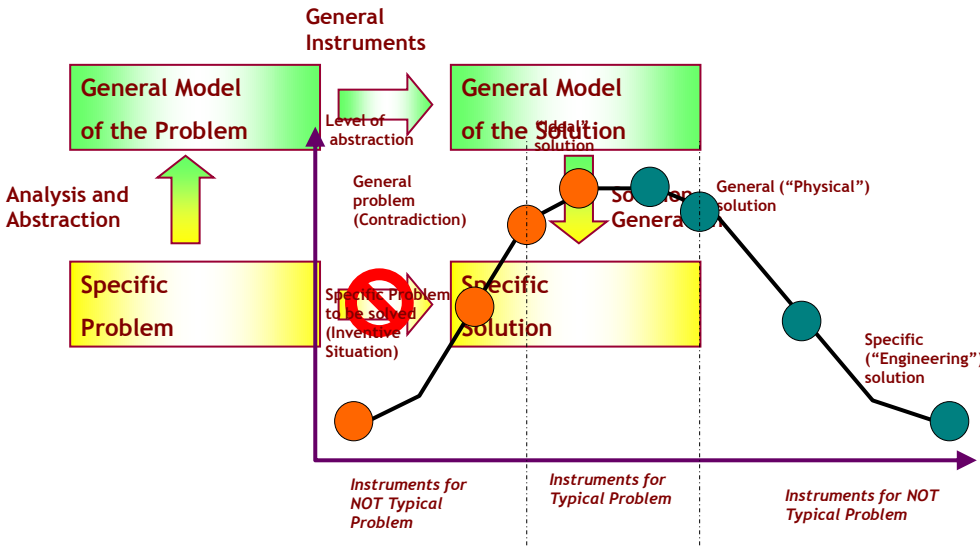
OTSM-TRIZ "Hill" model of problem solving process



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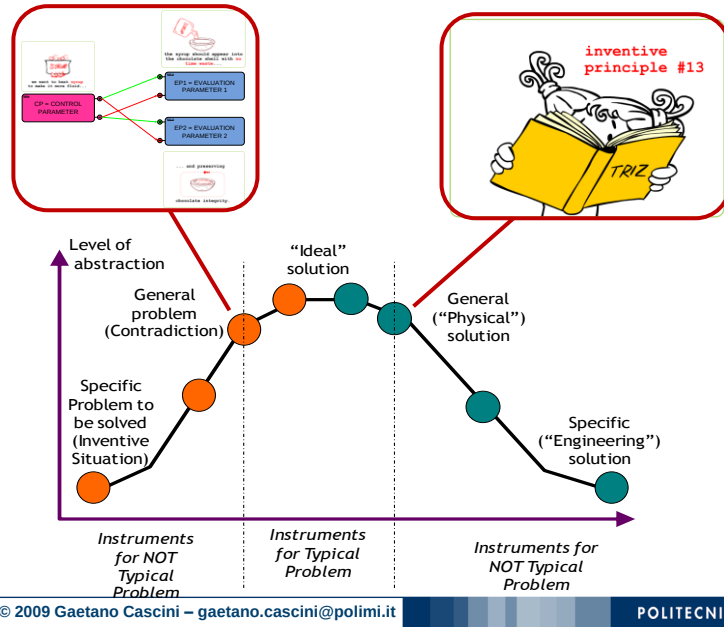
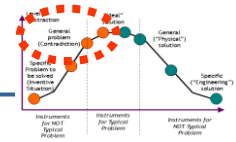
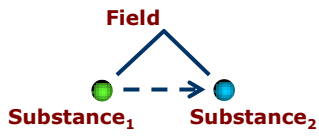


Models of problem

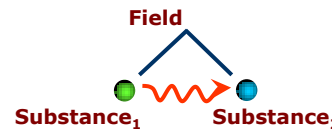


Su-Fields

Missing-Insufficient Useful Interactions



Harmful Interactions



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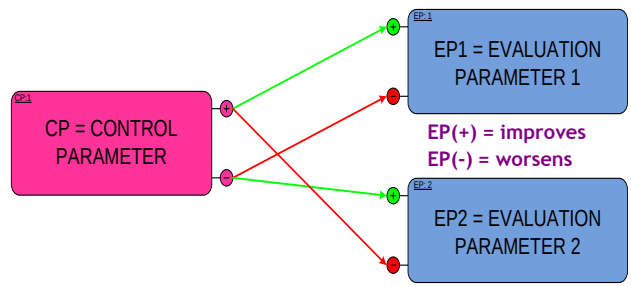

tetris "Creativity is not a born gift. Every engineer can learn to be inventive."

http://www.tetris-project.org/

- 5 Animations
  - TRIZ History
  - Nina @ school/university/work
  - Theory of Inventive Problem Solving
- Handbook
  1. Introduction(s)
  2. Laws of Engineering Systems Evolution
  3. Algorithm of Inventive Problem Solving
  4. Su-Field Analysis and System of Inventive Standards
  5. Tools and Principles for solving contradictions
  - Appendix (Step-by-step solved problems)

Education and Culture DG
Lifelong Learning Programme

Freely accessible educational materials in English, French, German, Italian, Latvian

Structure

- Definition: short definition of the selected topic (T);
- Theory: theoretical aspects related to T;
- Model: conceptual model and graphical representation of T;
- Method/Tool: operative instructions about how to use/implement T;
- Example: exemplary application of T;
- Self-Assessment: exercises to assess the reader's level of understanding about T;
- References: further readings about T.

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TRIZ Applications

alintec Innovazione Sistematica

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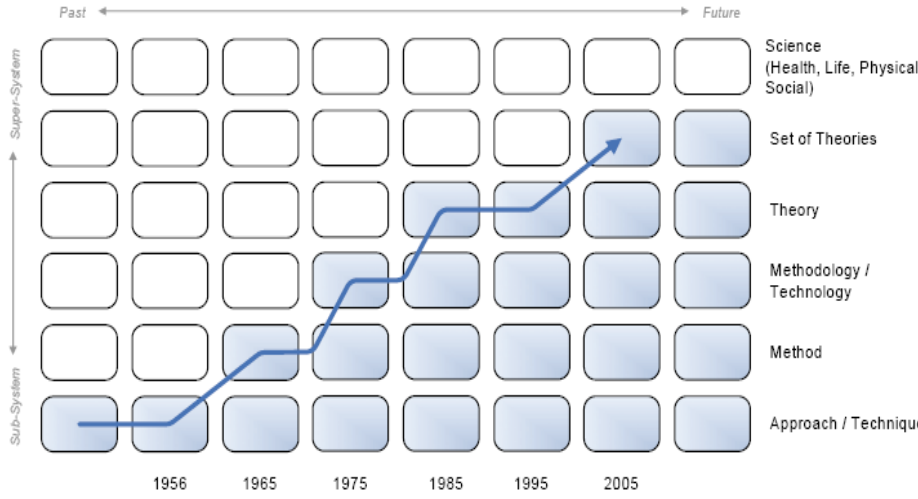
Short history of TRIZ Instruments



Source: Nikolai Khomenko

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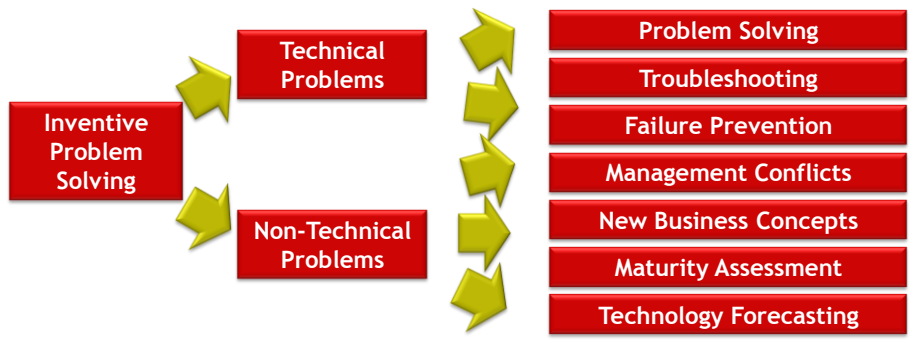
TRIZ Applications



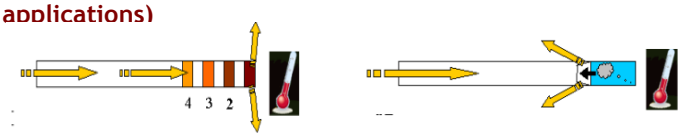
TRIZ Applications

- Fields
  - Product development
  - Industrial research
  - Scientific research
  - Industrial strategy
  - Non technical applications…
- Target:
  - Products
  - Processes
- Where:
  - Big companies
  - Small and Medium Enterprises
  - University

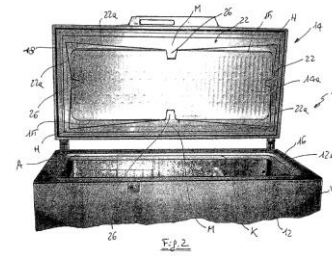
World Wide status of TRIZ perceptions and uses (www.etria.net)

Exemplary case studies: innovation & problem solving

- **Bracco Imaging:**
  Method and device for localized thermal ablation of biological tissue, particularly tumoral tissues or the like (3 EP applications)



- **Whirlpool:**
  Low frost chest freezer (1 EP patent)



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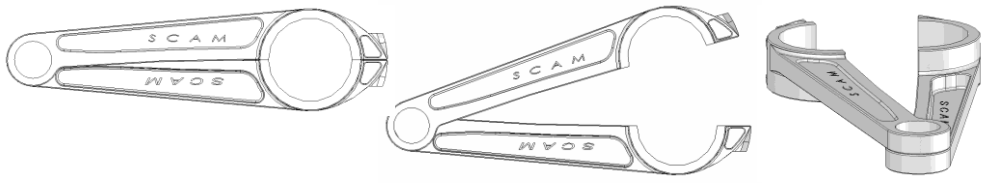
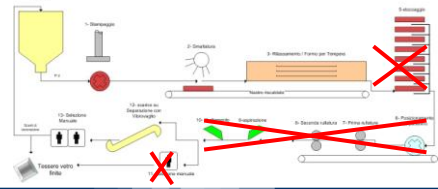
Exemplary case studies: problem solving for SMEs

- **Scam:**
  High performance connecting rod (1 IT patent)



- **CIVE – Vetrerie Toscane:**
  Glass mosaic production (process innovation)



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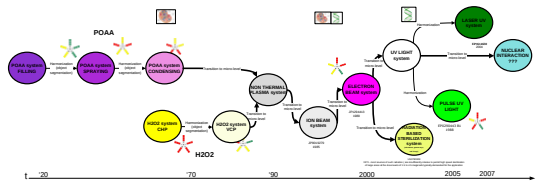
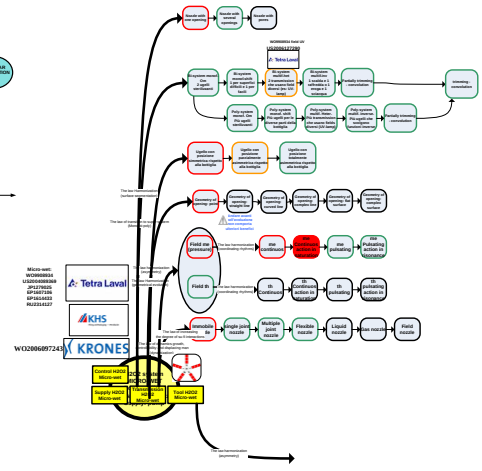
Exemplary case studies: technology forecasting

- **Procomac:**
  Sterilization technologies for aseptic filling





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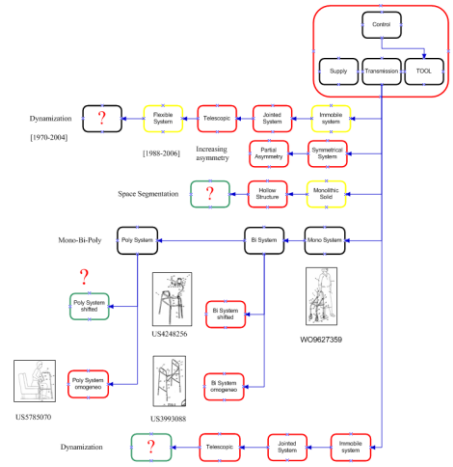
Exemplary case studies: technology forecasting

- Meccaniche Fiorentine: walkers



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Warnings and Suggestions

- "Simplified TRIZ" is probably better than nothing, but very far from ideal!!
  - Using the Inventive Principles as "Stimuli" for brainstorming sessions has nothing to deal with TRIZ
  - Problem formulation requires repeatable models and procedures
- Even if TRIZ learning is a long process, avoid using wrong procedures and tools just because it's faster!!
  - Is it really worth to use the Contradiction Matrix?
  - Skipping a proper identification of the underlying contradictions can be faster, but it's certainly useless and dangerous!!
- Currently available "TRIZ software" tools don't substitute education
  - Can you avoid studying Romanian/Russian/Korean just having Word on your pc??
  - Why do we study Maths, since we have calculators?

TRIZ in Industry

Some companies using TRIZ (at least a preliminary experience with)

- Avon
- BMW
- Boeing
- Borden
- Case
- Caterpillar
- Clorox
- Cummin
- Daimler-Chrysler
- Datacard
- Delphi
- Dial
- DuPont
- Electrolux
- Edi Lilly
- Ford
- Fujitsu
- General Motors
- Heidelberg
- Hitachi
- Honeywell
- HP
- IBM
- Intel
- ITT
- Johnson & Johnson
- Kimberly-Clark
- Kodak
- LG
- Lockheed Martin
- McDonnel Douglas
- Motorola
- NASA
- NEC Electronics
- Pfizer
- Pilkington
- Procter & Gamble
- PSA Peugeot Glacio
- Raytheon
- Rockwell
- Rolls Royce
- Samsung
- Sanyo
- Sara lee
- Shell
- Siemens
- Gillette
- Toyota
- USPO
- Xerox

Source:
David Silverstein,
Neil DeCarlo,
Michael Slocum

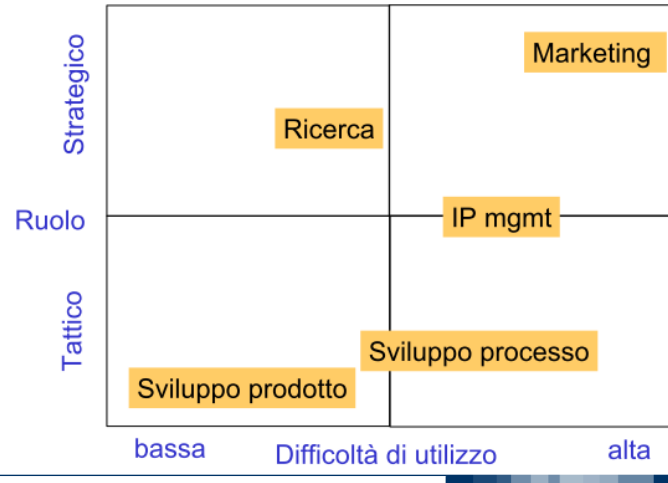
TRIZ in Industry

TRIZ in Whirlpool: breve storia

- 1997: viene acquistato il sw Invention Machine TechOptimizer™
- 2001: progetto *Technoledge*
  - coinvolte 6 persone (10%-20%) e un program leader full-time
  - attività di training e primi progetti pilota
- 2002-2005: consolidamento e diffusione. Applicazione in vari progetti in ambito R&D.
- 2004-2005: si comincia a diffondere nella corporation.

TRIZ in Industry

Chi può beneficiarne



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TRIZ in Industry

L'individuo

- TRIZ non *dà* soluzioni
  - conoscere le regole dell'armonia non basta per scrivere buona musica.
- TRIZ non è per tutti
  - E' fondamentalmente un "modo di pensare", non tutti sono disposti a cambiare il proprio modo di pensare
- L'Innovazione è basata sulla conoscenza
  - apertura mentale, curiosità, capacità analitiche sono essenziali che l'individuo esposto a TRIZ dovrebbe sempre avere

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TRIZ in Industry

Esempi organizzativi

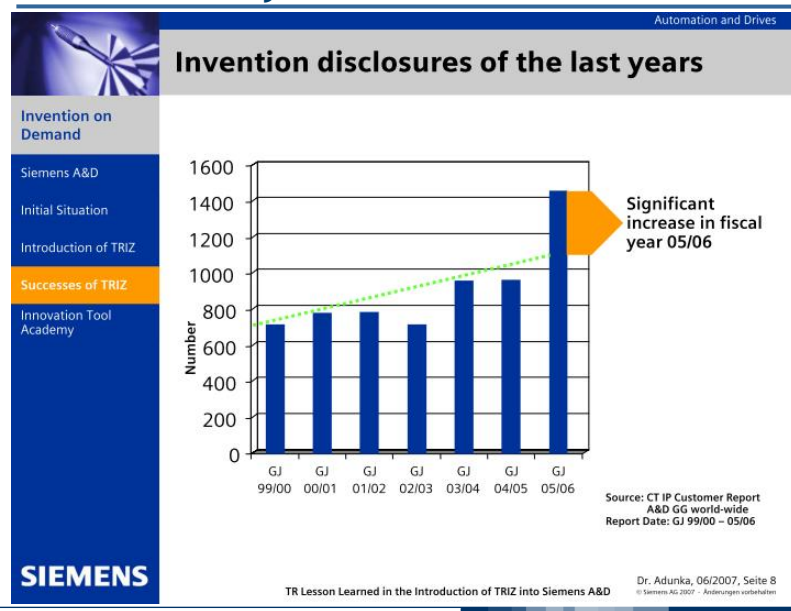
- Approccio Bottom-Up - Modello "Internal Consultancy"
  - task force di max 10 persone, altamente formate e autonome
  - PLUS: risorse concentrate, fortemente motivate
  - MINUS: difficoltà ad operare, reperire informazioni; sindrome NIH
- Approccio Top-Down - Modello "Mass Deployment"
  - esposizione massiccia
  - PLUS: molto veloce, pervasiva
  - MINUS: senza altri supporti è destinata a morire
- Approccio integrato - Modello "Virus"
  - Nuclei de-strutturati organizzati a rete
  - PLUS: molto stabile, efficace
  - MINUS: difficoltà nell'attecchire, tempi lunghi (le grandi aziende hanno anticorpi incredibilmente efficienti)

TRIZ in Industry

Esempio Whirlpool

- Strutturato in 4 livelli e 7 proposte formative
  - livello 0 : Awareness
  - livello 1 : Basic TRIZ + Basic software
  - livello 2 : Advanced TRIZ + Advanced software
  - livello 3 : Long Term Forecasting + Patent analysis and circumvenction

TRIZ in Industry



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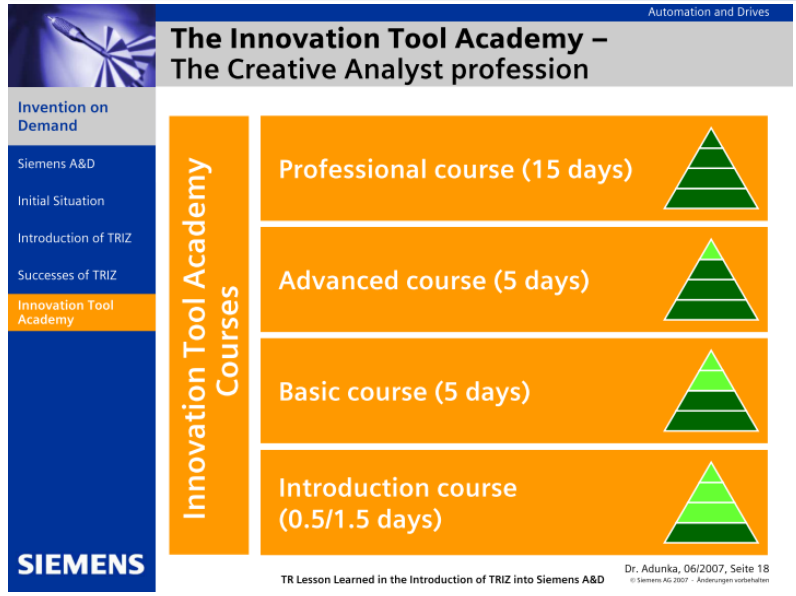
TRIZ in Industry



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TRIZ in Industry

TRIZ in Industry

Key Learning

- If it's a new program with no track record, start with small wins. Need to show that program adds tangible value
- Constant & regular 1/1 with key stake holders is essential
- Networking is essential. It has to start now, not later
- Trust comes with networking and interactions based on proven track record. Programs can move relatively quicker
- Understand factory/customer issues, gear towards needs
- Disciplined follow-up/through: key to ensure sustainability
- Risk taking is a norm as success is not guaranteed
- Persistence is necessary
- Passion is key

Networking, Persistence, Risk taking, Passion

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TRIZ Experiences in Industry: examples

TRIZ History at Samsung Electronics

- 1998~ 2000 : Early exploration stage
  - First Introduced to Samsung('98) → Study on TRIZ effectiveness
- 2001~ 2003 : Establishing TRIZ Foundation
  - Established TRIZ promoting department ('01, Russian TRIZ Experts)
  - Established STA & Samsung training program : Started to certify Level 2 ('03)
- 2004~ 2006 : Expanding the base
  - Developed TRIZ online Training program ('05, basic course)
  - Samsung TRIZ Conference('06~) : STA
- 2007~ 2009 : Accelerating TRIZ propagation
  - TRIZ trainees increased rapidly
  - Organized TRIZ community and TRIZ Forum
  - Introduced TRIZ to executive at R&D and manufacturing Field (2HR)

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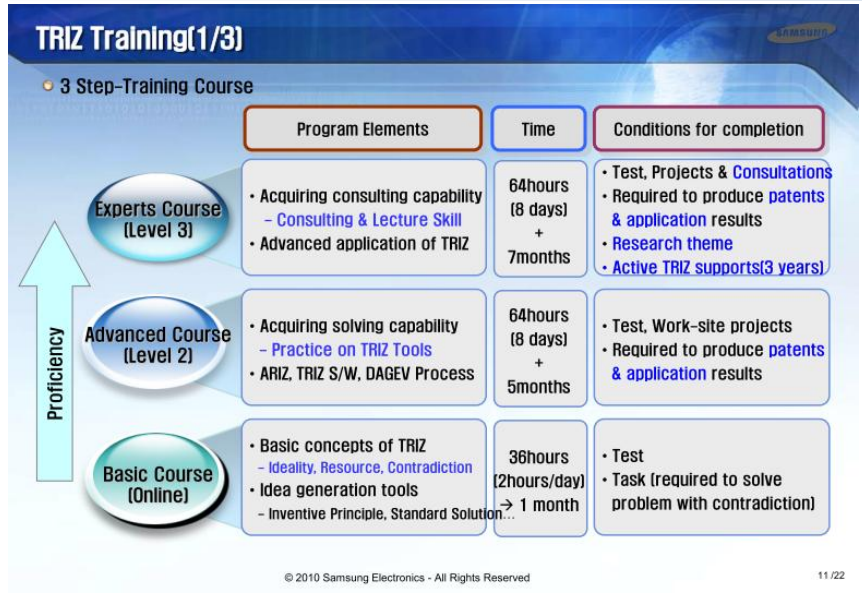
TRIZ Experiences in Industry: examples



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TRIZ Experiences in Industry: examples

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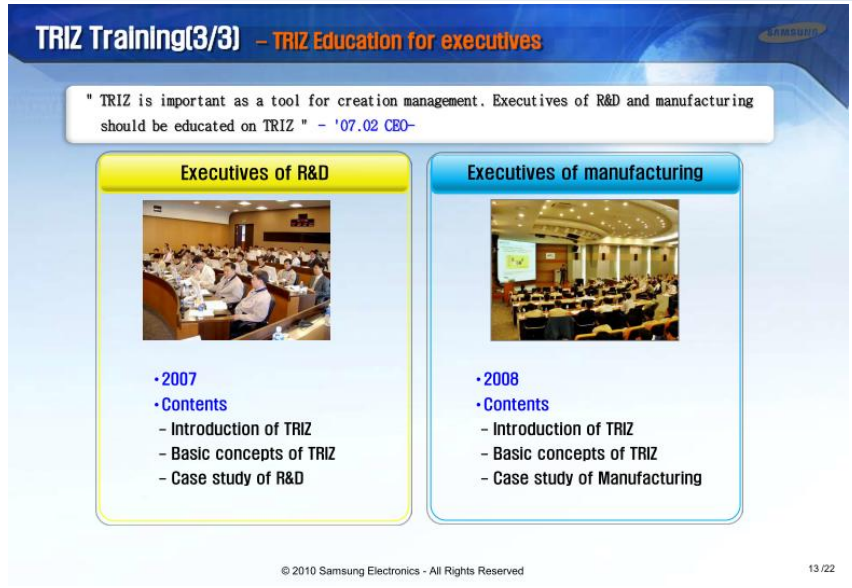
TRIZ Experiences in Industry: examples



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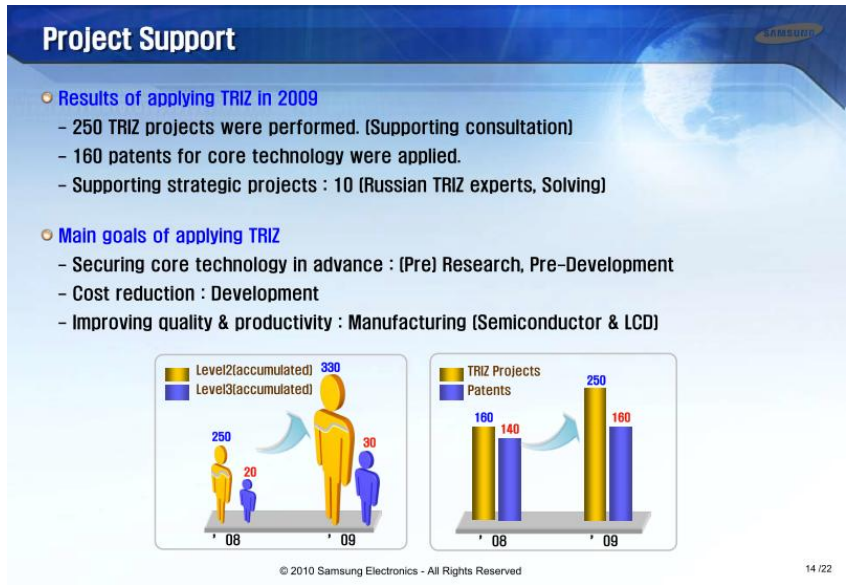
TRIZ Experiences in Industry: examples



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TRIZ Experiences in Industry: examples

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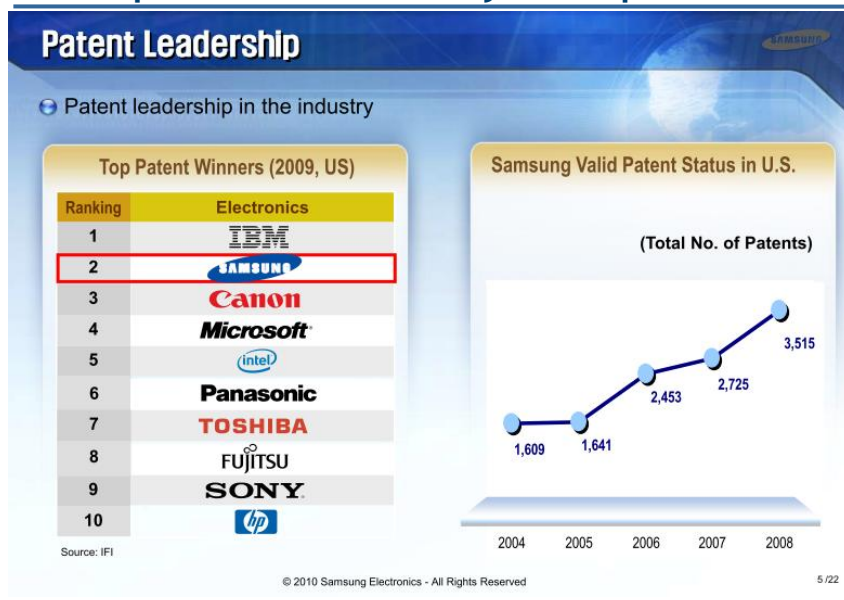
TRIZ Experiences in Industry: examples



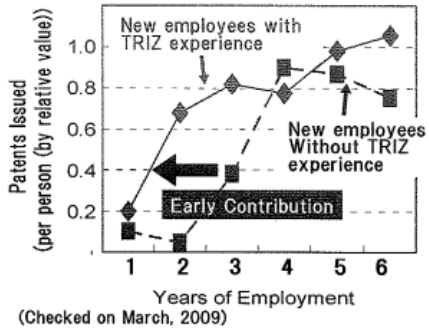
TRIZ Experiences in Industry: examples

PANASONIC

5. Effect on New Employees

Effect on New Employees

- We checked number of patents issued by New employees.
- New employees in the second and third year of employment have remarkable difference.



(Checked on March, 2009)

Vertical axis presents the relative value of the average of number of patents issued ever since one joined the company.

New employees with TRIZ experience
New employees who have joined in a TRIZ activity team and solved the problem as a member (the team consists of non-Fresh Person)

New employees without TRIZ experience
New employees who have no experience to solve a problem using TRIZ

Web Resources

Web Sites:

http:///www.innovazionesistematica.it (Centro di Competenza Interuniversitario)
http://www.tetris-project.org/ (TETRIS Project: TEaching TRIZ at School)
http://www.etria.net/ (European TRIZ Association)
http://www.computeraidedinnovation.net (IFIP WG5.4 Computer-Aided Innovation)
http://www.matriz.ru (International TRIZ Association)
http://www.aitriz.org/ (Altshuller Institute for TRIZ)
http://www.triz-journal.com/ (TRIZ journal)
http://www3.sympatico.ca/karasik/ (anti Triz-Journal)
http://www.triz.co.kr/TRIZ/intro.html
http://www.trizminsk.org/
http://www.thinking-approach.org
http://www.seecore.org/

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Thanks for your time!!

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