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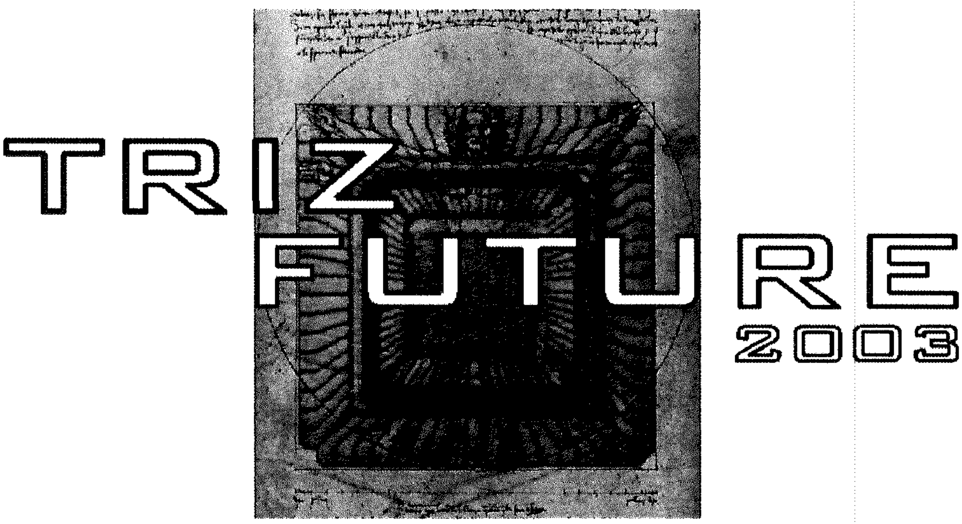
TRIZ FUTURE 2003

November 12-14, 2003



IPT

Fraunhofer Institut Produktionstechnologie

WZL an der RWTH AACHEN forum

Directory
Inhaltsverzeichnis

TRIZ Future 2003

Aachen, November 12-14, 2003

TRIZ for people: psychological aspects

Nelly Kozyreva,
Belarus-TRIZ, Belarus

23

TRIZ Future 2003

Worldwide Best Practices in Systematic Innovation
through Automotive Industry

2nd seminar day: *Thursday, 13th Nov. 2003* *08.30 - 16.15*

08.30 - 09.15	**Keynote speech: TRIZ – past, present and future** *Vladimir Petrov, Master of TRIZ, Israel*
09.15 - 09.45	**Innovation process as a key to the market success in the engine manufacturing business** *Thomas Novacek, MTU Aero Engines GmbH, Germany*
09.45 - 10.15	**About non technical barriers preventing from an efficient TRIZ integration into organisations** *Prof. Dr. Denis Cavallucci, LRPS / INSA, France*
10.15 - 10.45	***Coffee break***
10.45 - 11.15	**Observing opportunities of deployment through step-by-step involvement of actors** *Dominique Benoît, ArvinMeritor, France*
11.15 - 11.45	**Levels of TRIZ support for the innovation and problem solving projects in the automotive industry** *Dennis Murnikow, TriSolver oHG, Germany*
11.45 – 13.00	***Lunch break***
13.00 - 13.30	**TRIZ Case study at Volkswagen of Mexico** *Dr. Edgardo Córdova López, Benemérita Universidad Autónoma de Puebla / Volkswagen of Mexico, Mexico*
13.30 - 14.00	**The integration of QFD, TRIZ, and Six Sigma in an Axiomatically Driven Total Product / Process development System** *Dr. Michael Slocum, Breakthrough Management Group, USA*
14.00 - 14.30	**Innovative Process Chain Optimization – Untilizing the tools of TRIZ and TOC for Manufacturing** *Martin Tillmann, Fraunhofer IPT, Germany*
14.30 - 15.00	***Coffee break***
15.00 - 15.30	**Constraint-Dominated Breakthrough Innovation in a Manufacturing Process Situation** *Ian Mitchell, ILFORD Imaging, England / Darrell Mann, Creax, Belgium*

15.30 - 16.00 **Solving technical problems in manufacturing processes by using embedded-TRIZ**
Prof. Dr. Jan. C. Aurich / Karsten Jenke, FBK der Universität Kaiserslautern, Germany

16.00 **Poster Session**

TRIZ Future 2003

Worldwide Best Practices in Systematic Innovation through Automotive Industry

3rd seminar day: *Friday, 14th Nov. 2003* *08.30 - 15.30*

08.30 - 09.00	**Applying the TRIZ Principles of Technological Evolution to Customer Requirement Based Vehicle Concepts – An experience report** *Dr. Eckhard Schüler-Hainsch, DaimlerChrysler AG, Germany*
09.00 - 09.30	**Utilising patent prior art descriptions and the cited harmful function (CHF) concept as a means to ascertain TRIZ S-curve status and pinpoint future evolutionary innovation directions** *Barry Winkless, University College Cork, Ireland*
09.30 - 10.00	**Observing the Development Trends of Glass Moulds using the Laws of Technogical Systems Evolution** *Pavel Jirman, The Technical University of Liberec, Czech Republic*
10.00 - 10.30	***Coffee break***
10.30 - 11.00	**TRIZ experience at Hutchison** *Nicolas Gombert, Hutchinson, France*
11.00 - 11.30	**TRIZ based patent analyses for lighting electronics** *Siegfried Luger, Luger Research, Austria*
11.30 - 12.00	**TRIZ-based Technology Intelligence** *Markus Grawatsch, Fraunhofer IPT, Germany*
12.00 – 12.30	***Coffee break***
12.30 - 13.00	**Peculiarities of structural and functional analysis of forecasted engineering systems** *PhD Peter Chuksin, LG Electronics, South Korea*
13.00 - 14.15	***Lunch break***
14.15 - 14.45	**Using TRIZ to Create Innovative Business Models and Products** *Atsuko Ishida, Hitachi, Japan*
14.45 - 15.15	**TRIZ for people: psychological aspects** *Nelly Kozyreva, Belarus-TRIZ, Belarus*
15.15	**Discussion**

Index of speakers and participants
Teilnehmer- und Referentenverzeichnis

TRIZ FUTURE 2003

Worldwide Best Practices in Systematic Innovation
through Automotive Industry

November, 12-14 2003, Aachen

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Brief Résumé & job descriptions:

Vladimir Petrov, Master of TRIZ, member of the Executive Board of the International TRIZ Association (MATRIZ) Russia, scientific consultant of the European TRIZ Association (ETRIA), president of the TRIZ Association of Israel (ATI).

More then 30 years of experience in TRIZ science, education and problem solving. He was one of the first followers and colleagues of Genrich Altshuller, the founder of TRIZ.

V. Petrov organized the TRIZ scientific schools in USSR, Czech Republic, Bulgaria, Vietnam and Israel and educated more then 6000 students worldwide. He is an author of 47 patents and more than 150 publications, conference papers and books.

TRIZ - past, present and future

Vladimir Petrov

Executive Summary: The Structure and Functions of TRIZ

1. Functions of TRIZ

The Theory of Inventive Problem Solving (TRIZ) was developed by the soviet researcher Genrich Altshuller [1-4, 6-7, 9-12, 18, 21], whose first publication about TRIZ appeared in 1956 [1]. The essence of TRIZ is the discovery and use of laws, regularities and tendencies for the development of technological systems.

The specific functions of TRIZ are as follows:

1. Solution of creative and inventive problems of any degree of difficulty and directivity without the exhaustive trial-and-error search for variants.
2. Solution of scientific and research problems.
3. Uncovering of problems and tasks during work with technical systems and during their development.
4. Uncovering and elimination of the reasons for failures and emergency situations.
5. Maximally effective use of natural resources and technology for the solution of most problems.
6. Forecasting the development of technological systems (TS) and obtaining perspective solutions (including ones that are fundamentally new).
7. Objective evaluation of solutions.
8. Systematization of knowledge from any field, significantly increasing the effective use of this knowledge and allowing the development of the pure sciences on a fundamentally new basis.
9. Development of a creative imagination and thinking skills.
10. Development of the qualities of a creative personality.
11. Development of creative communities.

2. Structure of TRIZ

The Theory of Inventive Problem Solving (see fig. 1.1 and table 1) includes:

1. Laws of Technological System Evolution (TS).
2. Knowledge base.
3. Su-field analysis (structural substance-field analysis) of technological systems.
4. Algorithm for Inventive Problem Solving (ARIZ).
5. Techniques for the development of a creative imagination.

The knowledge base consists of:

- a system of standards for the solution of inventive problems (standard solutions for a specific class of problems);
- engineering effects (*physical, chemical, biological, mathematical*, and particularly *geometric*, the most developed of these effects at the present day) and tables for their application;
- techniques for the elimination of contradictions and tables for their application;
- resources of nature or technology and methods for their use.

The Algorithm for Inventive Problem Solving ARIZ consists of a program (sequence of actions) for the exposure and solution of contradictions, i.e. the solution of problems. ARIZ includes: the program itself, information safeguards supplied by the knowledge base (shown by an arrow in fig.1.1), and methods for the control of psychological factors, which are a component part of the methods for developing a creative imagination. Furthermore, sections of ARIZ are predetermined for the selection of problems and the evaluation of the received solution. A modification of the algorithm, ARIZ-85-C [11, 18, 19].

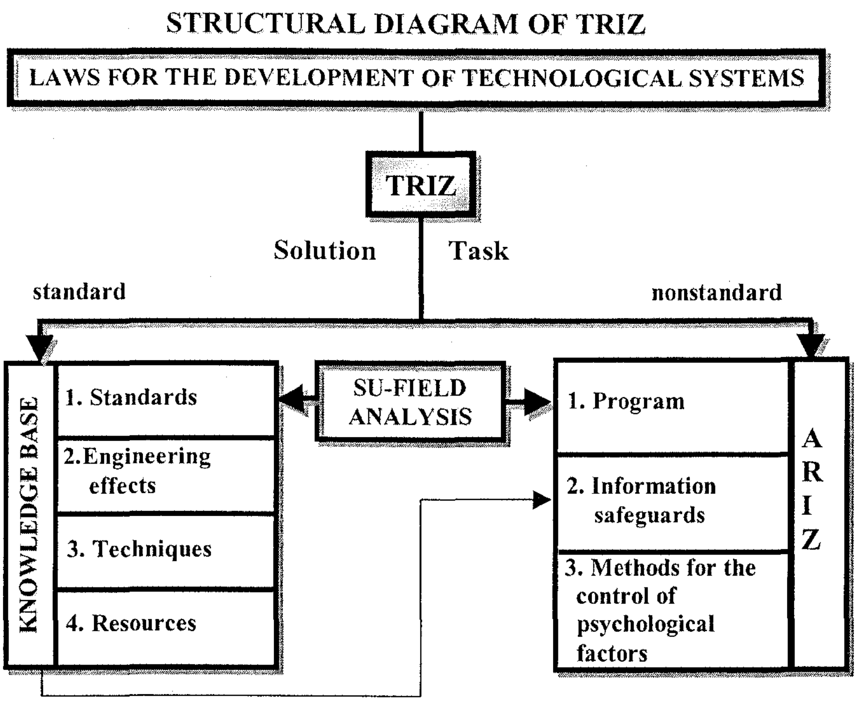

Fig. 1.1.

Su-field analysis (structural substance-field analysis) produces a structural model of the initial technological system, exposes its characteristics, and with the help of special laws, transforms the model of the problem. Through this transformation the structure of the solution that eliminates the shortcomings of the initial problem is revealed [6, 7]. Su-field analysis is a special language of formulas with which it is possible to easily describe any technological system in terms of a specific (structural) model. A model produced in this manner is transformed according to special laws and regularities, thereby revealing the structural solution of the problem.

Classification of a system of standard solutions for inventive problems, as well as the standards themselves, is built on the basis of *su-field analysis* of technological systems. Su-field analysis is also a component part of the program ARIZ (shown by arrows in fig.1.1).
A method for revealing and predicting emergency situations and undesirable occurrences was developed by B. L. Zlotin and A. V. Zusman and named the "subversive" approach [28, 57]. It is based on the use of TRIZ, functional, systematic and morphological analyses, and specially developed lists of control questions. With the help of this methodology, emergency situations and undesirable occurrences are “invented” for the given system, and the probability of their appearance is calculated. Analysis of the existing situation and tendencies in its development takes place, and contradictions that arise during the solution of the problem are formulated and solved. Furthermore, the method searches for and analyzes ways to avert emergency situations and undesired occurrences.

Methods for the development of a creative imagination [5, 11, 27] decrease psychological inertia during the solution of creative problems.

Theories for the development of a creative personality and creative communities have been developed.

The theory for developing a creative personality describes traits of a creative personality and provides a life strategy for the development of these traits. The theory for developing creative communities reveals and uses laws for the development of creative communities.

The use of different elements of TRIZ for specific functions are shown in Table 1: "Functions and Structure of TRIZ." A system of laws for the development of technology, a system of standards for the solution of inventive problems, and su-field analysis are used to forecast the development of technology, to search for and select problems, and to evaluate the received solution. For the development of a creative imagination, all elements of TRIZ can be used, although particular stress is given to methods for developing a creative imagination.

The solution of inventive problems is realized with the help of laws for the development of technological systems, the knowledge base, su-field analysis, ARIZ, and, in part, with the help of *methods for the development of a creative imagination*.

By means of TRIZ, known and unknown types of problems can be solved. Under known (standard) types of problems are understood problems with a known type of contradiction, and unknown (nonstandard) types – problems with an unknown type of contradiction.

Known (standard) types of inventive problems are solved with the use of the knowledge base, and unknown (non-standard) – with the use of ARIZ. As experience grows, solutions for a class of know types of problems increase and exhibit a structure.

At the present time, computer programs have been developed on the basis of TRIZ that provide intellectual assistance to engineers and inventors during the solution of technological problems. These programs also reveal and forecast emergency situations and undesirable occurrences.

Table 1. STRUCTURE AND FUNCTIONS OF TRIZ

Functions		Structure												
		Laws of TS Evolution	ARIZ	Su-field analysis	KNOWLEDGE BASE							METHODS FOR CREATIVE DEVELOPMENT		
					Standards	Engineering Effects				Principles	Resources	Imagination	Personality	C[illegible]nunity
						Phys.	Chem.	Bio.	Math.					
1	Forecasting of TS	1	-	2	2	-	-	-	-	-	-	-	-	-
2	Search for problems	1	-	2	1	3	3	3	3	4	3	4	-	-
3	Selection of problems	2	1	-	2	-	-	-	-	-	-	-	-	-
4	Solution of problems	2	1	2	1	2	2	2	2	2	2	3	-	-
5	Evaluation of solutions	1	2	2	1	-	-	-	-	-	-	-	-	-
6	Development of a creative imagination	2	-	-	-	-	-	-	-	3	2	1	-	-
7	Development of a creative personality	-	-	-	-	-	-	-	-	-	-	-	1	-
8	Development of a creative community	-	-	-	-	-	-	-	-	-	-	-	-	1

Note: In the table numbers represent the priority of the application, which approximately corresponds to the degree of importance of the element for the given function. The symbol "-" signifies that the given element is not used for this function.

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Vladimir Petrov

TRIZ – past, present and future

Genrich Altshuller

15 October 1926 – 24 September 1998

The beginning of work

- 1946 – statement and the analysis of a problem

  G.Altshuller and R.Shapiro

- 1948 - the concept and 1st inventive method

  4000 descriptions of inventions

- 1950 - 1954 – prison

Directions of development

- Development of the theory
- Development of education method
- Training of teachers
- Creation of scientific school
- Development of the TRIZ movement

The beginning of work

- 1956 – 1st article about invention method .
  - The general concept and the first invention method
  - 2 articles in magazines "Knowledge - Power" and "The Inventor and the Rationalizer" 5 articles and brochures in local editions
- 1957 - Seminars
- 1958 – Articles, Seminars
- 1959 – 2-nd article about the invention method
  - Step-by-Step approach for problem solving, 3 stages:
    - Analytical, Operative and Synthetic
  - Definition of "The Ideal Machine",
  - The first Laws of Development of Technical Systems.
- 1960 - Article "How discoveries are made"

 5

The beginning of development

- 1961 - The first book on TRIZ "How to learn to invent"
  - Science fiction "Legends about star captains"
  - Over 30 seminars are carried out
- 1964 - books of "The Basics of invention", "Algebra of harmony"
- 1965 - Attention: the Invention Algorithm!

  5000 Inventions

 6

Theoretical fundamentals - 1965

- "The Ideal Machine " and ways to achieve it.
- Some laws of technical development
- The forecasting opportunity of the future machines is described.
- The step-by-step algorithm for the Inventive Problem Solving (ARIZ) - 4 stages are formulated: (only 18 steps).
  - Choice of a problem - 5 steps,
  - The analysis of a problem - 4 steps,
  - Operative stage - 5 steps
  - Synthetic stage - 4 steps
- 31 technical principles for problem solving are formulated.
- The matrix 16x16.
- The seminar program with 10 lessons.

Mass introduction

- 1968 - Steps to mass introduction
  - Seminar in Dzintara - The Central Board of the All-Union Society of Inventors and Rationalizers (CB AuSIR)
  - Section of Methodical Council of CB AuSIR
- 1969 - the book "The Invention Algorithm"
- 1970 - Republican School and Public laboratory for invention methods - Baku
- 1971
  - The Invention Algorithm ARIZ-71, 40 principles, Matrix 36x36.
  - The Public Institute of Inventive Creativity (PIIC or its Russian acronym is AzOIIT)
- 1973
  - "The Invention Algorithm"-2-nd edition
  - The first variant of the Su-Field analysis
  - The first index of the physical effects
  - 1-st conference of teachers in Dnepropetrovsk with certification of teachers CB AUSIR
- 1974
  - TRIZ lessons in the Newsletter for pupils "The Pioneer Pravda"
  - 2-nd conference of teachers in Gorky with certification of teachers CB AUSIR
  - "Heuristics" - persecution on TRIZ
  - TRIZ Schools: Baku, Dubna, Dnepropetrovsk, Gorky, Kaunas, Leningrad, Petrozavodsk, Sverdlovsk, Chelyabinsk

1975-1977

- 1975
  - ARIZ-75 –The Physical Contradiction
  - Standards 1-5
- 1976
  - Standards 6-9
  - Courses of TRIZ in Institute of improvement of professional skill of the Ship-building Industry
  - TRIZ education in the professional technical schools
- 1977
  - ARIZ-77 – The Physical Contradiction (PC) and the Physical Contradiction at a micro-level (PC micro)
  - Standards 11
  - Value Engineering + TRIZ
  - The book "Inspiration on demand"
  - The Leningrad Seminar
  - Business games + TRIZ

1978-1980

- 1978
  - Standards 18
  - System of laws: vitality, efficiency, evolution
  - Систем Method of Forecasting of Development of Technical Systems
  - Resources (The Theory of Applicability)
- 1979
  - System of 28 standards
  - The book "Creativity as an Exact Science"
  - Complex method
  - TRIZ lessons in the Magazine Technique and Science
- 1980
  - System of 54 standards
  - Seminar of Teachers in Petrozavodsk
  - The book "Wings for Ikarus"
  - The Ministry of Higher Education of the Ukrainian Republic

1981-1983

- 1981
  - System of laws: The Organization and Evolution
  - Album of posters
- 1982
  - ARIZ-82, ARIZ-82B, ARIZ-82C
  - Scale of "Imagination"
  - The first practical forecast of development for the welding equipment based on TRIZ
  - Persecution on TRIZ
- 1983
  - System of 59, 60 standards
  - Chemical Effects
  - The advanced Method of the System Analysis and Forecasting
  - Hyper Su-Field Systems
  - Translations of books: "Creativity as the exact science" into Polish, "Wings for Ikarus" into German language, "Algorithm of the invention " (1973) into Vietnamese

1984 - 1986

- 1984
  - Scientific Seminar in Novosibirsk
  - System of 69 standards
  - "Subversive Analysis" (Anticipatory Failure Identification)
- 1985
  - ARIZ-85C
  - System of 76 standards
  - The book "The occupation - a search for novelty"
- 1986
  - Book "Find an Idea "
  - Foundation of the Kishinev Center "Progress"

1987 – 1989

- 1987
  - Life Strategy of the Creative Person
  - Geometrical Effects
  - The beginning of release of a Petrozavodsk series of books " Technique - Youth - Creativity " "Rules of game without rules "
  - The book "And start to invent"
  - The Russian computer program "Invention Machine"
- 1988
  - Scientific seminar in Miass (Chelyabinsk)
- 1989
  - Creation of TRIZ Association in the USSR.
  - Books "Search for New Ideas", "The Inventor has come to a Lesson "
  - Registration of the Minsk cooperative society Research Laboratory of Invention Machines "Invention Machine Lab"

1990 – 1992

- 1990
  - The beginning of release of "TRIZ Journal" (USSR)
  - Problem Formulator
  - The book " How to be an Inventor " (TRIZ: The Right Solution at the Right)
  - The beginning of mass emigration of TRIZ experts to Israel and USA and Germany.
- 1991
  - The book "How to be a Heretic"
  - Opening of the Center for Scientific and Technical Creativity (CSTC) in Vietnam
- 1992
  - Creation of the company Ideation International Inc., USA

1993 – 2003

- 1993-1996
  - The beginning of mass development of TRIZ- Pedagogic
  - Principles for journalism and advertising
  - Creation of the "Invention Machine Corporation" (1993)
  - The book "How to be a genius" (1994)
- 1996-1999
  - Foundation of the Altshuller Institute in the USA (1998)
- 2000-2003
  - Foundation of the European TRIZ Association - ETRIA (2000)

1. Shortcomings of the theory

General Shortcomings

- Absence of the general concept for construction and development of TRIZ
- The TRIZ tools are not unambiguous and accurate
- Repeatability (redundancy) of tools
- Absence of the general methods
  - Detections of problems
  - Exact use of tools and their sequences by the resolution of contradictions
  - Developments of Systems

1. Shortcomings of the theory

Shortcomings of separate tools

- Laws
- ARIZ
- S-F analysis
- Information Database
  - Standards
  - Effects (physical, chemical, biological, mathematical)
  - Principles
  - Resources
- The subversive analysis
- Development of Creative Imagination
- The Theory of Development of Creative Person (TDCP)
- Developments of collectives

2. Shortcomings of the education methods

- **Absence of complex educational and methodical programs on each of TRIZ directions**
- **Absence of the Educational Centers**

3. Shortcomings of education of teachers

- Absence of complex Educational and Methodical programs for education of TRIZ teachers
- Absence of the Educational Centers for TRIZ teachers
- Small number of highly skilled teachers

4. Shortcomings of development of TRIZ community

- TRIZ it is un-sufficiently known
- Small number of TRIZ centers
- Small number of skilled informational organizations of TRIZ

5. Lacks of Development of Scientific Schools

- **Small number the highly skilled TRIZ researchers**
- **Small number of scientific schools**
- **Separated Scientific Schools**
- **Absence of System for preparation of Scientists and Researchers**

The Future of TRIZ

Approaches to Development of TRIZ

- **Experimental approach** - ***research of existing systems***
- **Theoretical approach** - ***prediction of the theory***

1. The future of the theory

- Synthesis of the New Theory from resources available in TRIZ
- Development of specialized TRIZ
- Cybernation TRIZ

 23

1. The future of the theory

Synthesis of the New Theory from available TRIZ of resources

- Analysis of existing resources of TRIZ
- Definition of elementary TRIZ components
- Development of the concept for synthesis of the New Theory
- Synthesis of the New Theory

 24

1. The future of the theory

Development of specialized TRIZ

- Possible Directions:
  - *Technical*
  - *Natural*
  - *Social and Political*
  - *Art and Literature*
- Generalization of features of specialized TRIZ

2. The future of educational methods

- Development of complex Educational and Methodical programs
- Development of the automated educational systems
- Creation of an interactive educational web site
- Creation of the of Educational and Methodical Center with highly skilled experts

3. The future of education of teachers

- Development of complex Educational and Methodical programs for teachers
- Development of the automated educational systems for teachers.
- Creation of an interactive web site for training of teachers.
- Creation of the educational centers with highly skilled experts

4. The future of development of TRIZ community

- Creation of the system for self-development of TRIZ community
- TRIZ - an obligatory subject in all pre-schools, schools and universities
- Carrying out of serious marketing researches
- Attraction of highly skilled managers

5. The future of development of scientific schools

- Creation of the theory of development of sciences
- Creation of scientific centers with highly skilled researchers
- High professional (elite) conferences and seminars
- High professional (elite) magazines and sites.

Profile of Lecturer

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URL:	www.mtu.de

Brief Résumé & job descriptions:

1995	Bachelor of Science in Aerospace Engineering at Embry-Riddle Aeronautical University, USA
1997	Master of Science in Aeronautics and Astronautics at Massachusetts Institute of Technology, USA
1999	Senior Education Specialist at Parametric Technology Corporation, USA
2002	Project engineer in department of technology program at MTU Aero Engines GmbH
since 2002	Appropriation of technology development process in department of technology program at MTU Aero Engines GmbH

Innovation process as a key to the market success in the engine manufacturing business

Thomas Novacek
MTU Aero Engines
Munich, Germany

Executive Summary

The aircraft industry can also count in the next years on a rising traffic volume, must however adjust to large market fluctuations, increasing demands for environmental protection and more aggressive cost pressure. In order to meet these challenges, new technologies and business process are necessary. A focused innovation process, which does not leave the technology development to coincidence, must therefore be the goal. The innovation process of MTU covers the phases: determination of the customer requirements, systematic idea creation, selection of the correct innovations, purposeful development of the technologies, and finally securing the transfer of the technologies into the product. Presented will be the total concept and the tools of the innovation process as well as substantial results.

The technological requirements of the MTU from products and processes are already satisfied within the company through the offers of existing innovations. However, in many places new ideas must be developed. For that, TRIZ and a tool box of creative methods and measures support the creation of innovative ideas and concepts. In a 3-step selection process, which is divided in technical, product/process and enterprise orientation, the ideas/suggestions that bring the highest customer satisfaction together with business chances are selected.

The development of the technologies is finally controlled via a gating process. Within the gates an evaluation of market, development maturity, risks, budget and resources occurs. The technology gating is closely interlocked with the gating process of the associated products, so that a transfer of the technologies into the product is guaranteed.

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Innovation process as a key to the market success in the engine manufacturing business

ETRIA World Conference - TRIZ Future 2003
12 – 14 November 2003

Thomas Novacek
Dr. Jörg Sieber; Dr. Erich Steinhardt; Dr. Mark Welling

Center of New Products and Technologies
MTU Aero Engines

A DaimlerChrysler Company

- Introduction
  "What are the requirements of airlines for the engine manufacturing business until 2010?"
- MTU Technology Process
  " What are the elements of the new innovation process that brings MTU Aero Engine the key to market success?
- Results
  "The recognizable successes in MTU Aero Engine through the new innovation process"

Introduction

"The Future of Aviation "

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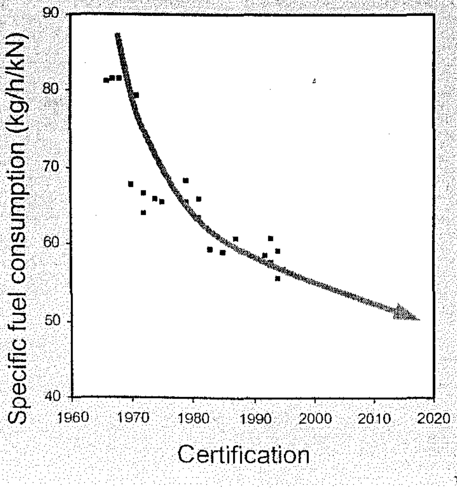
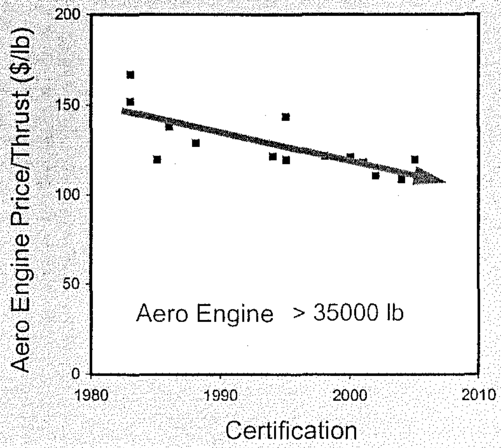
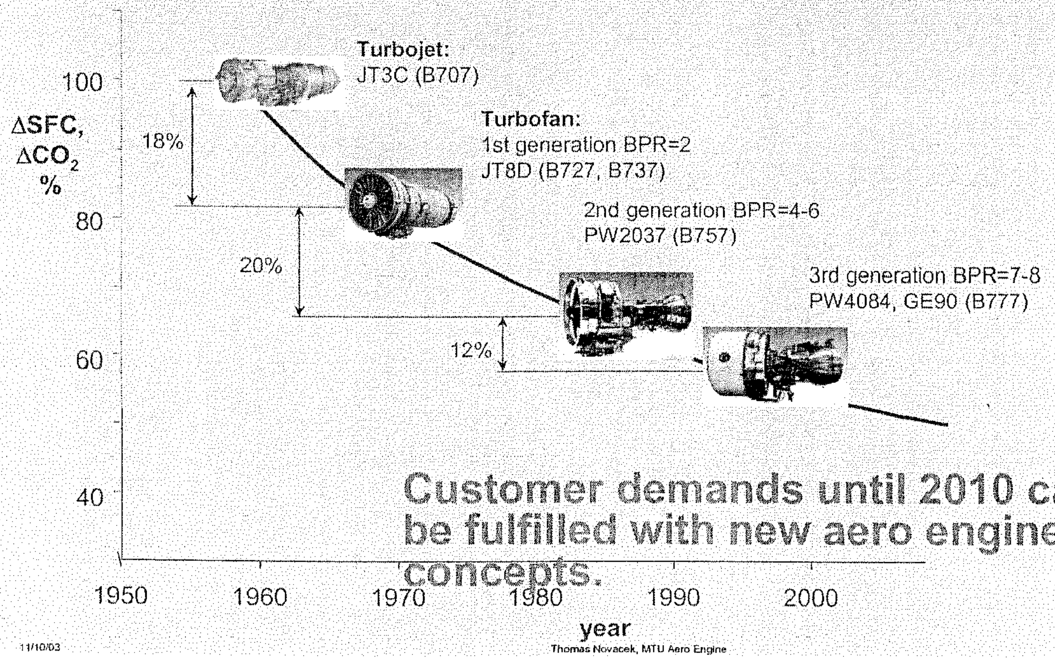
The Aviation Requirements until 2010

- For airline the cost effectiveness of the product is the focus
- Life cycle cost reduction of 20% to 30%
- Aero engine In-flight shut-down rate has to be cut in half
- Fuel consumption reduction of 10%.





The Future for Aero Engine Manufacturer



Customer demands until 2010 can only be fulfilled with new aero engine concepts.

The MTU Innovation Process

What are the objectives?

For the selection of right technology projects and the controlling of the technology development we want:

- simple, traceable and effective process
- maximum competence in the evaluation process
- minimum expense for forming an opinion and making a decision
- no parallel actions

What should the MTU technology process accomplish?

Orient the technology projects and development to:

- fulfill the requests and expectations of the customers,
- use the technological and commercial opportunities,
- strengthen the innovation,
- introduce the highest possible portion of the developed technologies into the product and/or process,
- introduce the innovations quickly into the product.

Phases in the MTU Technology Process

Technology Portfolio → **Technology Development** → **Technology Transfer**

Technology Portfolio

- Requirements are determined
- Ideas are selected
- Ideas are developed
- Ideas are evaluated
- Financing concepts are developed

Technology Development

- Development to technological maturity
- Successful testing of a prototype

Technology Transfer

- Responsibility is handed over to the customer (e.g. engine program or shop floor)
- Further development to reach all requirements for a certification and series production must be fulfilled

A crucial step is the Technology Portfolio phase

Technical oriented	Product/Process oriented	Enterprise oriented
Offer for the Requirements	**Specify the Requirements**	**What can we afford?**
The correct topics? Contentwise and timewise logic?	What do we need and when?	Strategic Requirements

Technical-Specialist Teams

- Aerodynamics
- Manufacturing technique
- Information technology
- Mechanics and stability
- Instrumentation and testing
- Control and monitoring
- Repair technology
- Thermodynamics & systems
- Materials
- ....

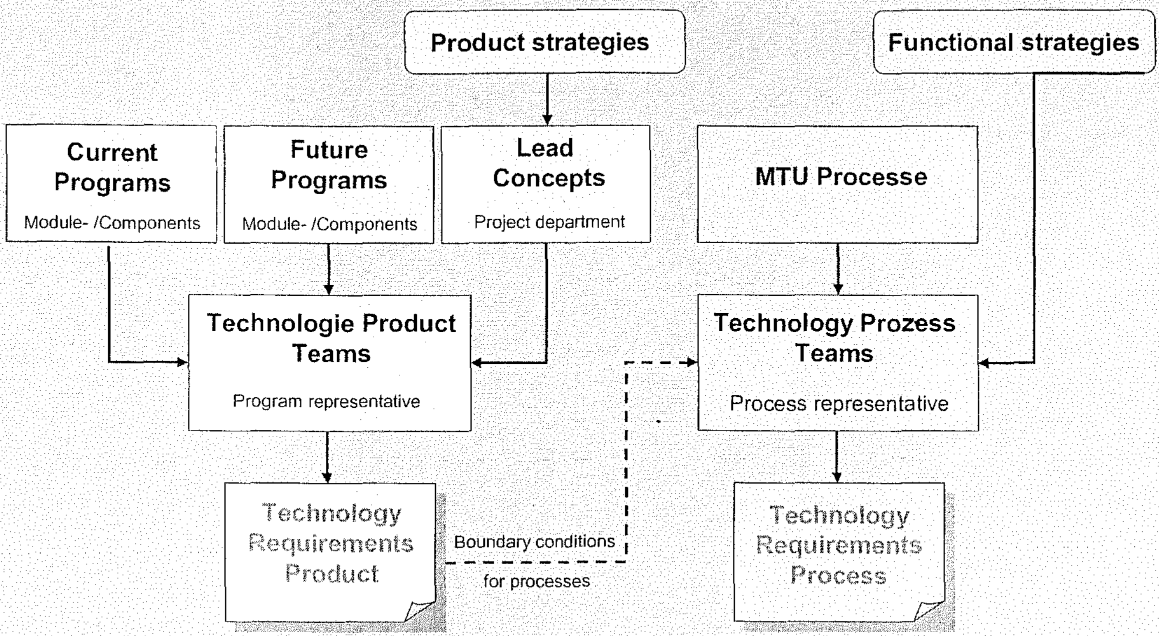
Product/Process Teams

- Compressor
- Turbine
- Aero Engine Systems

- Development
- Manufacturing
- Maintenance

Executive Committee

The Technology Requirements



Technology Requriements with high Priority...

....

- satisfied with existing ideas/innovations or
- development of new ideas supported by
  - innovation workshops
  - TRIZ
  - tool box of systematic creative methods to support the creation of innovative ideas and concepts
  - from internal and external creativity specialists

Technology portfolio management maintaines technology pull principle

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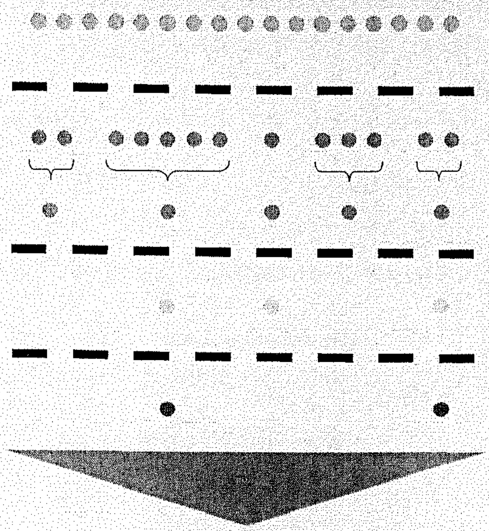
Technology Portfolio | Technology Development | Technology Transfer

Selection Process of the best Projects...

Technology Ideas



Technology Projects

Selection Process	Evaluate
1. Technical evaluation and and grouping	Benefit, costs, dates and risks
2. Requirement oriented evaluation	Benefit, expenditure and fit to requirements
3. Enterprise oriented evaluation and financing	Decides on execution, financial situation and strategic criteria

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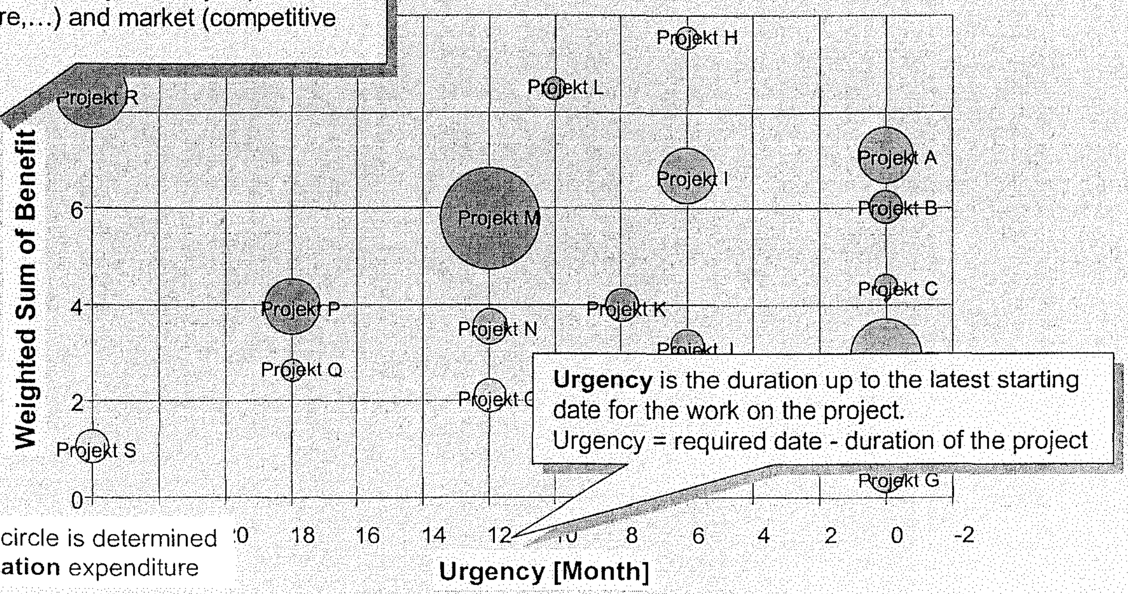
Technology Portfolio | Technology Development | Technology Transfer

The Technology Portfolio

Weighted Sum of Benefits evaluate criterias for function (efficiency, stability,...), costs (manufacture,...) and market (competitive position,..).

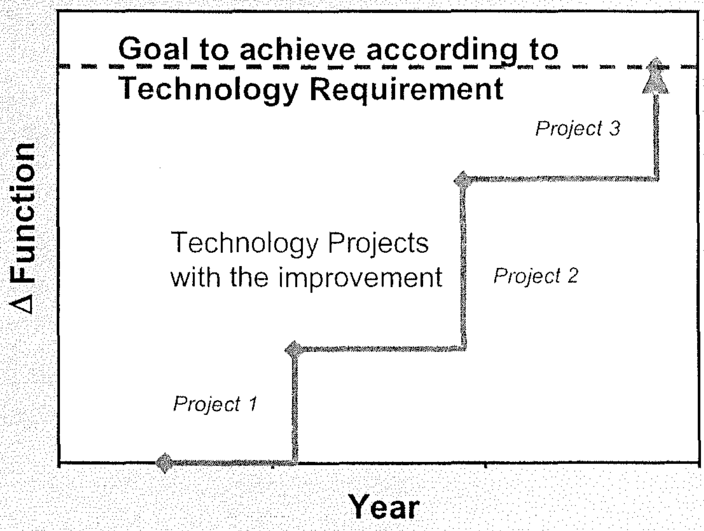


Urgency is the duration up to the latest starting date for the work on the project.
Urgency = required date - duration of the project

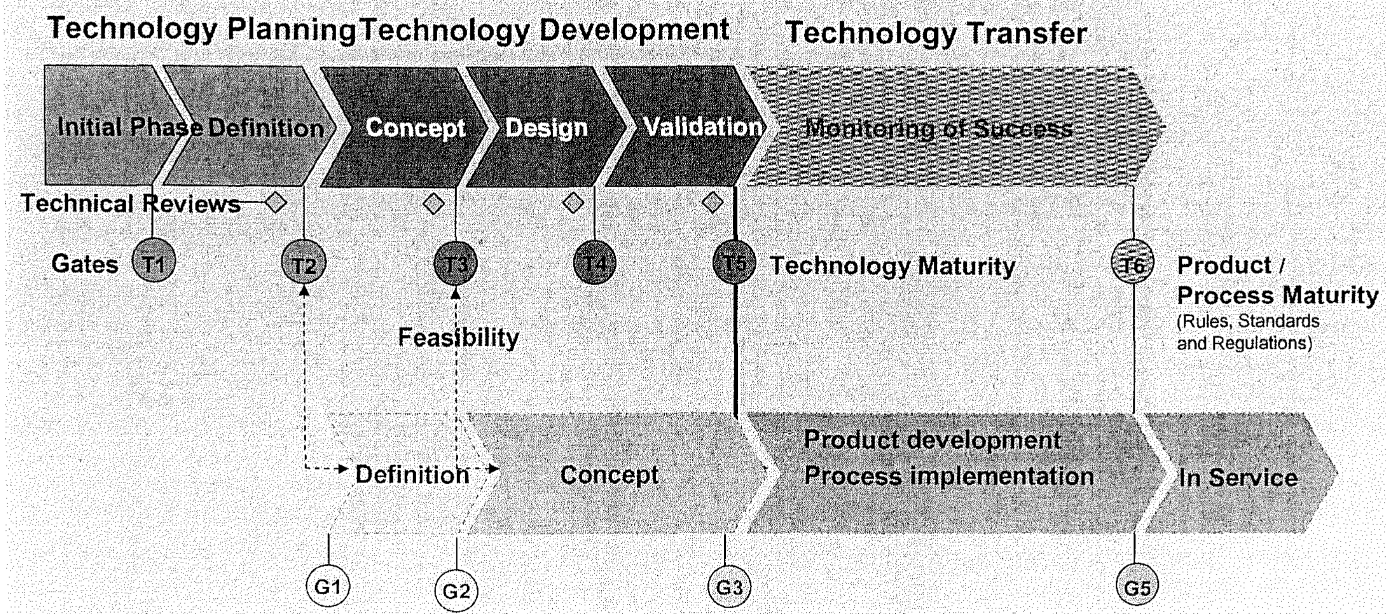
The size of the circle is determined from the **Realization** expenditure

Technology Roadmaps

- Shows the improvements by the individual technology projects
- Shows the goal values according to technology requirement (engine program).



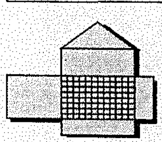
Development of the Technology Projects



Tools during the MTU technology process

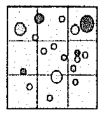
Technology Portfolio: Technology Requirements → Innovation → Project Selection → **Technology Development** → **Technology Transfer**

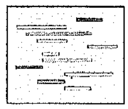
Technology Requirements
- QFD (Quality Function Deployment)



Innovation
- Brainstorming
- TRIZ
- Other creativity methods

Project Selection
- Technology Portfolio Management
- Technology Roadmaps
- Technology Calendar





Technology Development
- Technology Gating

Technology Transfer
- Aero Engine Gating

Technology Development / Technology Transfer
- Integrated Product Development
- Standard Work
- Design Make Build Guide
- Development Hardware Procurement

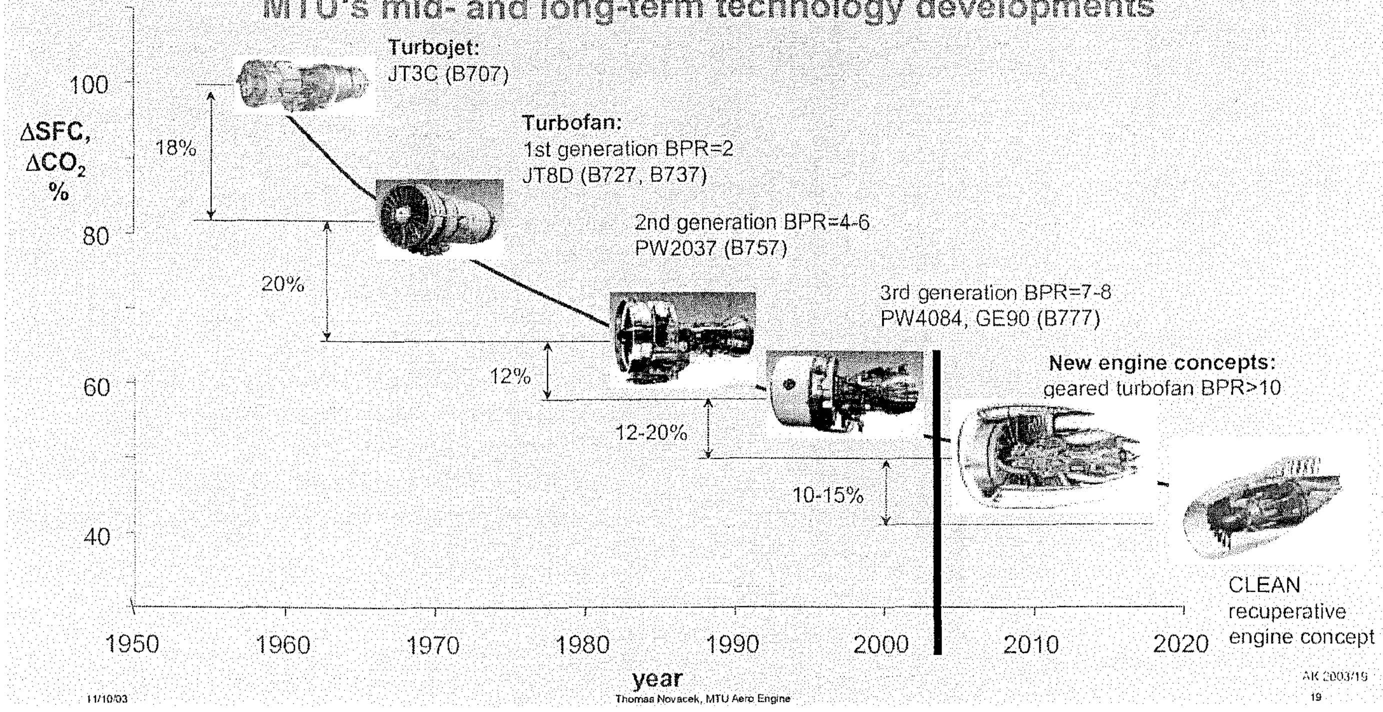
Across all phases
- Intellectual Property Management
- Production Cost Management

Results

"The recognizable successes in MTU Aero Engine through the new innovation process"

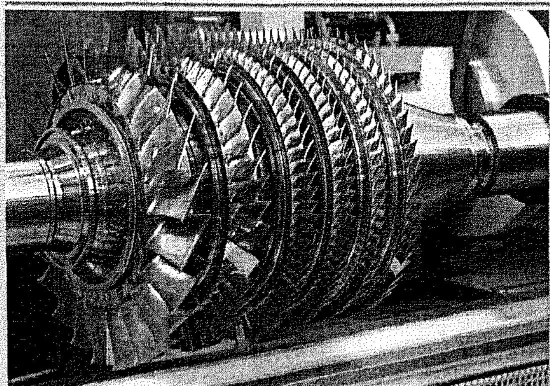
Three Lead Concepts

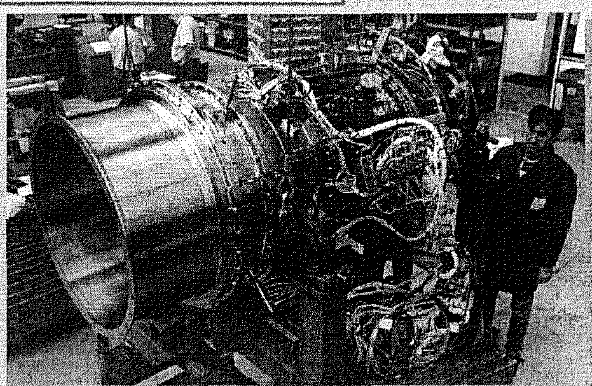
MTU's mid- and long-term technology developments



Most Recent Highlight of MTU Compressor Technology

Aviation Week & Space Technology: Aerospace Laurel Award 2002
Innovationspreis der Deutschen Industrie 2003

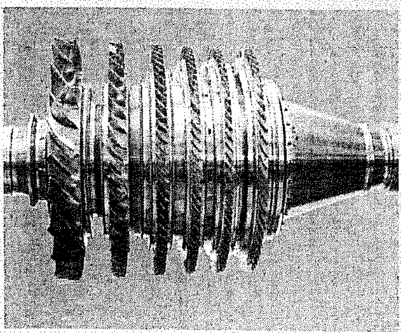




- → Highly loaded, affordable 6-stage HPC with Pressure Ratio 12
- → Advanced 3D airfoil design
- → High efficiency provides minimum fuel burn
- → represents world class compressor technology
- → the product for the PW6000 engine

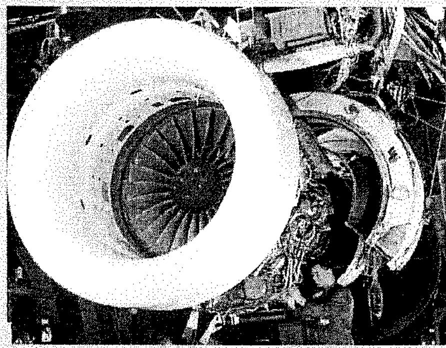
Successful Transfer of Innovative Compressor Technology into a Product

HDV 12 Technology Compressor



MTU Technology Process

PW6000 engine planned for A318



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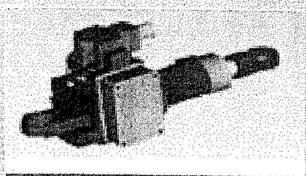
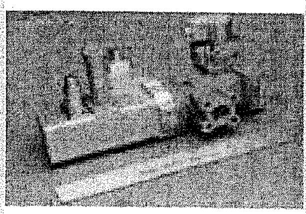
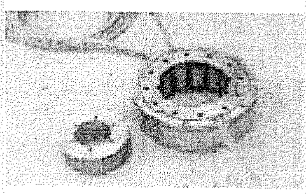
Evolution Principles lead into Intelligent Aero Engine Technology



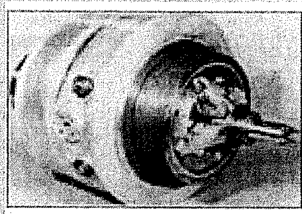
Electrical actuators



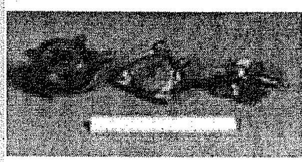
Electrical Fuel pump



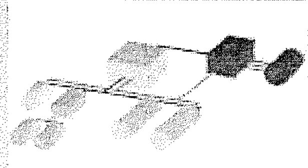
Magnetic Bearing



Integrated starter generator



Smart sensors

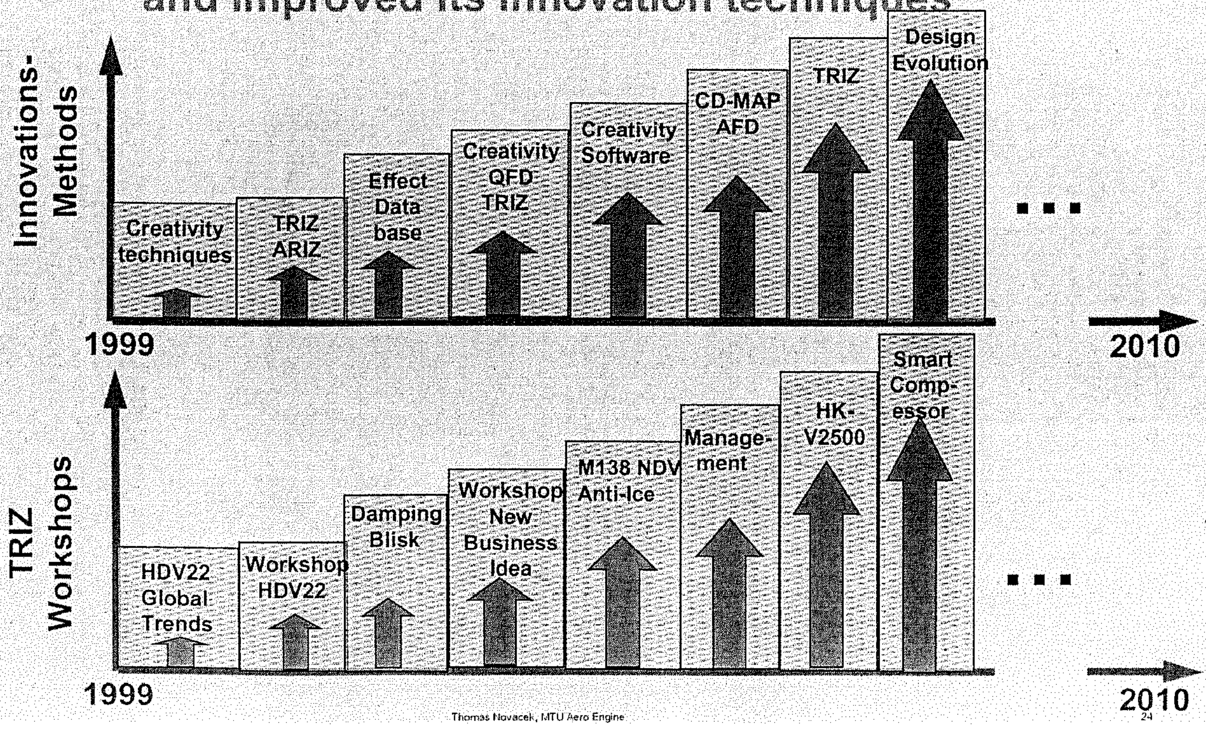


Distributed control systems

Experience with TRIZ

- Faster and effective method for innovations
- Toolbox of different methods
- Reduction of development risks and costs
- Evaluation of future trends of technologies
- Generation of ideas in situations where practically all ways are blocked through patents from the competition

MTU has continuously completed Small used and improved its innovation techniques



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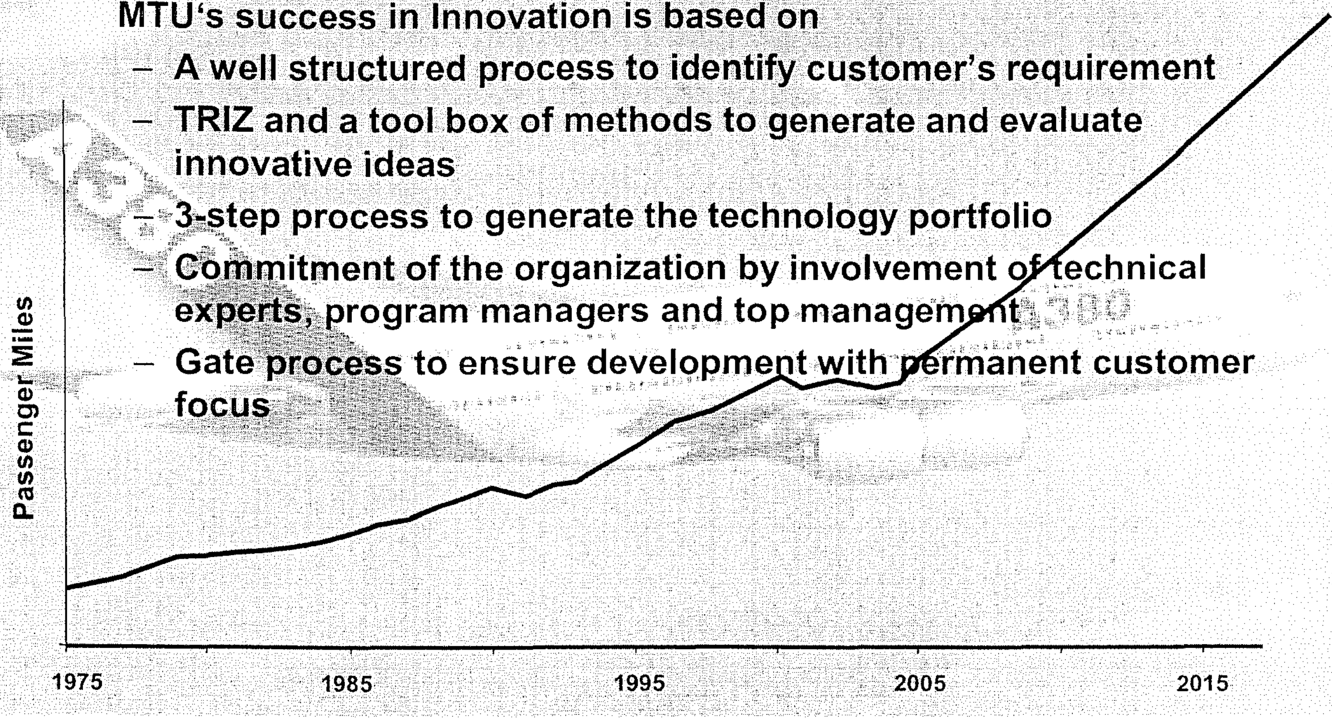
Summary

MTU's success in Innovation is based on

- A well structured process to identify customer's requirement
- TRIZ and a tool box of methods to generate and evaluate innovative ideas
- 3-step process to generate the technology portfolio
- Commitment of the organization by involvement of technical experts, program managers and top management
- Gate process to ensure development with permanent customer focus



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Thank You

MTU Aero Engine

MTU – The Company

Key business figures

MTU figures

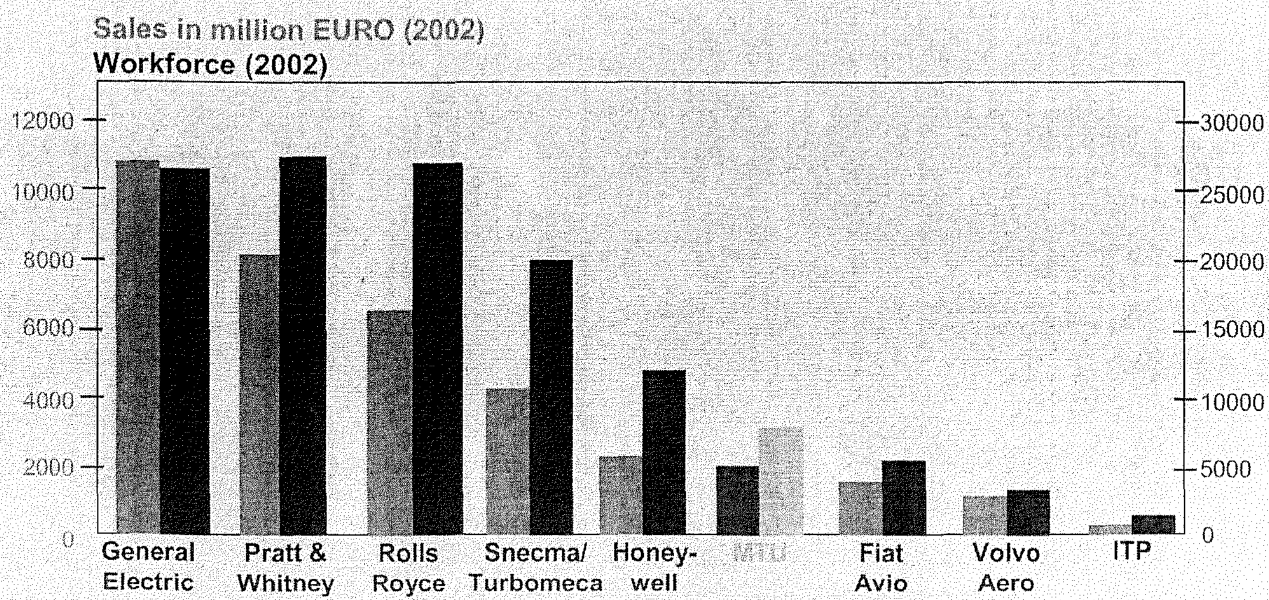
	1997	1998	1999	2000	2001	2002
Sales	1.515	1.660	1.742	2.106	2.487	2.215
Orders received	1.382	2.594	1.548	2.409	2.183	2.131
Undedicated R&D	66	50	48	70	85	129
Investments	34	37	58	93	101	112

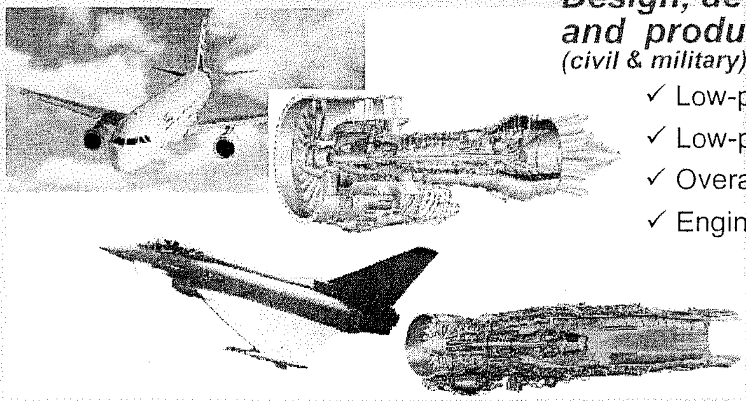
(Mill. EURO)

Total workforce	6.023	6.633	6.875	7.162	7.839	8.376
Of which employees in Munich	4.829	5.169	5.201	5.243	5.340	5.902

(employees)

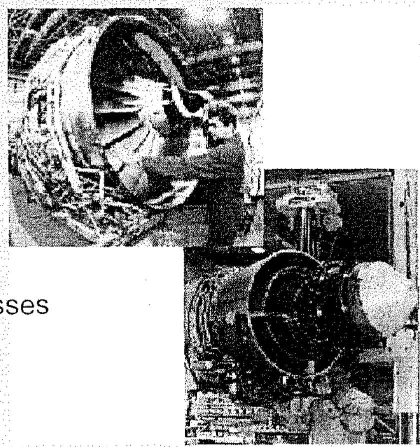
Engine manufacturers – a comparison





Design, development and production
(civil & military)

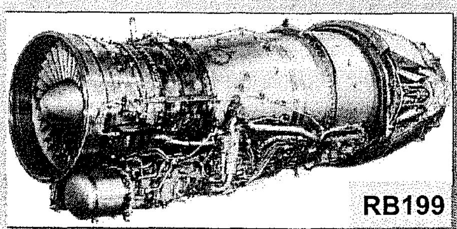
- ✓ Low-pressure and high-pressure turbines
- ✓ Low-pressure and high-pressure compressors
- ✓ Overall propulsion system integration capability
- ✓ Engine control and monitoring unit

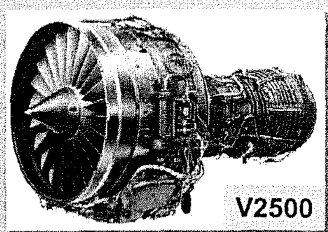


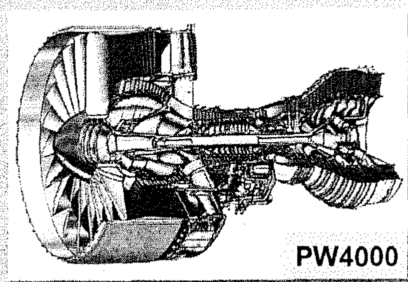
Maintenance

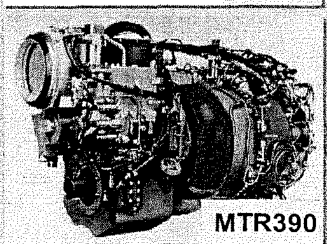
- ✓Integrated solutions for civil engines and industrial gas turbines
- ✓New repair processes
- ✓Integration of new development, manufacturing and repair processes
- ✓System integration

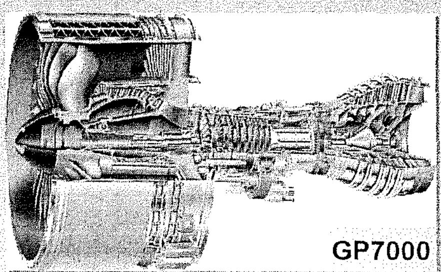
Long Experience in Engine Components

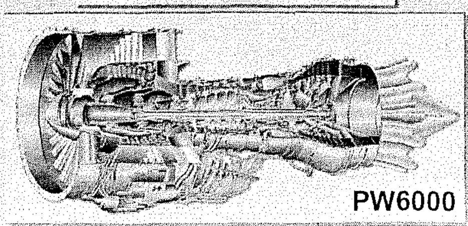


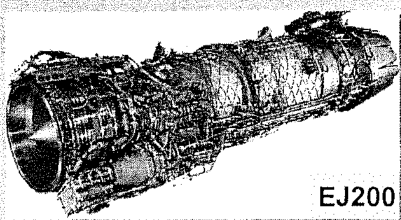










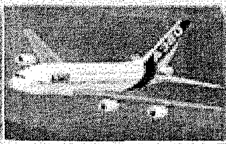


The commercial product application range

PW4000G

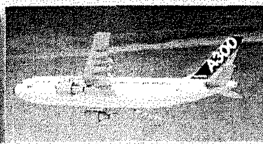
Boeing 777

GP7000



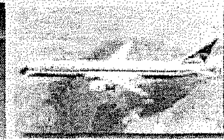
Airbus A380

CF6-80



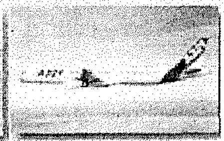
Airbus A300,
A310, A330,
Boeing 747, B767, MD-11

PW2000



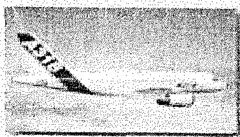
Boeing 757,
Boeing C-17,

V2500



Airbus A319,
A320, A321,
Boeing MD-90

PW6000



Airbus
A318

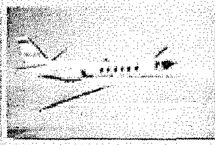
JT8D

Boeing MD-80-Reihe

PW300

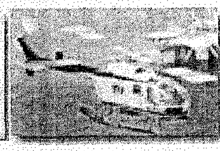
Learjet 60
Do328JET
Gulfstream G200
Hawker 1000
Dassault Falcon 7X
Cessna Sovereign

PW500



Cessna Bravo
Cessna Excel

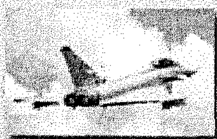
250-C20



Bo105
Jet Ranger

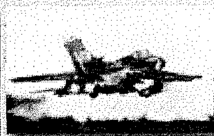
The military product application range

EJ200



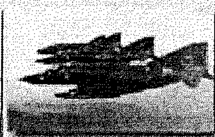
EF2000
Eurofighter
Typhoon

RB199



Panavia
Tornado

J79

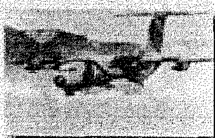


F4-Phantom II

Larzac

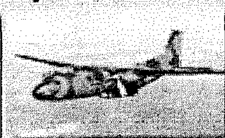
Alpha Jet

TP400D6



Airbus
A400M

Tyne

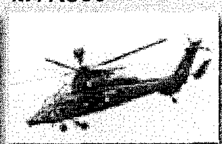


Transall
Breguet
Atlantic

T64

Sikorsky
CH53-G

MTR390



Eurocopter
Tiger

Profile of Lecturer

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Brief Résumé & job descriptions:

Dr. Denis Cavallucci is currently associate professor at the National School of Arts and Industries of Strasbourg (in France) and researcher in the Laboratory of Research in Production Systems. He started his teaching and research activities in design methods and theories in 1988 and dedicates his research towards TRIZ body of knowledge in 1996. This led Dr. Cavallucci to hold a Master in Industrial Engineering (with "State of the art of TRIZ" as a subject of his master's thesis) and a PhD in Mechanical Design with a contribution on the Intuitive Design Method (IDM) (proposal for TRIZ introduction into western approaches). Worldwide lecturer and speaker, Dr. Denis Cavallucci has given over a hundred lectures on TRIZ and is author of about forty papers in worldwide reviews and scientific conferences. He also wrote chapters about TRIZ in co-authored books about the Science of Engineering Design. Co-founder and first president of TRIZ-France, co-founder an actual president of ETRIA, Dr. CAVALLUCCI is also active in transferring his research outputs into industrial world with case studies and research partnership with international organizations and, as an output, is co-inventor of about 20 patents with several companies design teams.

ABOUT NON TECHNICAL BARRIERS PREVENTING EFFICIENT TRIZ INTEGRATION INTO ORGANISATIONS

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When adequately performed, every TRIZ action on a problem-solving situation undoubtedly leads to an inventive solution, often satisfying the initial technological requirements imposed by the company. Nevertheless, when observing the arrival of TRIZ for the past ten years in highly industrialised countries, we have witnessed how incredibly difficult its progress in corporate strategies has been. The paradox lies in the sense that while successful actions are there and properly trained people are ever more numerous, there still remains (ever stronger) obstacles to TRIZ penetration in these organisations. This paper aims to provide the reader with the results of an analysis of blocking factors through the state-of-the-art knowledge found in the human sciences and their link with several realities found in TRIZ and its arrival in an organisation.

KEYWORDS

TRIZ, psychology of actors, educational process, innovation management, multidisciplinary approach.

1. INTRODUCTION

1.1. Context of this study

The hindsight we now have concerning the modes of acceptance of TRIZ by companies is based on a full ten years of experience. The sources for this article are taken from the last seven years (the period which seems to us more significant in terms of efficiency) and concern around fifty companies where our actions have helped us gain the experience relevant to the theme of this article. The source for our proposed contribution lies in the fact that a paradox has arisen in the situations we have experienced, which may be presented as follows: nowadays, TRIZ is formally acknowledged as an efficient way of addressing technological problems and consequently, when it is adequately performed, it meets with the full and total satisfaction of its sponsors (the companies). However, in spite of all these positive points never before attained by a methodological approach relative to industry, the psychological and educational problems encountered as to its acceptance by organisations confronted with the problem of its integration, are very significant, and may even lead to integration options being eradicated very early on in the decision-making process.

We wish to clarify the reasons for this paradox blocking the progress of acceptance, firstly by analysing the findings of three scientific domains belonging to the human sciences relating to "traditional" resistance to the arrival of any novelty in the company, and secondly, by analysing what is specific to TRIZ and how a relationship can be set up between this resistance and the "standard" behaviour patterns that should be adopted in such cases. The aim is to provide the architects in charge of introducing TRIZ into organisations with viewpoints that sometimes have little in common with their integration plans since they stem from disciplines which are alien to their own. This article also aims to propose a set of basic rules which should be incorporated into integration plans so that the may be taken into account in a specific process.

1.2. The classic integration plan

This section is not going to deal with developing a new theory on how to integrate TRIZ into organisations. This theme, while being extremely interesting, must be subjected to in-depth research and integrated into an exhaustive state-of-the-art assessment of strategic practices linked to innovation management in companies and how it can be involved in the development of the innovation process in organisations. This research should, moreover, be conducted in collaboration with a multidisciplinary team of researchers from management sciences, economics, psychology, sociology and educational sciences so that its impact in companies may become a reality. For the purposes of this article, we have decide to draw up a partial picture at a given time T of what has contributed to the success and failure of TRIZ practices in organisations.

The diversity of practices can be summarised in 9 categories. When we examine these categories, it is easy to conclude that there is an evolution in the passage from refusal to acceptance, passing through an intermediary phase, which is doubt. Our aim in this article is to elucidate the cognitive aspects which enable companies in the situation of the first group to develop towards the last group. A brief description of the 9 situations follows:

- Organisations which do not even want to hear about it (adamantly against what they have heard or read).
- Organisations which have never heard about it (not alerted by their intelligence departments or too engrossed in their own affairs or who have passed over the information without looking at it).
- Organisations disappointed or unconvinced by the basic arguments (including when the culture of the decision-makers is opposed to the basic postulates because of what they have read or heard about TRIZ).
- Organisations which want to find out more but at no extra cost (at least at the beginning, or want to wait until others have done the spade work).
- Organisations which have "tested it just to have some idea" (a budget is allocated to see what it is all about).
- Organisations which have "trained an engineer" (sometimes in the hope of repercussions at a later date).
- Organisations which have set up a strategy of "integrating skills" (or searched for a solution giving them autonomy in their practices).
- Organisations which have taken the decision to "outsource skills" (they understand the relevance of TRIZ, but think that their needs for TRIZ and the efforts required have not reached a threshold level for a return on investment in terms of in-house integration).
- Organisations which have decided to "set up a strategy" (convinced of the relevance of TRIZ, and having decided to build an integration strategy, have committed human and financial resources thereto).

When one or more of these actions towards adopting TRIZ is undertaken, we find records and results of the process. Some companies have developed a practice tending towards another action, whereas others have stopped all expenditure linked with TRIZ due to disappointment, lack of clarity in relation to the added value it represents for them or an obvious lack of enthusiasm among the actors of innovation. It seemed worthwhile investigating into the problem of this obvious lack of enthusiasm in order to attempt to identify the underlying psychological motives which, in the end, often result in the following paradox: TRIZ disappears from a company's practices, although its benefits and potential have turned out to be positive for the company's future development.

1.3. Stating the problem

As they contain an element of the unknown, innovations destabilise the operating modes and comforting inertia inherent in the notion of habit. They also give rise to refusals, reticence and fears from those whose existence and habits are disturbed. Resistance is demonstrated in a variety of forms at all levels in the company. In the following section, we shall attempt to identify and briefly analyse the points of divergence between the operating modes of corporate actors and the same modes as seen from the TRIZ perspective in order to establish rules which will favour its development within the company, whether they are adopted by external or in-house TRIZ actors.

2. ANALYSIS OF THE BLOCKING FACTORS

2.1. Difficulties associated with inaptitude compared with traditional models

We shall now attempt to describe the models inherent in traditional modes of thought and compare them with the thought models provided by TRIZ. The aim here is to highlight the differences and explain, through different scientific domains, the reasons underlying the difficulties of accepting these modes of thought.

Example of a psychological stumbling block

Divergent process versus convergent process

Traditional model: Man is creative by nature: by increasing the multidisciplinary approach of the group and idea-generating opportunities in a structured way, the statistical spectrum in terms of sheer numbers will surely lead to "good ideas" being collected.

Model proposed by TRIZ: The divergent approach consisting in generating a maximum number of ideas only leads to superfluous cognitive and financial expenditure; a convergent process must be set up leading, through reflection, to a narrowed search area before embarking on the creative approach.

Compromise is inevitable versus to innovate, we must refuse compromise

Traditional model: In a design action, compromises are inevitable and the designer's efforts must be focussed on the most appropriate compromise in view of the initial project specifications.

Model proposed by TRIZ: A compromise is never a solution. The action of designing must focus on formalising the key contradiction which is blocking the evolution of the system and solve it without any compromise, by ensuring that the two contradictory properties progress.

Analysis of the psychological state of the actors

The mind is more easily fed with opinions than reason-oriented thought, because opinions translate people's worries, hopes and fears into ideas, whereas scientific thought presupposes a real breaking down of opinions and a rejuvenation of the mind. Our opinions are as old as our prejudices. TRIZ forces us to think under the influence of reason, and not under the influence of our prejudices. This requirement is not doubt one of the reasons behind the resistance to developing TRIZ in a group or a company.

The second, easily identifiable, reason does not stem from mere inertia of thought processes, but lies elsewhere - with power games. Resistance to new ideas is also due to the fact that they upset the power structure and relationships. Introducing TRIZ in an organisation calls into question the position of those who direct research and development based on other practices. Here, we come up against power strategies as decrypted in the work of Michel Crozier and Erhard Friedberg (1977) through their analysis of the strategic behaviour of the actors.

Examples of managerial stumbling blocks

The customer dictates evolution versus laws govern evolution

Traditional model: The Company designs and manufactures the products required by the customer through the more or less explicit expression of his needs.

Model proposed by TRIZ: Laws formalised by Altshuller govern the evolution of systems built by man - they must dictate design actions.

Associating innovation and cost-cutting at the same time versus dissociating these parameters in the timeframe

Traditional model: We associate innovation with the desire to achieve new concepts, while avoiding the feeling that they will generate high costs.

Model proposed by TRIZ: The laws of evolution teach us (especially the law linked to ideality) that at the beginning of its life, it is inevitable that the synthesis of a system will generate costs - to give it some chance of existing. Cost-cutting will only occur at a later stage.

Analysis of managerial difficulties

The stumbling blocks highlighted here are fundamental to management sciences, since they quite simply constitute a strong barrier to putting real innovations on the market.

Indeed, in the innovation project, marketers must be and very often are involved, quite simply because they are in direct contact with the customers and are therefore in a better position to express the customers' needs. Dissociating the needs of the customer and the natural evolution of a technical system such as it is given in TRIZ, is tantamount to taking the risk of making the innovation fail. It therefore becomes essential to make sure the two dimensions are coherent and, by taking care that the marketers are properly integrated in the project, to ensure that a very high level of coherence is preserved between the needs of the customer and the evolution of the product, i.e. the innovation about to be introduced.

Another dimension which must be integrated into any TRIZ approach concerns the objectives to be set in terms of defining the product range. Indeed, what are we trying to do? Introduce a totally new product, complete a range of products, introduce incremental modifications to an existing product to step up sales, etc.? Each of these objectives is going to have a high impact on investment, and also on the turnover generated. In view of this, it is important to understand that we will not necessarily have the same standpoint on the laws of evolution when putting the TRIZ approach into practice. Integrating questions as to investment and profitability in an efficient manner becomes possible at this stage.

Example of an educational stumbling block

Functional analysis versus systemic analysis

Traditional model: The teachings of functional analysis tell us that any technical system must be observed through a morphological breakdown of its elements and attributing a hierarchy-associated function to each component part described.

Model proposed by TRIZ: The system is analysed through modelling, placing it in a multi-screen pattern in order to understand its "real systemic barriers" and evolutionary jumps in time.

Analysis of the actors' educational difficulties

One educational difficulty that the TRIZ expert may encounter during his intervention in the company is due to the fact that the cognitive environment in which the learner finds himself is insufficiently identified. Here, for the purposes of the analysis, we consider that any person exposed to an intervention by a TRIZ expert is in a learning environment, and that the TRIZ expert is there to train, inform or solve a technical problem.

A survey of the cognitive environment aims to describe how the learner interacts with the people around him by attempting to give an accurate answer to the following question: why does the learner refuse to learn? How can someone totally reject everything to do with TRIZ? The reasons may be psychological or managerial, but may also depend on what the learner is capable of knowing.

His abilities can be picked up by the TRIZ expert by observing the learner from the angle of his cognitive instincts, i.e. what irresistibly drives him to adopt one cognitive behaviour pattern rather than another. From this point, the cognitive problem involving the TRIZ expert consists in assessing the importance of each type of instinct for each learner.

3. PROPOSAL FOR ANALYTICAL LOGIC PRIOR TO ANY TRIZ ACTION

Since the previous section has led us to observe that the differences in cognitive modes of thought has obviously hindered acceptance of TRIZ, we shall now propose the use of rules specific to knowledge stemming from the human sciences as modes of action which should be adopted to counter these difficulties.

3.1. Synthesis of the aspects to be implemented

Considerations inherent in the cognition sciences

The way in which we address the issue of the difficulties TRIZ encounters in terms of corporate acceptance – in terms of epistemological obstacles or the strategic behaviour of the actors – will also determine which answer should be applied. In the first instance, it is more a matter of making an effort on an educational level and in the second instance; it is a question of searching for a strategic alliance. These two concepts are no doubt complementary.

Yet, here, we would like to suggest another path. On the one hand, resistance to TRIZ is in fact only one example of the difficulty that a group or a community encounters in taking on board new ideas and intellectual approaches. Let us not forget that in his day, many years passed before Louis Pasteur managed to convince the scientific community of the time about his ideas on fermentation, despite the backing of experimental controls available to everyone. From 1898 to 1864, proponents of the theory of spontaneous generation, which included renowned scientists such as Félix Archimede Pouchet, contested his discoveries at first. On the other hand, solving technical problems concerns technical facts which are defined by the laws of Nature, whereas psychological resistance stems from subjective representations which are built up during interactions. Resistance is therefore included in discursive exchanges and can be addressed as a question of legitimacy.

From the standpoint of the psychology of the actors, the problem of resisting the development of TRIZ can therefore also be put as follows: while TRIZ is scientifically acknowledged, it is not easily accepted in companies. This leads us to say that it is not because someone is right scientifically that he is not wrong socially. For us, there is a clear distinction between the scientific statement which can be proved and social adherence which is gained through experience. The scientific statement depends on the laws of Nature and can be demonstrated, whereas social adherence depends on acknowledged legitimacy which is built up collectively. In other words, there is a great difference between the approach to a technical problem and the approach to a problem of social legitimacy. Proof is not enough to convince - the legitimacy of an idea depends on its acceptance. This process involves a discursive exchange and not just an authoritative assertion. Social, but not scientific, legitimacy depends on a vision of the world, or more simply on a shared representation based on a "social structure". In groups, ways of thinking, asking questions and finding solution-seeking approaches which are believed to be legitimate are built up through discursive statements.

If we start with this way of putting the question, we can understand the problem a bit differently. Commitment to problem-solving thought processes inspired by TRIZ can be roughly compared to training the scientific mind. But instead of only addressing this difficulty from the angle of the epistemological barriers, we also propose to address it from the angle of social legitimacy.

Considerations inherent in educational sciences

With respect to the educational rules which the TRIZ action leader must follow, it seems to us that the assessment of a person's cognitive capacity must, among others, consist in observing:

- the questions the learner puts to himself and the questions he asks other people,
- what the learner learns from his mistakes, his ignorance and his lack of reflection,
- whether the learner accepts that what he has always known and what he strongly believes in will be contradicted,

- if the learner prefers that others ask him questions rather than giving answers
- if the learner is capable of not having opinions about problems which he does not know how to express clearly to the team

Going on from these observations, we can distinguish between two behaviour patterns:

- The first arises from a conservative instinct. It is illustrated by the learner's refusal to question the knowledge he has acquired in the past; a mode of reflection, expression and action upheld by opinions and prejudices; and an old-fashioned thought process based on repetitive patterns. For these learners who reject novelty, we are tempted to suggest that for the TRIZ expert, the battle is virtually lost from the start.
- The second arises from the formative instinct and is opposed to the conservative instinct. It purports that the learner acts through destroying (opinions and prejudices) and rebuilding knowledge. It is with these learners that the TRIZ expert should work.

This list of observations and conclusions is not exhaustive and should be further investigated. It can nonetheless help us to understand the cognitive environment of a group of learners and therefore clarify, both for the expert and the company, the cognitive barriers TRIZ may encounter on the path to development.

Considerations inherent in management sciences

Corporate strategy is one aspect that must absolutely be taken into account from the managerial point of view in all TRIZ approaches. Indeed, an innovation project which develops independently of any reference to the strategic dimension is bound to fail: no coherence on the market, no coherence in the product range, no account taken of the accepted and expected investment and profitability level etc. In view of this, it becomes essential, right from the start of the project, to integrate the dimensions linked to the company's medium-term objectives, and even its long-term objectives. One essential stage therefore consists in making the TRIZ approach coherent with the real, global corporate strategy. Initially, it is therefore helpful to set aside the aspect of tools in order to focus more on innovation management and its appropriateness compared with the corporate strategy and the current organisation of the company. Once this has been done, it will then be possible to integrate the problem-solving aspects which will satisfy the company overall, into the TRIZ approach.

3.2. Basic rules to be followed

In view of these analyses and the discussion put forward in the preceding sections, we propose the following rules as points that are indissociable from the use of TRIZ in an organisation.

Setting up preliminary actions:

- Identifying the actors needed to put it into practice according to the following typology:

The actors / players are divided into four categories:

- The decision-makers: those who have the decision-making power in terms of the company's commitments (managers, R&D or marketing managers, others);
- Special partners: those who have all the skills acknowledged as being favourable to accepting TRIZ ;
- Contradictors: those who feel that TRIZ is a threat to the integrity of their personal project within the company;
- Resource persons: those who have the knowledge required for TRIZ to progress.

We should note in passing that some specific actors may have several characteristics at one and the same time and that the hierarchical level does not systematically correlate to a type of actor.

- Conducting educational observations

The ability each member encountered during an action has to grow out of their traditional cognitive reflexes;

The capacity each member of the study has to be malleable to an evolution in their opinions;

The capacity each resource member in the action has to accept the unacceptable and to contribute clear answers during the project;

The extent of social feelings in the face of the challenges raised by the project;

The real expectations of the decision-makers and the aptness of their desires as they are expressed compared to the objective status of their situation.

- Conducting a synthesis of individual and collective characteristics

The company's hierarchical organisation must be informed of the analysis and its results, and give its backing not only to the assessment approaches, but also to any necessary choices that result therefrom. With respect to the synthesis, the actors should be ranked in order of their ability to adhere to the cognitive criteria put forward. However, it is imperative that at no moment during the process should an actor feel he is being assessed, for if he is discarded by the decision-makers, then there is a high risk that he will become a systematic opponent

- Setting up strategic alliances

The decision-makers, in conjunction with the TRIZ experts and the top-rankers who have the appropriate cognitive profile, must then agree on a strategic alliance which will lead to the efficient and robust development of the TRIZ action and also agree on the specific adoption modes for the actors involved in the project.

- Drawing up a TRIZ strategy to be adopted by all the actors

Putting into practice an adoption strategy for the actors hasn't existed until now in terms of the problem of introducing TRIZ. However, it will eradicate the reticence which generates subsequent social barriers. In the logical approach which we advocate, the method must be constant and dynamic (adapted to each player) throughout the action, as any actor who has been misinformed or discarded becomes a strong enemy of the progress of TRIZ within the company. If the social adherence of some people has not been attained, they must not disappear completely from the introduction phase. The main aim of the adoption strategies advocated is therefore to make sure that the introduction and practice of TRIZ in a collective situation involves everyone, and that each person should find a comfortable role in keeping with his own objectives.

All these analyses can be summarised in four major phases prior to any development linked to TRIZ. They are suggested by the authors of this article as rules to be taken into account to facilitate the acceptance of latent cognitive aspects which often block the progress of TRIZ in an organisation. We shall summarise these phases as illustrated in figure 1, pointing out that their chronology and duration as well as the means used to put them into practice have been drawn up using a particular company model - that of a medium-sized or large industrial group in which the structuring of the innovation process is already advanced or well-established.

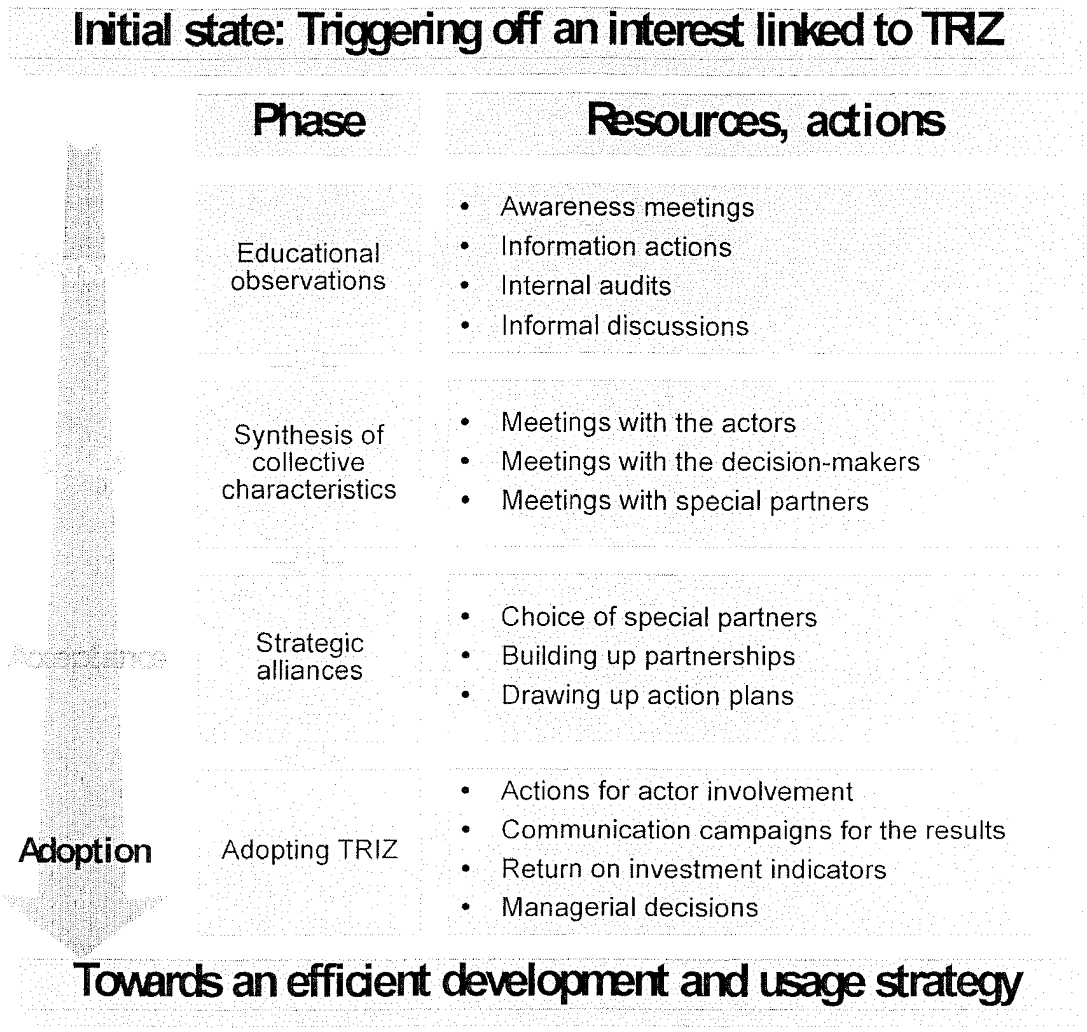

Figure 1: Generic diagram of the chain of non-technical considerations prior to the development of a TRIZ action

4. CONCLUSIONS

In this paper we do not wish to confine ourselves to identifying the types of barrier encountered in terms of the TRIZ way of thinking, but to push ahead with an analysis of resistance to a thought process whose pertinence has been scientifically acknowledged. At present, it is as if people say that it is not because TRIZ is right scientifically that it is not likely to be sociologically wrong. This observation results from our experience of the difficulties encountered in implementing TRIZ in companies, despite its power of invention. Bearing this perspective in mind, we are not dealing so much with a struggle against some prejudice, as ensuring the social legitimacy of inventive thought.

The notion of legitimacy mentioned here in a larger framework (a country, community of countries, all highly industrialised countries) is built up through the existence of benchmark groups which openly manifest their interest and trust in TRIZ's power of invention - the objective here being to help each individual or each potential actor to speak out in positive terms on the subject of TRIZ of his own accord, reflecting on the control he has of it.

In our multi-disciplinary synthesis and proposal to make the problem linked to the introduction of TRIZ in western organisations evolve, we wanted to highlight some of the less visible barriers encountered during so-called "classic" TRIZ actions. They were sometimes latent in the actors we met in the companies, but nonetheless explain why many a determination to implement TRIZ in a collective environment disappears. This contribution towards adoption modes purports to be perfectly coherent with the practices stemming from classic TRIZ methods and does not need a remodelling of the initial scientific models to be accepted more easily. Of course, such situations would generate a drop in the relevance of the development because the basis would be a compromise in terms of the originality of the method. And yet, the basic rules presented in this article together with the recommended adoption approach hold their share of chance. This is a well-known factor in the human sciences as there is no guarantee at any time that an action directed towards the human mind will end in success, since it is highly unlikely that one can control the complexity of reactions to manipulation. And it is a question of manipulation here, although in a more positive meaning of the term, imposing a latent breakdown of the initial cognitive patterns and then rebuilding them so that they are properly in line with the acceptance of the fundamental principles of TRIZ. In all cases, we are involved here in approaches which depend on the idea that social legitimacy is based on discussion and debate which enable us to break down and rebuild collective representations. Consequently, one of the aims we are working towards is to see TRIZ practices develop in organisations with fewer difficulties than currently witnessed, and to see development strategies being built up and receiving an appropriate welcome because of their efficiency and convincing results which at last disclose the truth of Altshuller's clairvoyance when he started out on his crusade. But let us not forget that social legitimacy is first and foremost an issue of community thought and not just scientific thought.

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Profile of Lecturer

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1979-1980	Military service, Voluntary Service Overseas in Québec, Canada
1980-1982	Body-in-white Engineer at Automobiles PEUGEOT, Sochaux, France
1982-1985	Door Team Engineer at Automobiles PEUGEOT, Sochaux, France
1985-1986	Door Team Manager at Automobiles PEUGEOT, Sochaux, France
1987-1991	Director of Advance R&D Center at MAGNA International, Toronto, Canada
1991	Engineering Manager at MGI Coutier, Paris, France
1992-1995	Director of Engineering, Metal Division of MGI Coutier, Paris, France
1995	Vehicle Project Director at MGI Coutier, Paris, France
1996-2001	Director of Advance R&D Center at MGI Coutier, Altkirch, France
since 2001	Director R&D worldwide, Motor, Latch, Complete door, Electronics, W. Regulator at ArvinMeritor Door Systems Division, Sully-sur-Loire, France

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TRIZ Conference Presentation Summary
Observing opportunities of deployment through step-by-step involvement of actors

Chris RHODES / Dominique BENOIT, ArvinMeritor, France

This case study shows a recent application of TRIZ to solve a problem within an automotive context. The study was run by the Complete Door engineering team in the ArvinMeritor Light Vehicles division, in collaboration with INSA Strasbourg.

Consumers are becoming ever more demanding with regard to the reduction of noise within the passenger compartment of cars, with air noise at high speed being a particular problem. A major cause of air noise is the loss of contact between the door seal and car body, which occurs when speed generated aerodynamic pressure effects cause the upper section of the door to be 'sucked' outwards.

Current solutions to this problem include increasing the number of seal lines or using a motorised closure system to provide a very high initial closure pressure on the seals. Both have cost disadvantages and increasing the number of seal lines also increases the closure effort felt by the user. The goal was to improve noise reduction without compromising on cost or closure force.

Analysing the problem it became clear the seal was the element to improve as other factors were beyond the company's control. Using TRIZ tools two major concepts were identified. Firstly a system to eliminate inter-seal air circulation and increase contact lines without major cost or closure effort penalties. Secondly a self regulating inflatable seal system using an existing pressure differential to increase contact force without the need for any additional pump or compressed air supply. Both concepts escape from the traditional compromises by substantially increasing performance for little or no extra user effort and at negligible cost.

The inter-seal concept has already been tested in prototype form and demonstrates a very clear improvement over current systems. Patent protection has been applied for.

Résumé de la conference TRIZ
Déploiement de la théorie TRIZ sur l'application d'un problème automobile

Chris RHODES / Dominique BENOIT, ArvinMeritor, France

Cette étude de cas montre une application récente de TRIZ pour résoudre un problème dans un contexte automobile. L'étude a été dirigée par l'équipe Porte Complète de la division Door Systems d'ArvinMeritor, en collaboration avec l'INSA Strasbourg.

Les consommateurs deviennent de plus en plus exigeants en ce qui concerne la réduction de bruit dans l'habitacle, avec le bruit aérien à grande vitesse en particulier. Une cause principale de bruit aérien est la perte de contact entre le joint de porte et la caisse, ce qui arrive lorsque la vitesse produit des effets de pression aérodynamiques qui déforment la section supérieure de la porte vers l'extérieur par un effet de "succion".

Les solutions actuelles à ce problème incluent l'augmentation du nombre de lignes de joints ou l'utilisation d'un système de fermeture motorisé pour fournir une très haute pression de fermeture initiale sur les joints. Ces deux solutions ont des inconvénients, d'une part sur le prix, d'autre part sur l'augmentation du nombre de lignes de joint, ce qui augmente aussi l'effort de fermeture qui est ressenti par l'utilisateur. Le but de cette étude était la réduction sonore sans accepter de compromis sur la force de fermeture ou sur le coût.

Lors de l'analyse du problème il est devenu clair que le joint était l'élément à améliorer parce que les autres facteurs étaient au-delà du contrôle d'ArvinMeritor. En utilisant TRIZ, deux concepts principaux ont été identifiés. Premièrement un système pour éliminer la circulation d'air entre les joints ("inter-seal") ainsi que l'augmentation des lignes de contact sans accroissement du coût ni de l'effort de fermeture. Deuxièmement, la solution d'un joint auto gonflable utilisant un différentiel de pression existant pour augmenter la force de contact, ceci sans le besoin d'une pompe complémentaire ou d'une provision d'air comprimé. Les deux concepts s'échappent des compromis traditionnels tout en augmentant considérablement la performance, et cela avec peu ou pas d'effort supplémentaire pour l'utilisateur, le tout pour un surcoût négligeable.

Le concept " inter-seal" a déjà été évalué par le moyen d'un prototype et démontre une amélioration sensible par rapport aux systèmes actuels. Un brevet est en cours de dépôt.

Vehicle soundproofing : Improved door seal

Dominique BENOIT,
(Director R&D worldwide)
Chris RHODES,
(New Products Engineer)

ArvinMeritor Door Systems Division,
(Sully-sur-Loire, France)

Aachen, 13th November, 2003

TRIZ FUTURE 2003 ArvinMeritor

Figure 1

Company Background

ArvinMeritor

Meritor Automotive and Arvin Industries merged on July 7th, 2000 :

- **Turnover of 6.9 billion dollars**
- **Headquarters in Troy (Michigan, USA)**
- **32,000 employees**
- **150 manufacturing facilites located in 27 countries.**

TRIZ FUTURE 2003 ArvinMeritor

Figure 2

Company Background

Products - Light Vehicle Systems

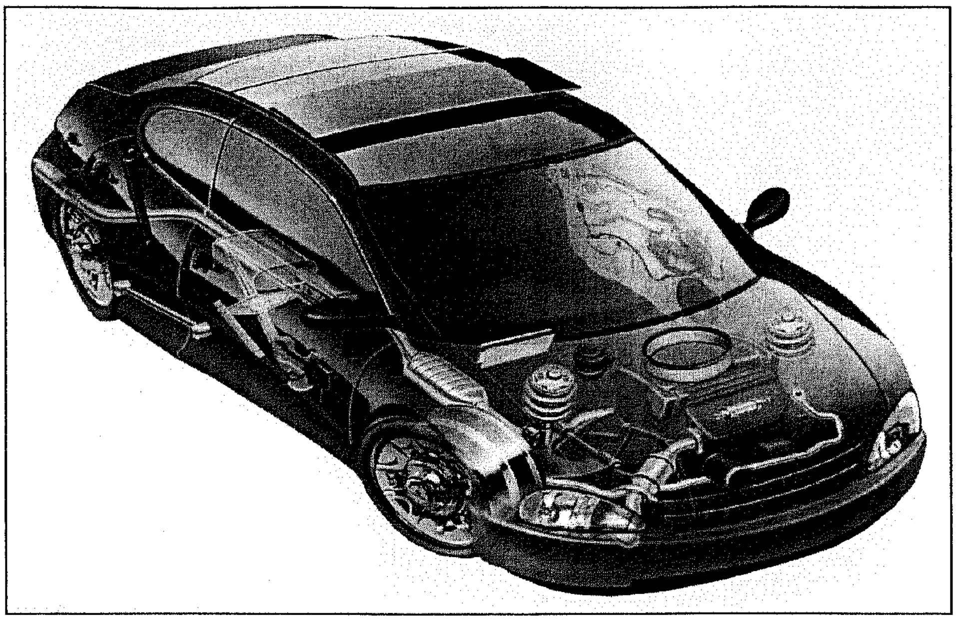

Figure 3

Company Background

Door Systems

Oct. 2002

Figure 4

Company Background

Door Systems

(Million units)

- Complete doors 0,600
- Door modules 4,968
- Window regulators 27,232
  - arm & sector 8,703
  - drum & cables 17,015
  - push pull 1,514
- Electric motors 13,181

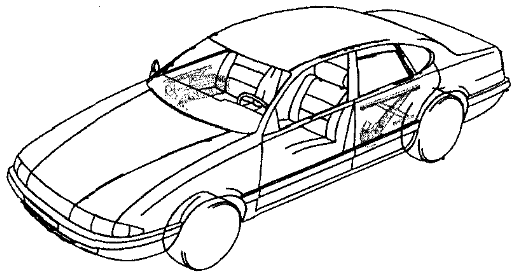

Figure 5

Company Background

Door Systems

Product Strategy

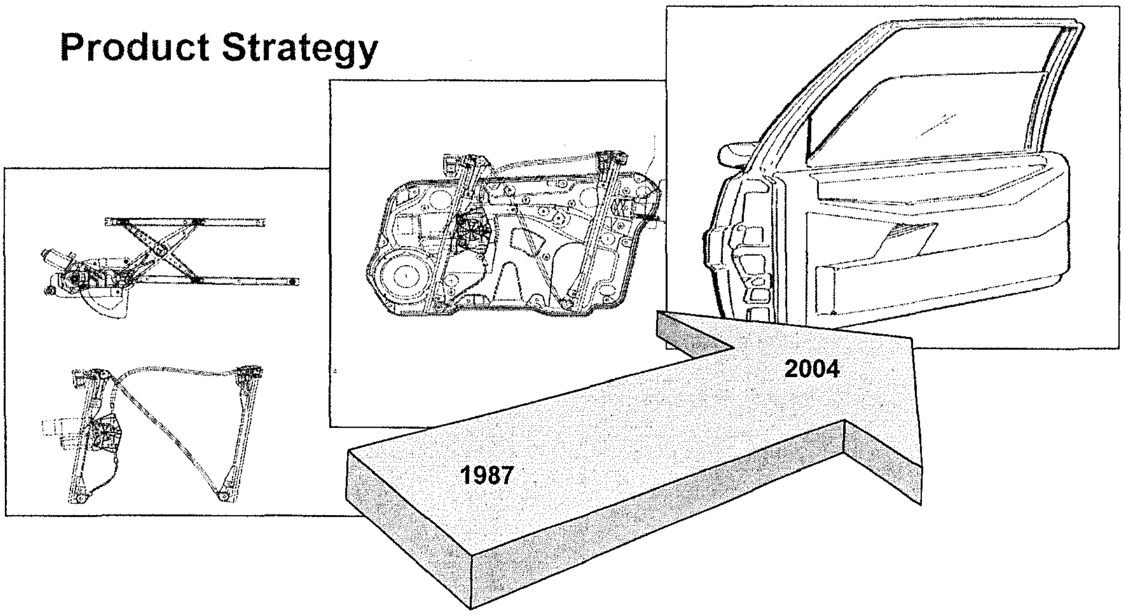

Figure 6

University Collaboration

- **Company new to TRIZ**
- **Collaboration with INSA Strasbourg**
  - guidance from TRIZ experts
- **Final year student engineering project**

Figure 7

TRIZ at ArvinMeritor

• **Introduced by D. Benoit**	**2001**
• **2 day awareness raising**	**2001**
• **Training on TechOptimiser**	**2002**
• **2 university assisted projects**	**2002/3**
• **Continuing projects**	**2004...Future**

Figure 8

Problem

- Consumer demand for soundproofing
- Wind noise common at high speed
- **Objective**: Reduce noise in vehicle

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Figure 9

Aerodynamic Turbulence

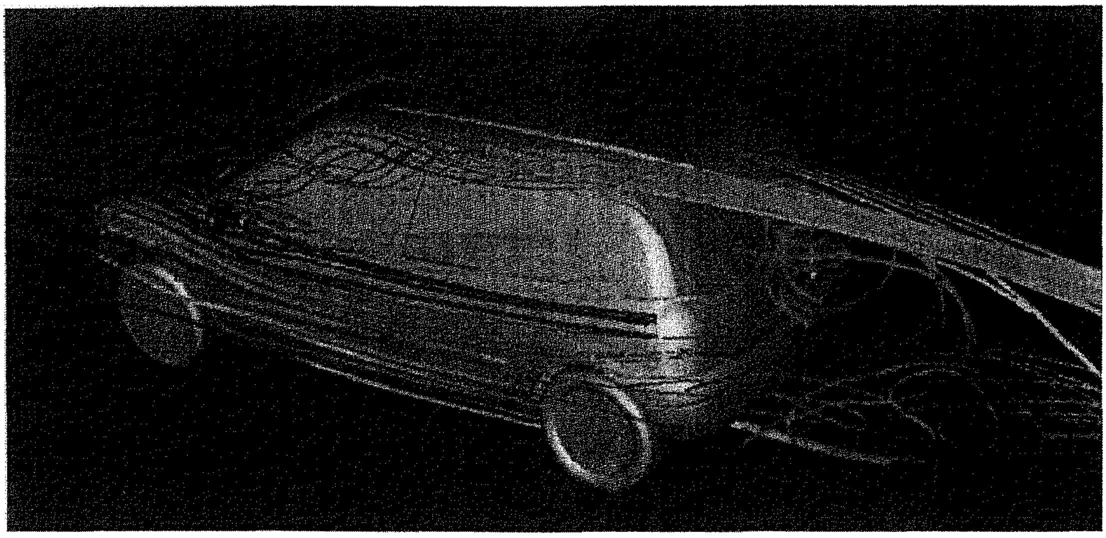

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Figure 10

Door Movement

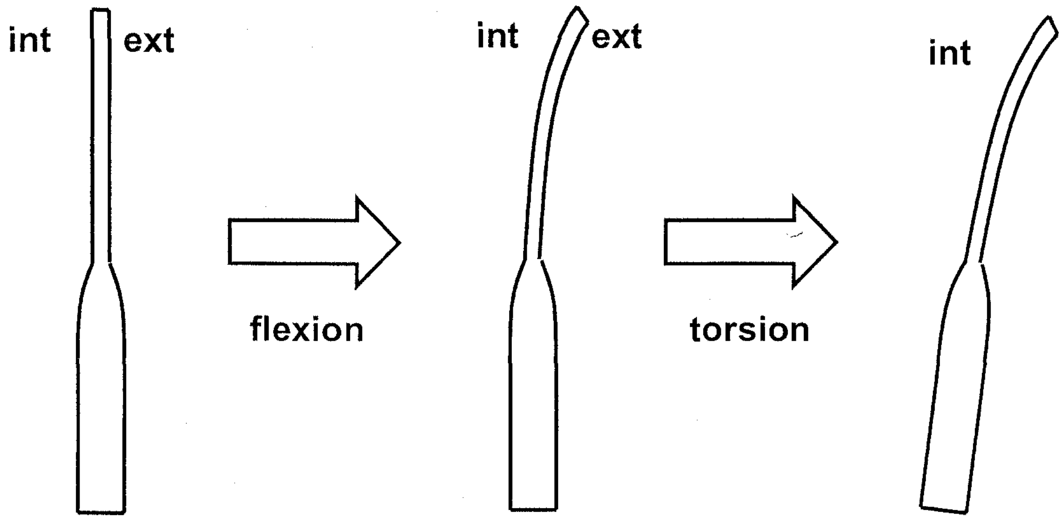


Figure 11

Door Interior Acoustics

High Frequency Image

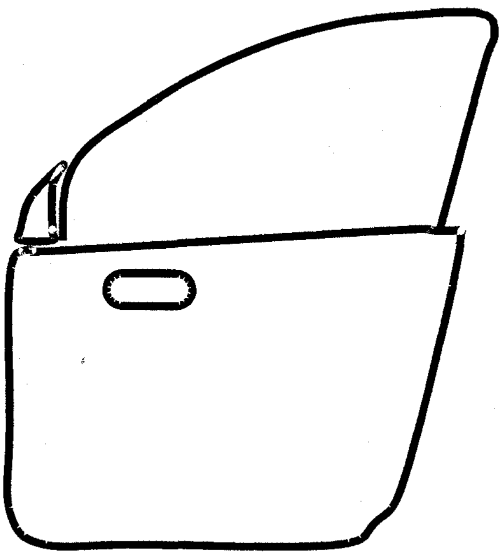


Figure 12

Door Interior Acoustics

High Frequency Image

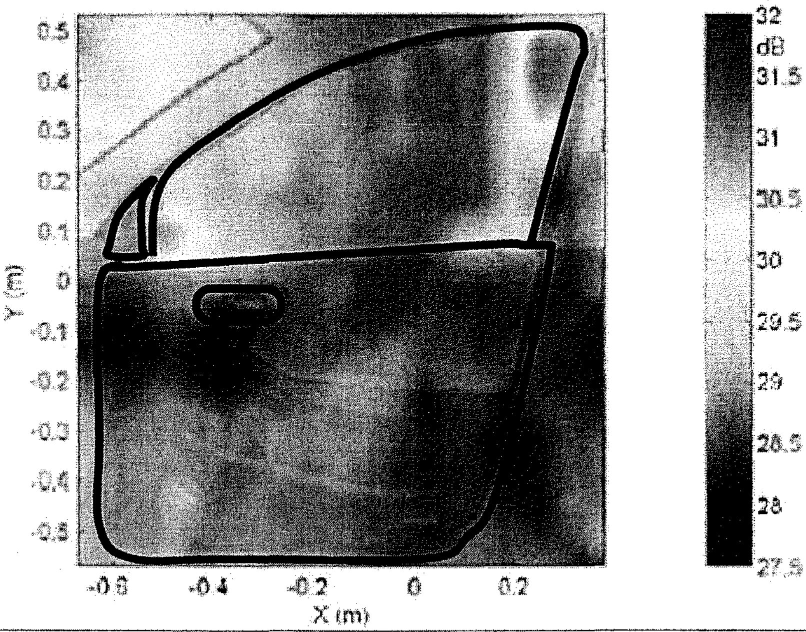


Figure 13

Door Interior Acoustics

High Frequency Image

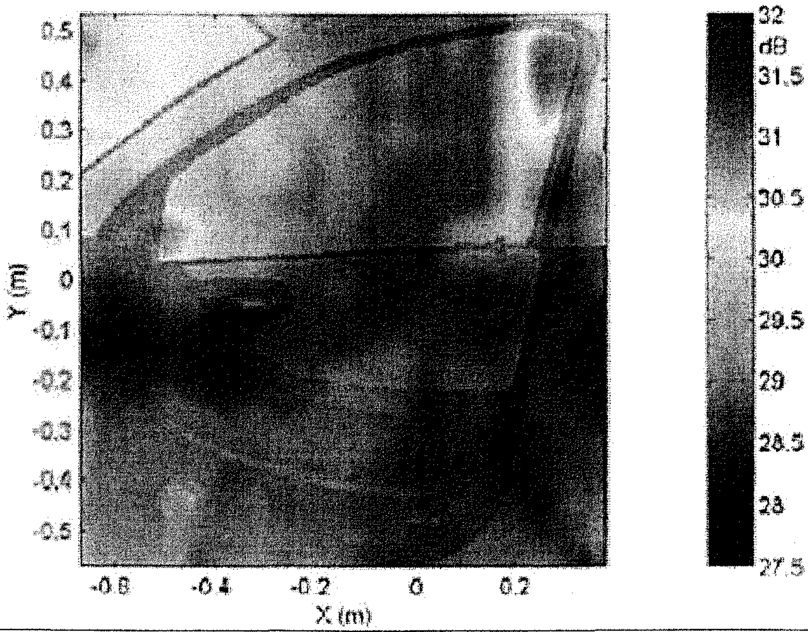


Figure 14

Typical 2 Line Sealing

Figure 15

Seal X Section

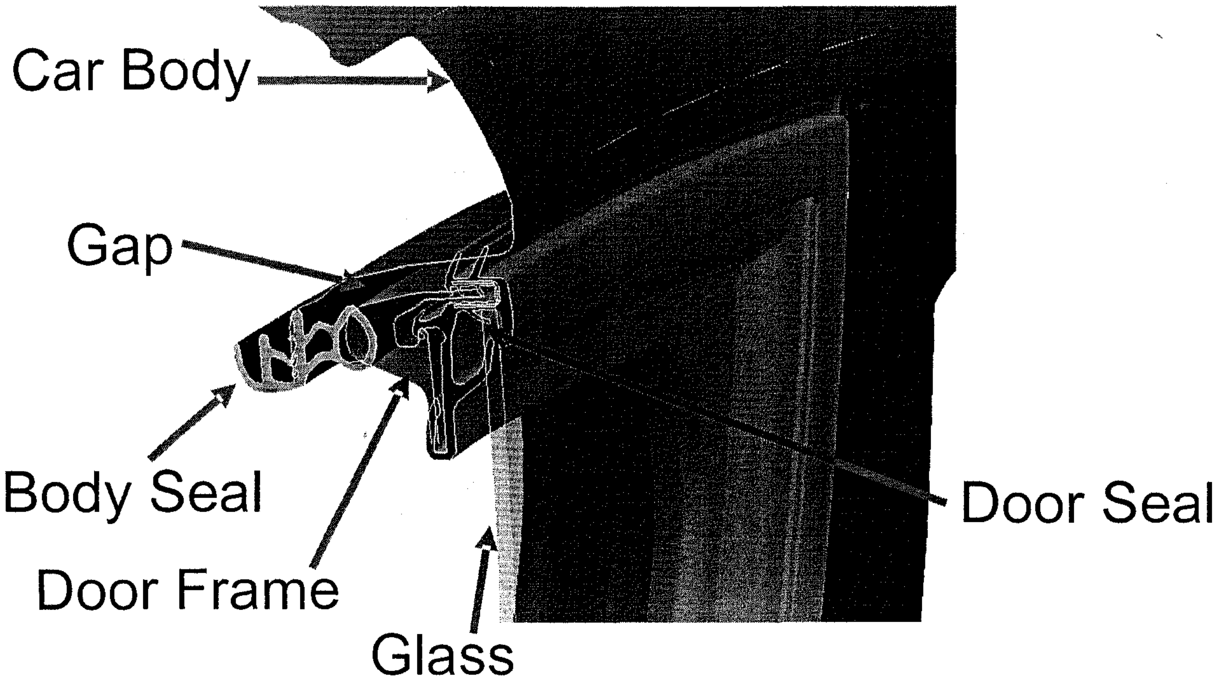


Figure 16

Door Rotation

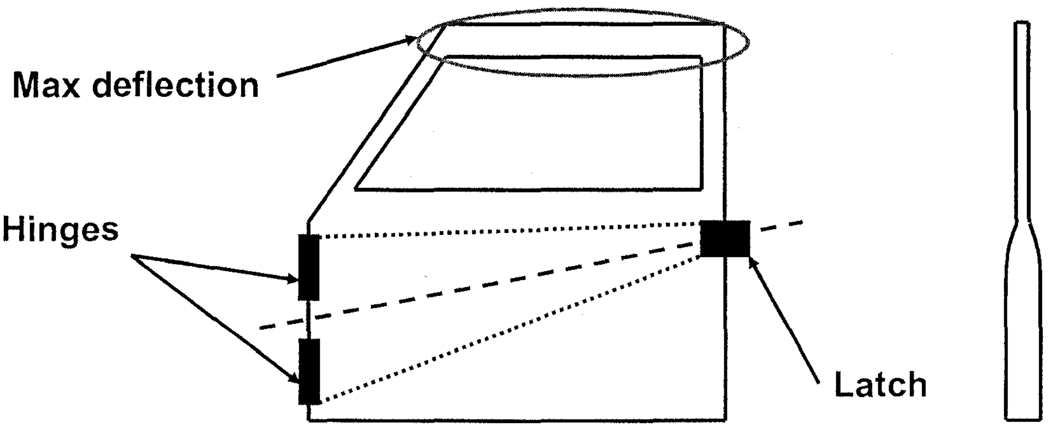


Figure 17

Criteria Used to Assess Seals

- Water + sound + dust barrier
- Closure energy
- Ageing
- Cost
- Visual effect

Figure 18

Abstraction

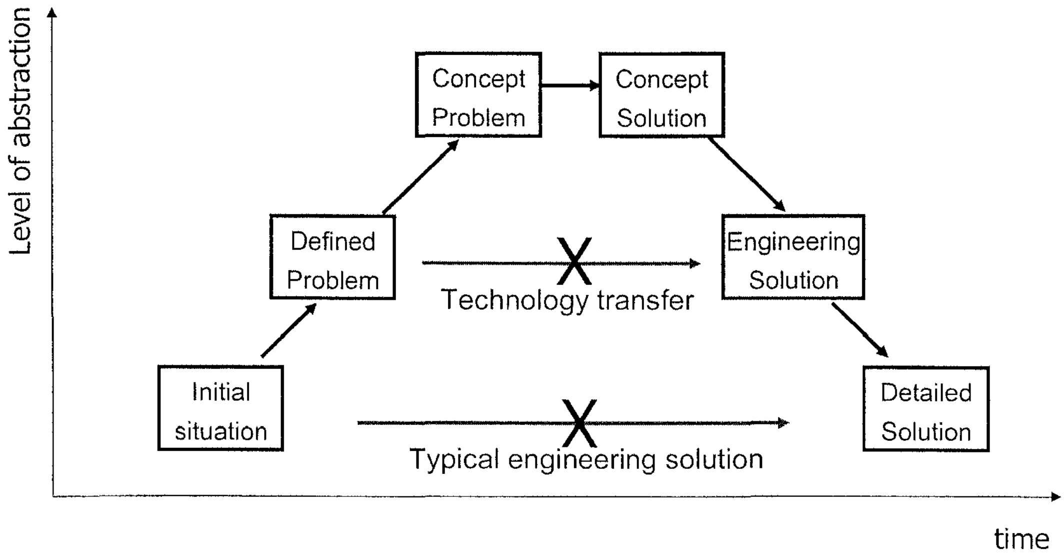


Figure 19

TRIZ Method

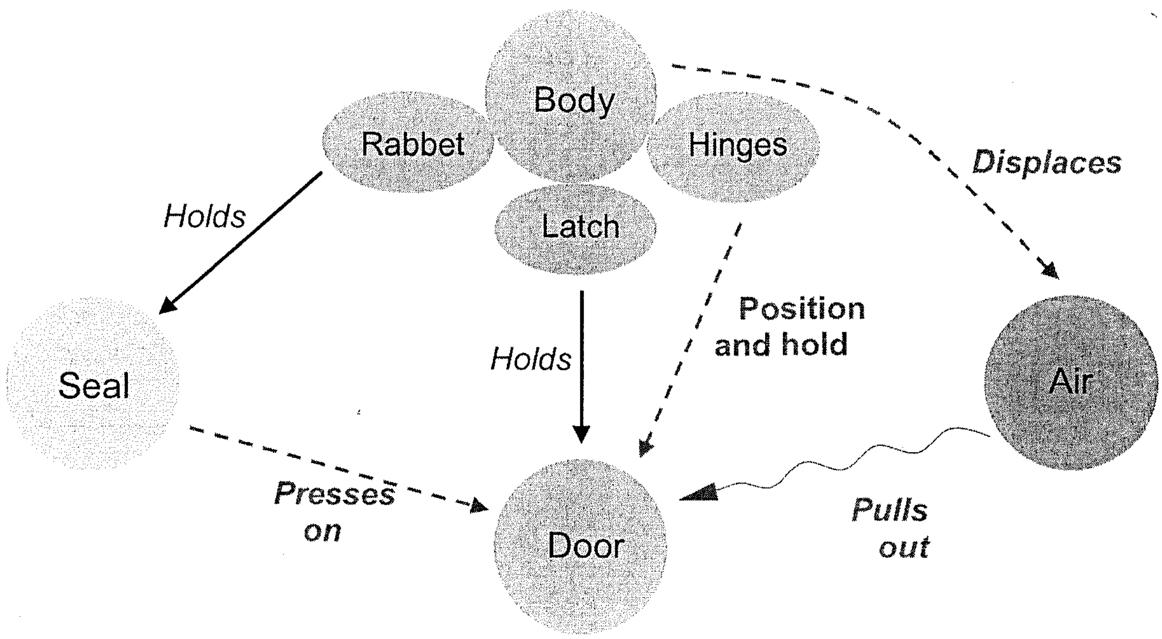
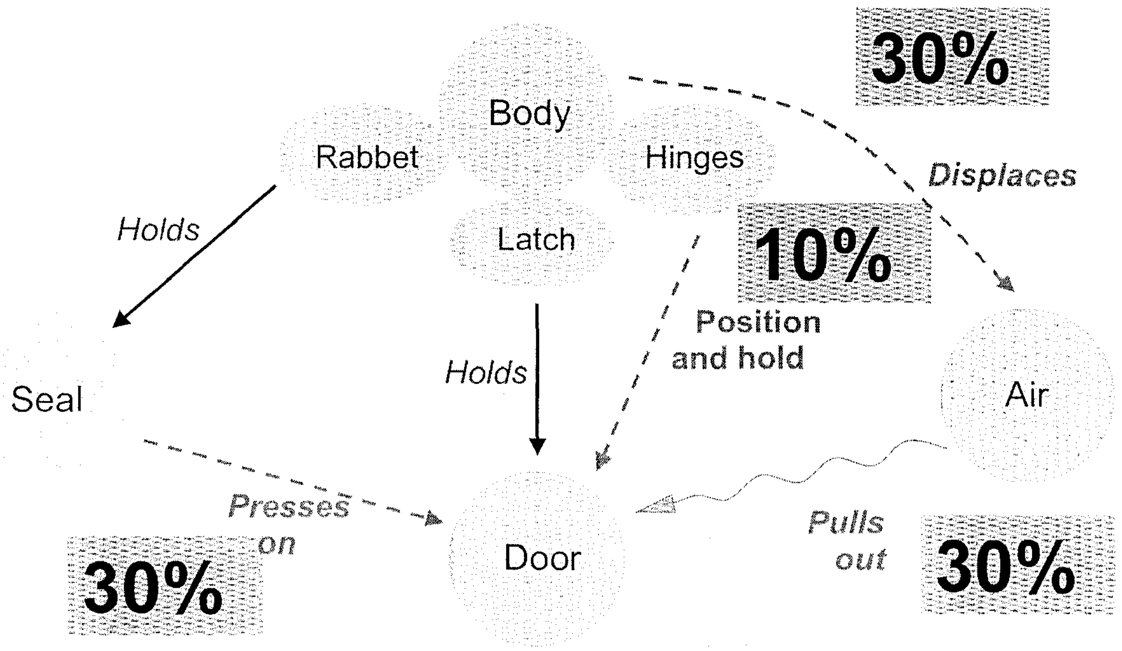


Figure 20

TRIZ Method



Ideal Final Result

- Function maintained without system
- No seal
- Door/Body interface ensures sound and water proofing

Laws of Evolution

Potential for improvement

- **Transmission of Energy**
  - aging of the seal
- **Harmonisation**
  - loss of contact
  - seal profile
- **Ideal System**
  - 3 line sealing => penalties

Figure 23

Technical Contradictions

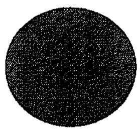
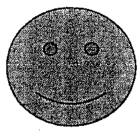
		
+ Seal density	Aging	Noise damping
+ Seal thickness	Closure effort	Noise damping
+ Nº lines	Cost + Closure effort	Noise damping

Figure 24

Physical Contradictions

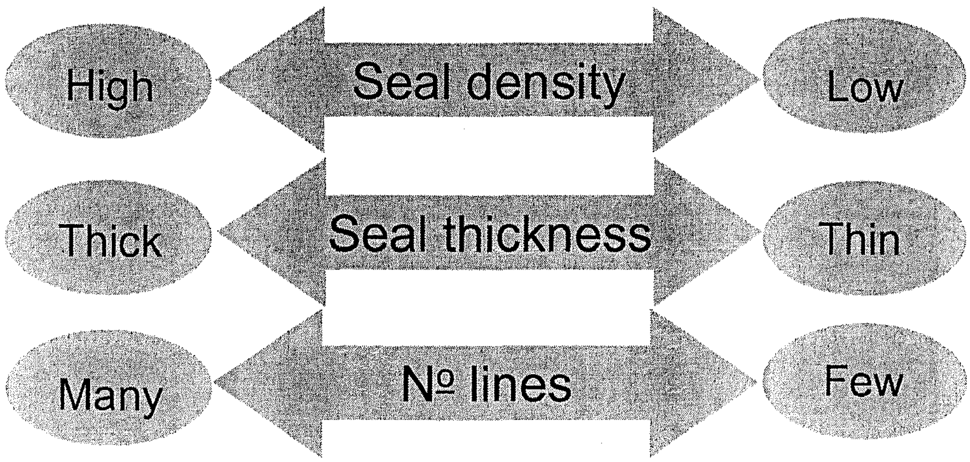


Figure 25

Separation in Space

- Target upper frame
  - Close to ear
  - Saves seal length

Resource

Constant section in frame

Figure 26

Separation in Time

	Stationary	High Speed
Noise		
Closure effort		

•Seal force should vary with speed

Resources

Speed (aerodynamic effects)

Closure effort

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Figure 27

Concepts => Technical Solutions

- 3rd line in upper frame
- Need to block air circulation between seals
- Designs to
  - reduce aging effect
  - Minimise closure effort
  - Respect styling

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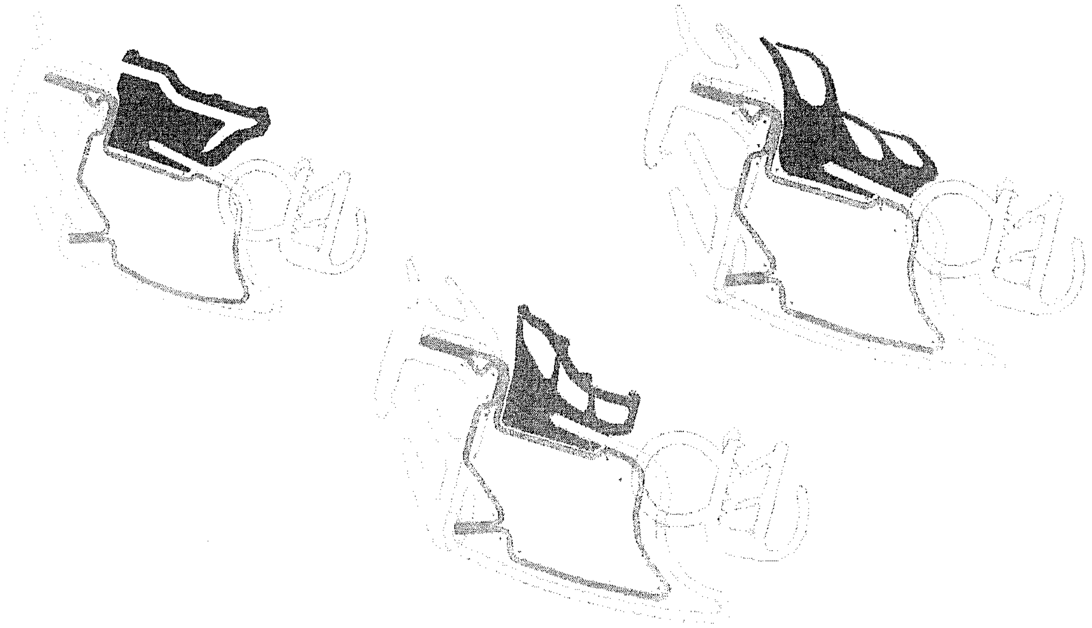
Figure 28

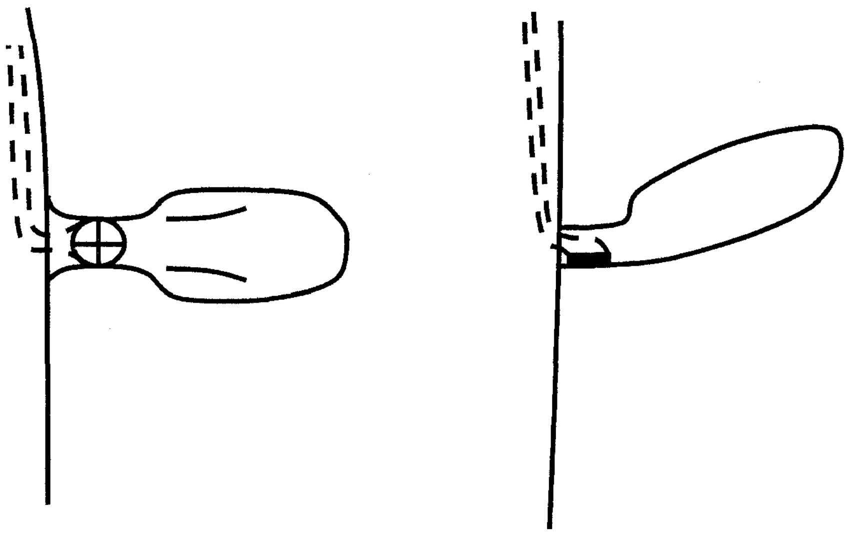
Concepts => Technical Solutions



Concepts => Technical Solutions

- Seal pressure change according to speed
- Concepts
  - Use existing speed induced pressure differential
  - Use door closure effort

Concepts => Technical Solutions



Inflatable seal air intake

Concept Comparison

	Current System	Multiline Seal	Inflated Seal	Deflated Seal
Style	0	-	-	-
Wear resistance	0	-	0	0
Water seal	0	+	0	+
Noise reduction	0	+	+	+
Aging	0	0	+ +	0
Closure effort	0	-	+	+
Assembly	0	+	0	-
Manufacturing	0	+	-	-
Cost	0	0	-	- -
Risk	0	0	- -	- -

Validation

- Road tests
- Foam blocked inter-seal gap
- 90km/h
  - -13% to -19%
  - -0.6 to -0.9dB
- 130km/h
  - -30% aprox

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Figure 33

Intellectual Property

- Many patents on inflatable joints
  - None found using speed to generate pressure
  - No known systems in production
- No patents found on interseal system
- Patents applied for

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Figure 34

Summary

Compared to current system the new concept has:

- Better noise attenuation
- Fewer aging related problems
- Better waterproofing
- Reduced cost

Conclusions

Use of TRIZ techniques permitted:

- No compromise
- Original concepts
- Solutions with different risk levels

Acknowledgements

Yves Stoeffler

Denis Cavallucci

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Figure 37

Questions

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Figure 38

Profile of Lecturer

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- Studied mechanical engineering in Moscow (Russia) and electrical engineering in Hanover (Germany).
- Worked five years as a developer and head of electrical and software development department (high speed packaging machines).
- Since 1998 TriSolver Group consultant and head of TriSolver software development department.
- TRIZ experience in software development, research and problem solving projects since 1997.

Levels of TRIZ support for the innovation and problem solving projects in the automotive industry

Dennis Murnikow
TriSolver Group Germany - www.trisolver.com

Introduction:

TRIZ is already recognized from broad range of German companies as a powerful tool for solving innovation tasks more efficient. Especially automotive industry can boast a lot of experience of integrating TRIZ into the innovation process. This conference contribution will show the most common way which currently is being applied in Germany from both car manufactures and their suppliers.

This article uses five general innovation steps as a path map for illustrating the best praxis of TRIZ support and also the levels of this support due to specific innovation projects.

Typical types of innovation projects are:

A. New product or product features development
The most comprehensive type, which includes all five steps:

- Formulating the innovation tasks
- Analyzing initial situation (current technical system)
- Solving problem (idea generation)
- Evaluating ideas
- Developing and evaluating concepts

B. Improvements of the entire technical system
Innovation task (e.g. cost optimization of the system) is already clear and the formulating is not necessary:

- Analyzing initial situation (current technical system)
- Solving problem (idea generation)
- Evaluating ideas
- Developing and evaluating concepts

C. Small system modifications
The shortest type of the innovation project, but also the most frequent one consists only of one step:

- Solving problem (idea generation)

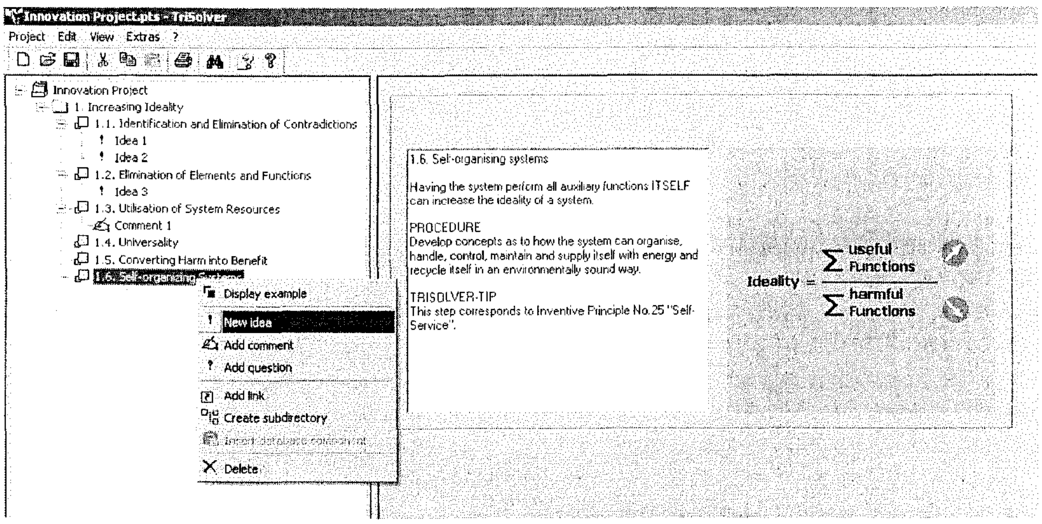
This article describes this support on example of **A** "New product development". **B** and **C** types are actually the sup-steps and the description of the TRIZ-support for them could be extracted from the description the most comprehensive type "New product development".

1. Formulating the innovation tasks.

This step is crucial for the entire innovation process.
Focusing development on the "wrong" tasks leads to the situation that 50% to 90% of all product initiatives are abandoned or fail.

Technical driven innovation

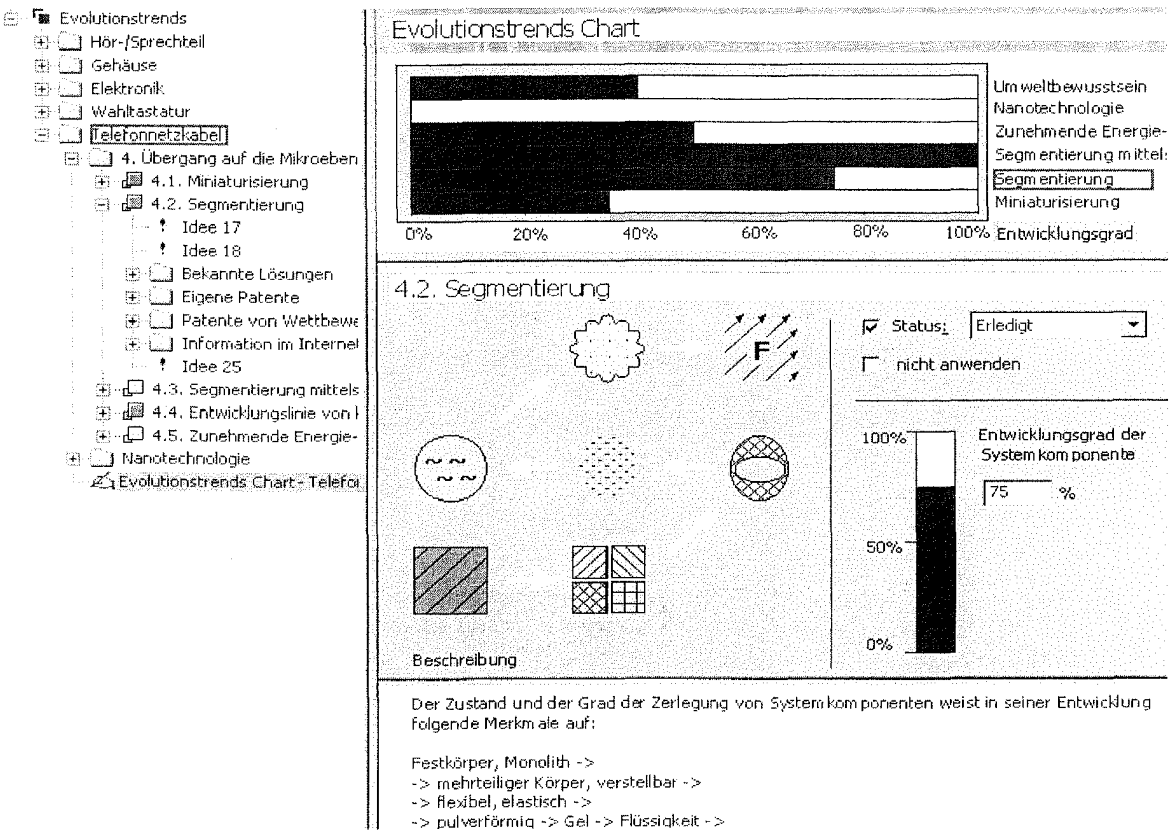
"What tasks should be solved?" Or "What tasks are most important ones?"
Present TRIZ can't deliver direct answer to these questions. Well-known, but in praxis relatively seldom used approach is deriving the innovation strategy from TRIZ's "Patterns of Evolution" [2], which allow to forecast the next stages of evolution of technical systems and to choose the most perspective direction for the product development.



Example: Working with Patterns of Evolution in TriSolver Software
The most practicable way for application of Evolution Patterns is to work on the level of the system components. It contains these main steps:

- Choosing system components for analyzing of the development/evolution potential
- Choosing evolution trends for evaluation (TRIZ or common trends)
- Creating the Evolution Checklist
- Capturing the grade of system components development due to each trend of evolution
- Evaluating results, defining development strategy

This approach results in a chart "Trend- Equalizer" which helps to overview the areas of opportunities (white areas in the chart) for the technical system development for each system component. Classical TRIZ Evolution Patterns could be extended through the common trends in society and science (e.g. using of nanotechnology, saving of the environmental resources, etc.).



Evaluation of results with Trend- Equalizer.
Limitations in practical use of this approach in industry:

- Complexity of use (highest TRIZ qualification needed)
- Amount of time needed for the forecast
- Innovation is "technically driven" and don't reflect the true market needs

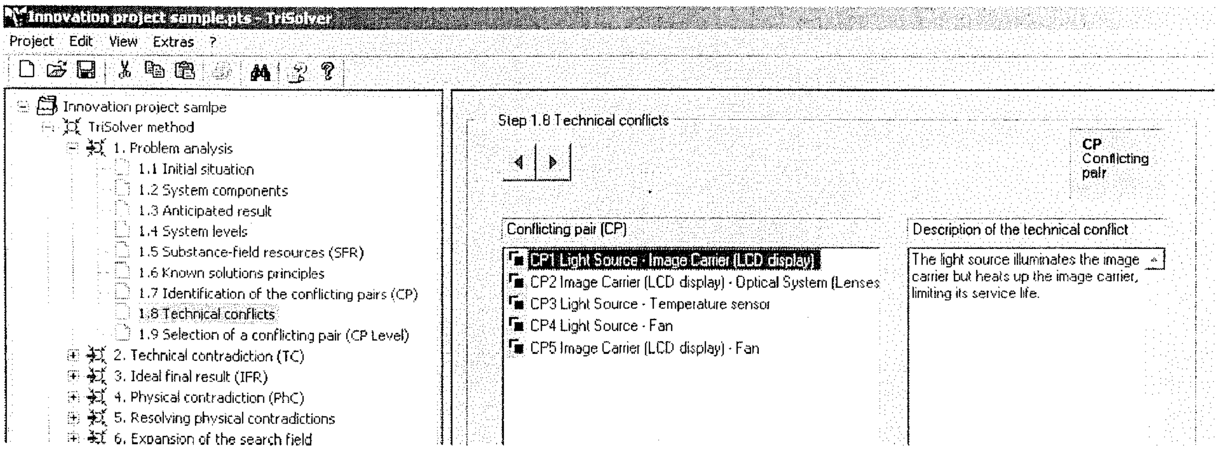
Customer benefits driven innovation
"What tasks should be solved?" Or "What tasks are most important ones?"
Experience of TriSolver Group proves that the best way to answer these questions is to "delegate" them to the customers. TriSolver market research method [5, 6] allows to determine true customer needs and to present them in form of prioritized list of customer benefits (innovation tasks). This approach results in controllable and systematic innovation process with a measurable and predictable market success.

Combinational approach
Combination of this both approaches (technical and market oriented) leads to the most reliable result, but because of high time expenditures is seldom used in praxis.

In spite of having strong TRIZ background TriSolver Group acknowledge that TRIZ Evolution Patterns should play the secondary role in this combination and warn of choosing the way of pure technical innovation without confirming the strategy on the market.

2. Analyzing initial situation (current technical system).

Independent from technical area and complexity of the innovation task the first part of ARIZ helps to get clear picture of the initial situation.



The TriSolver Method - based on the proven Inventive Algorithm ARIZ-85, is an algorithmic method for the systematic and comprehensive solution of inventive problems.

For corporate TRIZ use the software support plays the special role. It helps to save time for creative work with clear guiding through the algorithm and to gather and structure all project related information on one place. Working with the software, developer teams also automatically create electronic documentation of the entire innovation process. This documentation is vital for complex, long-term projects with big teams. It helps to integrate new team members and to get involved in the current project situation very quickly and to continue the work also after weeks of break.

Depending on the technical system and the innovation task Problem Analysis with ARIZ could take one till three days/workshops. Spending such amount of time analyzing initial situation is not very typical for many industrial companies. But after making first experience with TRIZ and getting excellent results the understanding of necessity for such time investment grows rapidly and becomes a common praxis.

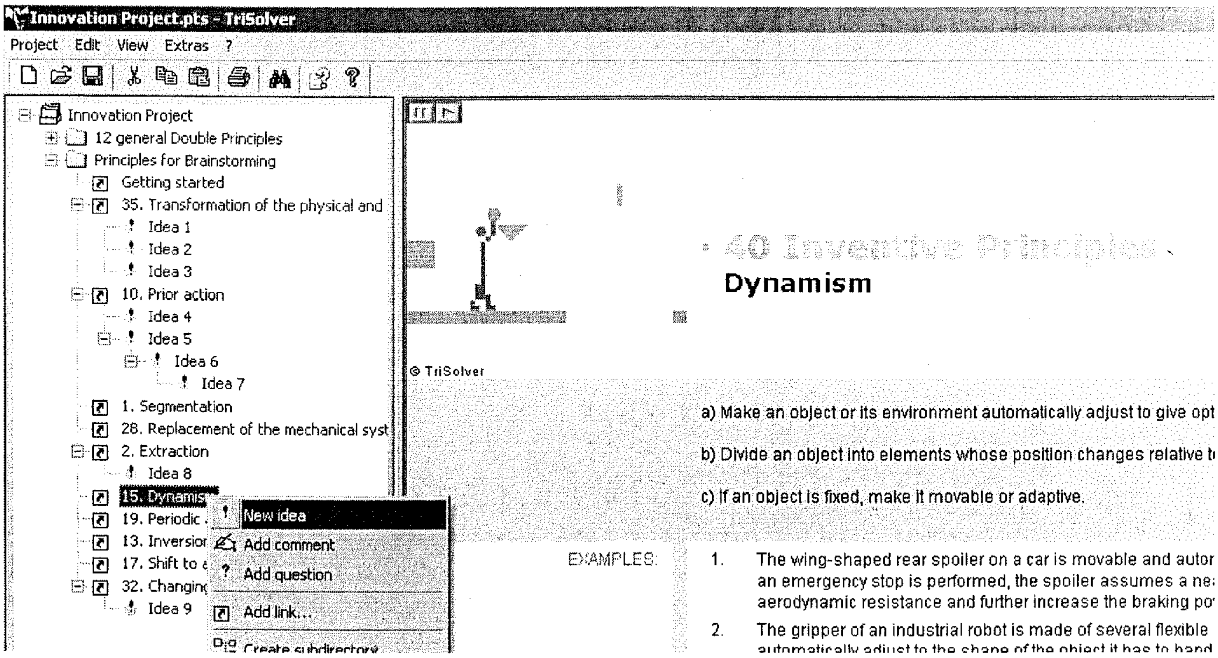
Additionally time expenditures of developer teams could be optimized if several internal or external TRIZ experts provide labor-intensive preparation-work. In this case other team members just get involved in the situation at the beginning of the workshop, supplement the information with their feedback and go to the next step of the innovation project – Idea Generation.

3. Solving problem (idea generation).

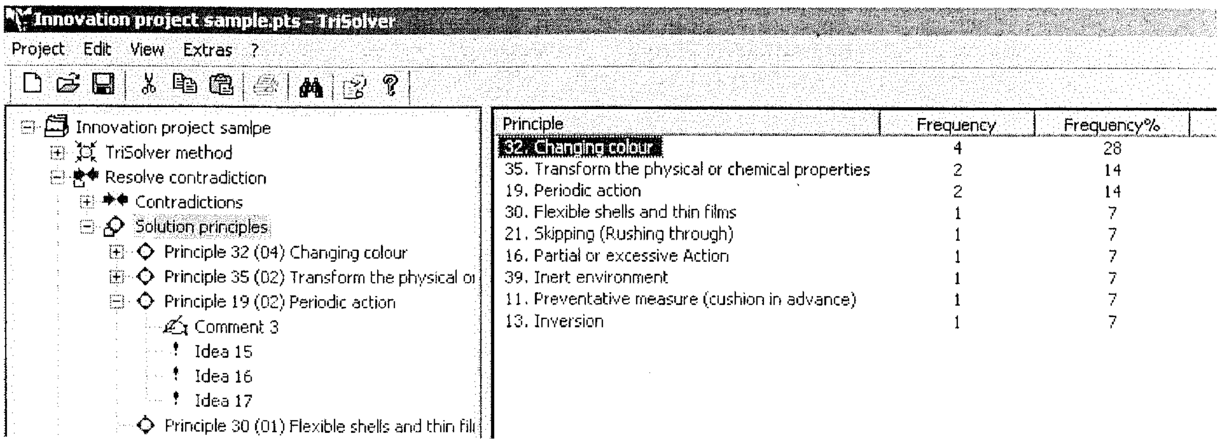
Level of TRIZ support in this step strongly depends on the TRIZ knowledge level of the whole project team. One TRIZ expert for workshop moderation is not enough in order to enable the efficient use of all TRIZ tools for the whole project team. The most typical situation is that team members with essential know-how about the technical system do not have TRIZ knowledge at all.

In this case idea generation proceed according to following pattern:

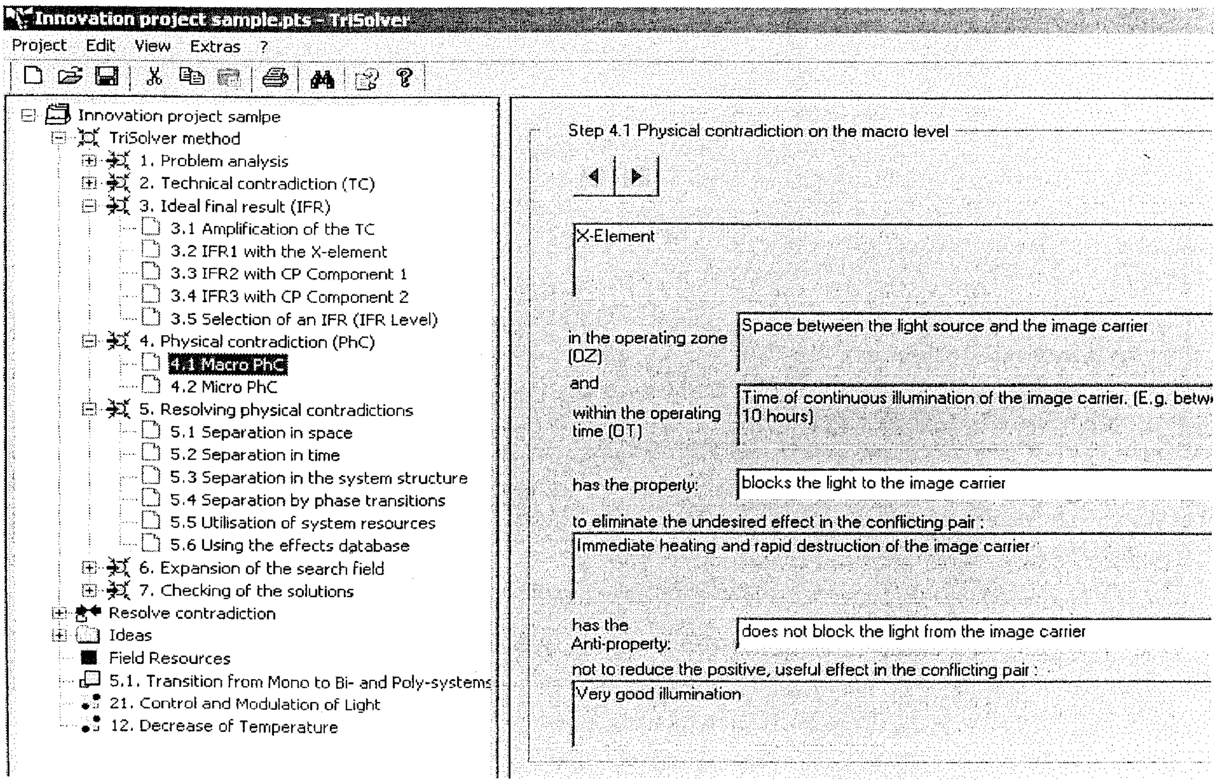
- After a short introduction all team members are able to work with 40 inventive principles. Divided in small groups, workshop participants generate ideas for solving contradictions found in conflicting pairs during the analyzing of initial situation.
- Our experience proves that the direct use of 40 inventive principles could bring excellent results. Each developer group works with pre-selected group of principles. E.g. Principles for Brainstorming in TriSolver Basic Edition:



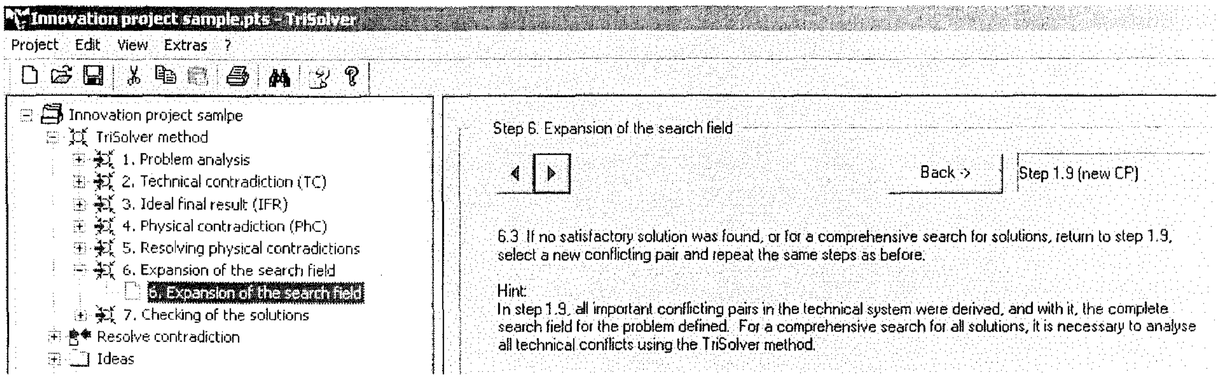
- On this step contradiction table can be used for focusing the search field. In case of non-trained team members the workshop moderator (internal or external TRIZ expert) should support the process of formulating contradictions.



- If team members are unsatisfied with achieved results the work with ARIZ should be continued. TRIZ-Expert leads the team till the formulation of the physical contradiction for the most important conflicting pair. A short introduction about the application of the TRIZ Separation Principles enables the entire project team to participate in idea generation. However using of TRIZ Standard Solutions can only unfold its power in a TRIZ-trained team.



For specific innovation tasks (e.g. complete search for solutions) TriSolver Method additionally enables expanding the solution search field through structural step-by-step support for analyzing all found conflicting pairs [1].
Complete Search is relatively seldom used praxis, because of high time expenditures and the fact that in the most cases teams are able to find acceptable results already after working with 40 Inventive Principles.

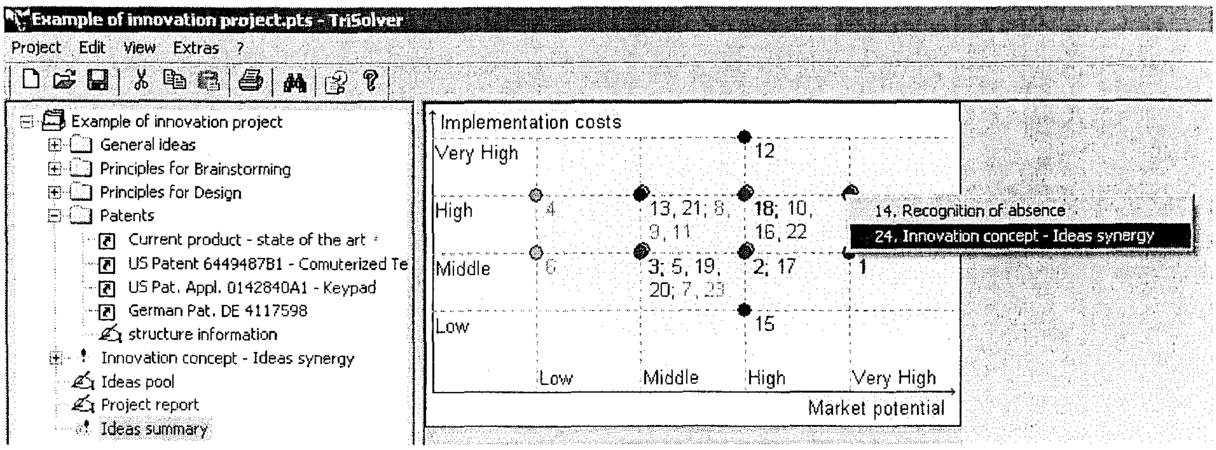


Complete search for solutions in TriSolver 2.2 Professional Edition

4, 5. Evaluating ideas and Formulating and evaluating concepts.

These two extremely important steps of innovation projects have to “get on” almost without direct TRIZ support. The approaches for evaluating are different and company-specific, but generally the most of them contain up to two parameters for idea/concept value (e.g. Market Potential, Priority) and several parameters for costs and risks of idea implementation (e.g. Implementation Costs or/and Implementation Risk, etc).

E.g. Idea portfolio with TriSolver Software:



Alternative approach for customer benefits driven innovation enables to calculate the added value of each idea or concept [5, 6].

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TRIZ CASES STUDY IN VOLKSWAGEN OF MEXICO

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ABSTRACT

Volkswagen of Mexico S.A. of C.V, the well-known german automotive industry is one of the most important entreprise using TRIZ methodology to improve processes of production. The line of foundry manufacture for one of its safety spare part, the steering knuckle, has presented since its beginning divers quality and operation problems. It is a strategic piece for the security of the passengers in cars since it is closely interacting with the direction, the shock absorbers and with the front wheels. Two great problems have been accurately identified: one is the slag and the other one is referring with sand system for the manufacture of molds. The matrix of Altshuller, a key milestone in the TRIZ methodology for innovation technology has allowed to help, for proposals of valuable and sustainable solutions, to solve these great problems that cause other that originates scraps causes, such as the "solidification shrinkage", "sand rain" or " porosity" all causes of a high percentage of scraps or reworks. In this paper, problems to be solved in both areas will be analyzed. This problem was already published in march and april 2002 edition of triz-journal. Nowadays, there are more interesting cases, mainly in the line of engines, thanks to a complete course about TRIZ in this automotive industry [4]

INTRODUCTION

The Volkswagen firm at Mexico is one of the most important automotive industries around the country and is conformed to a great amount of industrial ships and diverse processes of production that conform everything an industrial system that makes the manufacture possible of the different automobiles that at the present time are sold in the country. The macro-industry of more than 12,000 workers has produced more than 5 million units in more than 30 years of constituted and uses the most modern methods of production and the most advanced management quality systems. This entreprise is located in Puebla close to the famous pick "popocatépetl" and at only 80 miles from Mexico City. [8]

The steering knuckle is an important sparepart of the vehicle that allows to fix the front wheels brakes, the motion of direction, the fixation of the shock absorber and the axis of impulsion. This

piece is of safety importance whereas it is subject to diverse types of strengs in different directions and must strictly fulfill the design-required parameters.
This piece is made with ductile iron. After a magnesium-based reaction, the iron is impregnated with infinity of nodules that present at the microscopic level the appearance of spherical bubbles that allow for ductility and resistance to the tensions. It induces an extraordinary resistance to the breakage and/or the flexion. For that reason, it is necessary this process of reaction in addition to certain substances that are added such as carbon, silcon and other that give the required properties of security to the piece. [4]

THE PROCESS

The production in the foundry manufacturing line begins with the induction furnaces that are fed mainly with new material, material of return and the scrap pieces. These furnaces molt and mix the material with other necessary substances for the casting process (temperature upper than 1400°C). Later, the iron-base is put under a reaction process using magnesium in order to form nodules that allow it to acquire certain physical properties of ductility. It allows to manufacture a piece whose function is associated to diverse efforts and tensions that cause their critical parameters and its meticulous control. Then the casting process is performed. A casting is a metal part formed by pouring molten metal into a sand mold. The mold is comprised of two halves that form a cavity into which the molten metal is poured. The mold forms the external surface of the casting. If an internal cavity is required in the casting, a core is placed inside the mold cavity. It is the case of our piece.
After the metal solidifies, the mold is broken, the core removed and the part is ready for finishing operations. The sand is then remolded, prepared and used again in a cyclic process. [4]
Then there is a cooling process and it strips, there are two pieces by drained, a right and a left one, totally symmetrical that separate of the 'branch' that serves as joint between both pieces which is known like return material. At the same time the sand recovers to be reused through a transportation band until the sand tower where it has already been treated with water in order to fulfill the required humidity. It has also been added some pre-mixed substances that give to the sand agglutinates properties. The pieces, cold and clean are tested in laboratories to avoid that pieces out of specifications arrive at the machine process. Finally the pieces are rebabean. [4]

THE PROBLEMATIC SITUATION

The manufacturing line in its first foundry step of the steering knuckle has been recently started. It was implemented less than a year ago and since a lot of problems have had to be surpassing, being reflected in the high percentage of scraps and reworks increasing considerably the costs.
The main cause of these scraps are the 'solidification shrinkage', that it is a deformation of the piece because of the metal in fusion does not reach to fill the mold in certain points due to a premature cooling. Other cause is the 'sand rain' attributed to the molds that do not have the

properties with required humidity or agglutination and thus they are deformed at the moment of the casting. In addition to these two reasons that cause 90 % of scraps, there are also the porosity, the struck piece and others which causes are attributed to diverse reasons. Nevertheless, most of those problems may be eliminated or diminished if two great fundamental problems can be solved: the **slag and the return sand**. The excess of sand deposited in the hopper feeding the induction furnaces, impregnated in the return material is certainly the main cause. Using the Altshuller's matrix we will able to analyze these two great problems and we will try to propose a solution for each of them. In this paper we will analyze only the first problem. [4]

ANALYSIS OF THE PROBLEM

The slag is one of the most persistent problems; it is the impurities that are detected in the metal before the casting process. This problem is originated mainly in the material of return or the scraps pieces that are impregnated with an important amount of sand, as product of strips, which cannot be easily eliminated. The slag represents a contaminant element that is necessary to eliminate or to diminish before the casting process to avoid scraps. From the point of view of the Altshuller's matrix, we want to improve the adaptability of the metal, since the slag causes that the metal does not fulfill the wishing conditions for fluidity. Nevertheless, the main challenge is the natural effect of the high temperature and conditions of the process that prevent or make difficult any effective remedial action. The ideal solution is that the scraps pieces or the material of return do not contain sand at all, but it is a difficult task by the inherent conditions of the process. If we consulted the Altshuller's matrix in line 35 related to Adaptability and column 17 referring to Temperature, we find the numbers 2, 27, 3, 35 that correspond to the inventive principles suggested by the matrix. Each of them has been analyzed carefully in order to give the right answers. [5] [6]

Inventive principle 2. Taking out

A. Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.
   - *Locate a noisy compressor outside the building where compressed air is used.*
   - *Use fiber optics or a light pipe to separate the hot light source from the location where light is needed.*
   - *Use the sound of a barking dog, without the dog, as a burglar alarm. [11]*

Interpretation: The separation of the polluting elements that are accumulated in the superior part of the hoppers (Slag) must make with some special devices in the same way like takes off the cream from a glass of milk. This solution is in fact already practiced each day in order to control the excess of slag. Although this method is always of a partial way and it does not represent a really solution to the problem.

Inventive principle 27. Cheap short-living objects

B. Replace an inexpensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance).
   - *Use disposable paper objects to avoid the cost of cleaning and storing durable objects. Plastic cups in motels, disposable diapers, many kinds of medical supplies. [11]*

Interpretation: the addition of some component could neutralize the injurious effect of the slag, for example the use of salts or saline solutions that have a neutralizer effect and make easier the operation of extraction. This measurement is already considered and practiced in a regular way within the process, obtaining a significant decreasing of the problem.

Inventive Principle 3. Local quality

A. Change an object's structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.
   - *Use a temperature, density, or pressure gradient instead of constant temperature, density or pressure.*

B. Make each part of an object function in conditions most suitable for its operation.
   - *Lunch box with special compartments for hot and cold solid foods and for liquids*

C. Make each part of an object fulfill a different and useful function.
   - *Pencil with eraser*
   - *Hammer with nail puller*
   - *Multi-function tool that scales fish, acts as a pliers, a wire stripper, a flat-blade screwdriver, a Phillips screwdriver, manicure set, etc. [11]*

Interpretation. This principle suggests to avoid that the sand arrives at the furnaces or at least, it does not arrive in excess or if it arrives, that it is possible some reaction process in order that becomes operational or their effect is unnoticed.
Perhaps to obtain that some external agent allows avoiding the excess of sand in the furnaces. This problem will be analyzed in point 3 like one more contradiction.

Inventive principle 35. Parameter changes

A. Change an object's physical state (e.g. to a gas, liquid, or solid).
   - *Freeze the liquid centers of filled candies, then dip in melted chocolate, instead of handling the messy, gooey, hot liquid.*
   - *Transport oxygen or nitrogen or petroleum gas as a liquid, instead of a gas, to reduce volume.*

B. Change the concentration or consistency.
   - *Liquid hand soap is concentrated and more viscous than bar soap at the point of use, making it easier to dispense in the correct amount and more sanitary when shared by several people. [11]*

C. Change the degree of flexibility.

- *Use adjustable dampers to reduce the noise of parts falling into a container by restricting the motion of the walls of the container.*
- *Vulcanize rubber to change its flexibility and durability.*

D. Change the temperature.

- *Raise the temperature above the Curie point to change a ferromagnetic substance to a paramagnetic substance.*
- *Raise the temperature of food to cook it. (Changes taste, aroma, texture, chemical properties, etc.)*
- *Lower the temperature of medical specimens to preserve them for later analysis. [11]*

Interpretation: To obtain that the undesired material becomes more evident and manipulable in order to eliminate it with more facility. To use the effect of some chemical reaction to cause that all the impurities that cause problems ascend to the surface and make its elimination easier. This operation would be unnecessary if we managed to avoid that the sand arrives at the furnaces in excess.

Analysis of the problem of the non-adhered sand on the return material

Since the problem of the slag is mainly attributed to the high sand content, the problem must be presented in such a way that the possibility that the sand arrives at the furnaces does not exist or it arrives only in a minimal amount. The material of return as well as the scraps pieces are transported in freight elevators that in addition to the material cannot avoid to transport a great amount of sand non-adhered to the material. Let us say that the sand adhered to the material will require other methods of solution (point 4), but it is possible to avoid that the loosen sand arrives at the storage zone of the recovery pieces, being very difficult to eliminate it without increasing the cost of the process. Therefore the following situation exists: we would like to eliminate the undesired material during the transport process but the amount of material to transport prevents it; that is to say, the parameters are: line 33, **Ease of operation** and column 1, **Weight of a Mobil object**. The precognized inventive principles suggested by the matrix are: 25, 2, 13 and 15. Let us analyze carefully these principles and try to find answers adapted to our problem

Inventive principle 25. Self-service

A. Make an object serve itself by performing auxiliary helpful functions

- *A soda fountain pump that runs on the pressure of the carbon dioxide that is used to "fizz" the drinks. This assures that drinks will not be flat, and eliminates the need for sensors.*
- *Halogen lamps regenerate the filament during use--evaporated material is redeposited.*

- *To weld steel to aluminum, create an interface from alternating thin strips of the 2 materials. Cold weld the surface into a single unit with steel on one face and copper on the other, then use normal welding techniques to attach the steel object to the interface, and the interface to the aluminum. (This concept also has elements of Principle 24, Intermediary, and Principle 4, Asymmetry.)*

B. Use waste resources, energy, or substances.
   - *Use heat from a process to generate electricity: "Co-generation".*
   - *Use animal waste as fertilizer.*
   - *Use food and lawn waste to create compost. [11]*

Interpretation in the context of our problem: The own freight elevator must clean the return material during the transportation; that is to say, not only it has to transport but also it has to be able to clean it. This can be performed through some device of suction (aspiration) using its own calorific or electric power energy to avoid extra costs.

Inventive principle 2. Taking out

A. Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.
   - *Locate a noisy compressor outside the building where compressed air is used.*
   - *Use fiber optics or a light pipe to separate the hot light source from the location where light is needed.*
   - *Use the sound of a barking dog, without the dog, as a burglar alarm. [11]*

Interpretation: The extraction of the sand is confirmed with this principle as it was settled down in the previous principle.

Inventive principle 13. 'The other way round'

A. Invert the action used to solve the problem (e.g. instead of cooling an object, heat it).
   - *To loosen stuck parts, cool the inner part instead of heating the outer part.*
   - *Bring the mountain to Mohammed, instead of bringing Mohammed to the mountain.*

B. Make movable parts (or the external environment) fixed, and fixed parts movable).
   - *Rotate the part instead of the tool.*
   - *Moving sidewalk with standing people*
   - *Treadmill (for walking or running in place)*

C. Turn the object (or process) 'upside down'.
   - *Turn an assembly upside down to insert fasteners (especially screws).*
   - *Empty grain from containers (ship or railroad) by inverting them. [11]*

Interpretation: This principle suggests to undo of the leftover sand before the material is unloaded and not later, inverting the deposit, previously covered by a very resistant mesh that can load all the material, so that only the sand drains. Later the material without the protective mesh could be unload in the corresponding area.

Inventive principle 15. Dynamics

B. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.
    - *Adjustable steering wheel (or seat, or back support, or mirror position...)*

C. Divide an object into parts capable of movement relative to each other.
    - *The "butterfly" computer keyboard, (also demonstrates Principle 7, "Nested doll".)*

D. If an object (or process) is rigid or inflexible, make it movable or adaptive.
    - *The flexible boroscope for examining engines*
    - *The flexible sigmoidoscope, for medical examination [11]*

Interpretation: A double bottom of the return material deposit could be a good solution. The first bottom is a solid surface with innumerable perforations so that the sand filters to a second bottom. Once this has happened, a sliding device will cause that the perforations are obstructed so that to the deposited being the material by inverting, the sand remains caught between the two bottoms of the deposit. A system of aspiration using the same energy of the freight elevator (calorific, mechanical or electrical) will drain the even sand content to be taken to the corresponding area or, by inverting. (See fig.1)

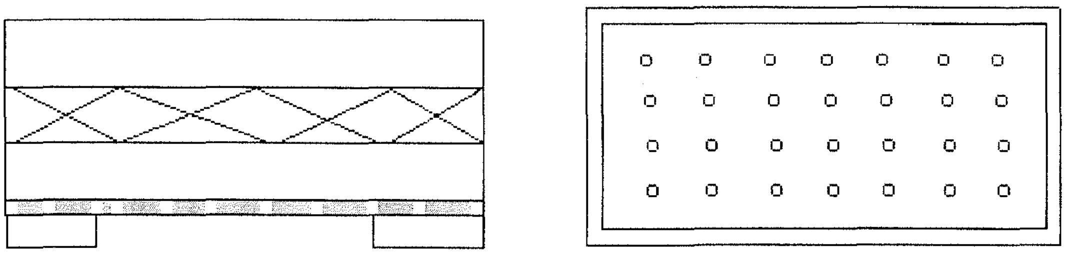

Fig.1 Deposit of return material with double bottom (lateral and upper view)

Analysis of the problem of the adhered sand on the return material

The problem of the adhered sand to the return material is one of most serious. It does not exist a method that allows to eliminate this sand that is going to contaminate the induction furnaces and increase the amount of slag that prevents the process as a whole.

The ideal solution would be that the premix* that is added to the sand had the property of which in hot this one maintained its properties of adhesion or agglutination but that in cold, these properties were lost. While there is not this solution (that rather corresponds to the sand supplier), it will be necessary to consider other solutions. We will pose this problem like a contradiction of the following way: What we want is to clean to the surface of a movable object that is the material that is transferred to the recovery area. Nevertheless, a resistance exists because the sand is compacted to the material and therefore the cleaning work becomes difficult.
Consulting the Altshuller's matrix, in line 18 (Brightness) and in column 14 (Strength) we find the numbers 35 and 19 as the inventive principles to be applied to solve this problem. Let us analyze each of them.

Inventive principle 35. Parameter changes

A. Change an object's physical state (e.g. to a gas, liquid, or solid).
- *Freeze the liquid centers of filled candies, then dip in melted chocolate, instead of handling the messy, gooey, hot liquid.*
- *Transport oxygen or nitrogen or petroleum gas as a liquid, instead of a gas, to reduce volume.*

B. Change the concentration or consistency.
- *Liquid hand soap is concentrated and more viscous than bar soap at the point of use, making it easier to dispense in the correct amount and more sanitary when shared by several people.*

C. Change the degree of flexibility.
- *Use adjustable dampers to reduce the noise of parts falling into a container by restricting the motion of the walls of the container.*
- *Vulcanize rubber to change its flexibility and durability.*

D. Change the temperature.
- *Raise the temperature above the Curie point to change a ferromagnetic substance to a paramagnetic substance.*
- *Raise the temperature of food to cook it. (Changes taste, aroma, texture, chemical properties, etc.)*
- *Lower the temperature of medical specimens to preserve them for later analysis [11]*

Interpretation: this principle suggests us to make react the sand adhered to the material, submerging it in an acid or an alkaline liquid of a certain concentration so when that reacting, the sand becomes loose in the same way as it happens with greare when reacting with the stoves liquid cleaning, this one acquires a favorable consistency for its cleaning without affecting the surface of the material. This operation can be conducted by those who makes the separation of the pieces with the call " branch" (material of return) without wasting a lot of time or effort.

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* the premix is elaborated with diferents adhesifs susbtances like sodic and calcic bentonites and carbon in order to give at the sand some adhesion propieties.

Inventive principle 19. Periodic action

A. Instead of continuous action, use periodic or pulsating actions.
   - *Hitting something repeatedly with a hammer*
   - *Replace a continuous siren with a pulsed sound.*

B. If an action is already periodic, change the periodic magnitude or frequency.
   - *Use Frequency Modulation to convey information, instead of Morse code.*
   - *Replace a continuous siren with sound that changes amplitude and frequency.*

C. Use pauses between impulses to perform a different action.
   - *In cardio-pulmonary respiration (CPR) breathe after every 5 chest compressions. [11]*

Interpretation: this principle is complemented with the previous one, because once the cleaning liquid has been applied to the material, a movement of oscillation or periodic impulses can be applied to the deposit in order that the return material is undone of the sand that previously has been already treated. These impulses can be made of more efficient way during their transfer using the same energy of the freight elevator. The sand can be eliminated by suction or by inverting the deposit with a mesh that it prevents to the material to fall. This solution is similar to the proposal for the loosen sand, therefore, the two solutions could be conjugated and obtain that any type of sand does not arrive, neither the release nor the adhered one.
However to assure a minimum sand in the induction furnaces (in case that the previous operations were not possible) is the following one: To modify the hopper that spills the material to the furnaces adding a great amount of circular perforations in all the base of the hopper. At the moment it has only these perforations in a small area that is not sufficient to collect all the sand that already is loosen in the hopper. Thus, once the scraps or return material is deposited in the hopper, this one will be vibrated in order to obtain an effect of sifted and eliminate the maximum of sand, a recollector will be adapted, Now this modifications are made with a minimum of investment (See fig. 2)

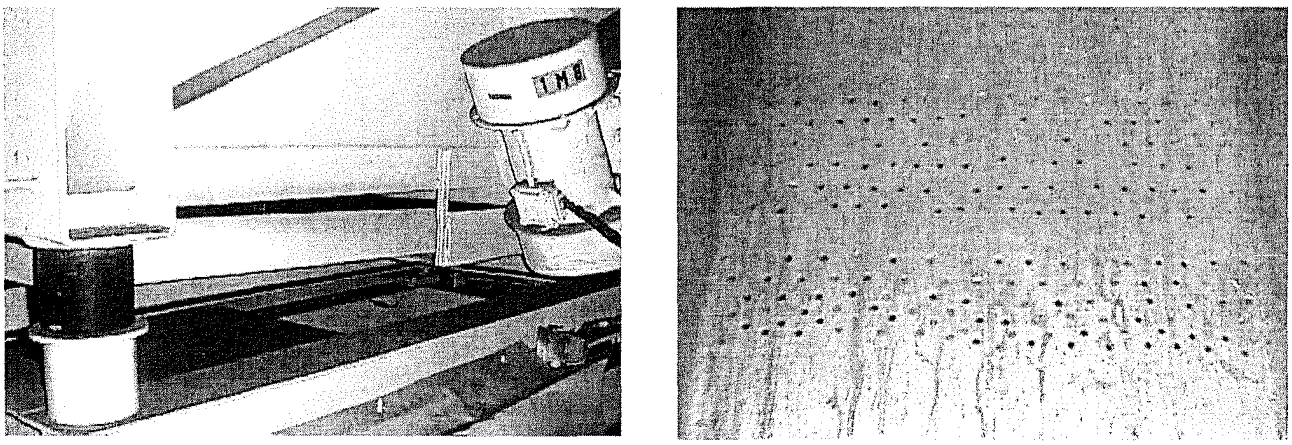


Fig.2 The hopper with the perforation and the recollector of sand

RETURN OF THE SAND TOO HOT

This problem is observed when the sand returns to its reusability area for the manufacture of molds, this one is still too warm (more than 39° C) and according to the parameters it is not acceptable since it can alter its physical properties, its humidity mainly. Even though a certain amount of water to room temperature is added, this one does not obtain that the sand reaches the wished temperature.

On the other hand, to add an excess of water to reach the suitable temperature (32-35 degrees) slows down the process and it increases the cost too much, since later it would be necessary to retire the excess of humidity, this problem also can generate another important problem that is scraps causes, that is called "*sand rain*" [4]

A technical contradiction must be eliminated: sand's temperature is needed less hot, and by the other hand, the repair capacity, that is to say, if the sand is hotter of 38° C , the sand will have less capacity to be reused.

According to the Altshuller's matrix, in column 34, **Capacity of Repair** and in line 17, **Temperature**, we find the numbers that correspond to the following inventive principles.4, 10 and 16. Let us see each of them.

Principle 4. Asymmetry

A. Change the shape of an object from symmetrical to asymmetrical.

Asymmetrical mixing vessels or asymmetrical vanes in symmetrical vessels improve mixing (cement trucks, cake mixers, blenders).

Put a flat spot on a cylindrical shaft to attach a knob securely.

B. If an object is asymmetrical, increase its degree of asymmetry.

Change from circular O-rings to oval cross-section to specialized shapes to improve sealing.

Use astigmatic optics to merge colors. [11]

Interpretation: The band that transports the sand to its reusability area is normally uniform (symmetrical) in its ascending movement. It would be recommendable that this one had an irregular movement (non-symmetrical), it is to say non-uniform but in small impulses in order that the sand undergoes a slight displacement with respect to the band and thus allows to avoid the isolation of the sand that is in internal layers, obtaining the contact with the air a greater amount of sand and not only the sand that is on the surface with the uniform movement.

Principle 10. Preliminary action

A. Perform, before it is needed, the required change of an object (either fully or partially).
Pre-pasted wall paper
Sterilize all instruments needed for a surgical procedure on a sealed tray.

B. Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery
Kanban arrangements in a Just-In-Time factory
Flexible manufacturing cell [11]

Interpretation: This principle suggests that the band that transports the sand towards its reusability area be dampened previously with cold water in order to neutralize the temperature that brings after its process of rinding.

Principle 16. Definition Partial or excessive actions

A. If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.
Over spray when painting, then remove excess. (Or, use a stencil--this is an application of Principle 3,
Local Quality and Principle 9, Preliminary anti-action).
Fill, then "top off" when filling the gas tank of your car. [11]

Interpretation:
It is possible that with the methods proposed are not absolutely suitable to achieve the objective to obtain the cooling wished since the sand is very hot and it has the property to keep the temperature, for that reason, it would be recommendable to move it by the band forming thin layers of sand instead of thick ones, so that is greater the amount of sand that is in contact with the air and thus, as much the inferior layer that it is in contact of the humid band like the outer layer will have an own cooling system, managing to balance the temperature of all the sand that arrives at the hopper just before its reusability. This can be obtained increasing the speed of the band. [4]

Observations

The ideal solution is to send the sand throughout the air without any band is needed, the sand will reach the hopper cool because of all the sand would be in contact wit the air. This solution must inspire us to give the best alternative in this process.
If we anlyse the principle 4 (Asymmetry) we can adapt the following alternative since all the sand could be in contact with the air but with the following adaptation:

To leave the movement continuous and to adapt it a small helicoidales plates in different points of their route. The objective is to keep the sand in contact with the air the most time possible. These plates would be placed at the external and at the central part of the band. This solution lets dynamism to the sand in order that this one presents all its layers to the external part. The solution is the closest to the ideal solution and has the advantage that doesn't consumes energy neither requires extra cost nor a change in the design of the band nor in its mechanism of transmission, fulfilling its objective of cooling. This solution was accepted and implemented for the managers of this area. Once implemented the changes proposed referring to the cooling of the sand, we noticed that the reduction of the temperature was in three or four degrees during the route of the sand by the transporting band towards the deposit hopper. This solution is already satisfactory but it is possible to improve it more yet using another TRIZ tool. [4]

SUBSTANCE - FIELD ANALYSIS

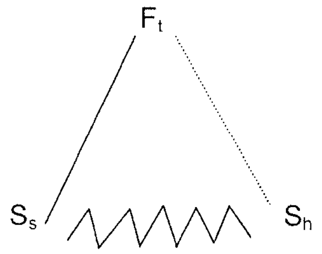
Altshuller has developed that he called S-Fields. S-Fields is an attempt to generate a systematic and universal language for the definition and solution of problems. In effect, the S-Field method represents a way of classifying different problem types in terms of both the number of interacting components (Substances) and the actions (Fields) which act upon them. It exists different combinations of Substances and Fields possible and subsequently identified Standard Inventive Solutions, which may be applied to solve any given Substance-Field combination. In all, 76 such Standard Inventive Solutions have been determined; any three or four of which are most likely to be relevant to a given combination type. [11]

The fundamental observation in our case is that the sand hopper is placed in the upper part of the molder machine and just for the passage of the hot air that takes place in the drained furnace. This originates that the hopper has a temperature between 50 to 55°C in the outer walls where they receive the calorific radiation and between 40 to 48°C in the opposite walls. (Of course that the higher temperature are registered in the superior part and the lowest in the inferior part). The inner temperature of the walls of the hopper registers a temperature between 2 to 5°C less than in the outer part of the same wall and height.
For this reason the hopper becomes a sort of furnace for the sand that stores in its interior.

According to the field-substance modeling the exposition would be as follows:
The elements of the model are:
Function: An undesired heating exists by effect of the furnace on the sand hopper.

S_h sand hopper S_s sand F_t radiating heat, action of the furnace.

Construction of the Model:



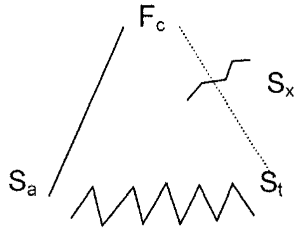
An injurious function exists between the sand hopper and the own sand that does not allow that its temperature diminishes but on the contrary, is increased it of sensible way. The calorific energy that arrives from the furnace represents an injurious function and it is the really cause of the problem According to procedure TRIZ, is as well necessary to try some of the 76 standard solutions [11]: Two ways to apply a standard solution are:

" To introduce another substance or to introduce another field "

To introduce a new substance is equivalent to interpose an object between the furnace and the hopper in order that it acts like a thermal reflector between two elements, this reflector would absorb the thermal radiation and the hopper will not warm up too much.

This thermal reflector is in fact a sort of shield that it will prevent that the radiation arrives at the hopper and this one heats the sand. This "shield" would be a metallic plate of provisional way in order to verify if it is functional, it could be later changed by a more appropriate design as much in form as in material.

The modified model would be of the following way:



Where S_x would be the thermal insulator that will avoid the overheat of the hopper.
With this thermal reflector, the temperature of the sand hooper was reduced in more than 10° C and the sand did not heat any more and could satisfy the specifications without any other problem

and we have given an innovant solution with a minimum of investment and without increasing the human effort.

CONCLUSIONS

The results presented and implemented in this important entreprise –with more than 10% of reduction of scraps in the fabrications of steering knucle- have led to the managers to organize a TRIZ cours in the capacitation center of Volksvagen of Mexico. Many of the problems found in diferents production lines are now solved with TRIZ. There are several students working in reserche's theses in diferents cases of problematic situation in the line of engines and other departaments. We will be able to present these cases in future publications. A year ago, TRIZ methodology were not known enough in our mexican enterprises. The most important uiversities in Puebla city are already teaching TRIZ in diferent levels. We are now in conditios to organize a TRIZ association in Mexico because there are many people who are interested in knowing more about this methodology and apply it.

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TRIZ CASES STUDY IN VOLKSWAGEN OF MEXICO

THE STEERING KNUCKLE

- The steering knuckle is an important part of the vehicle that allows to fix the front wheels brakes, the motion of direction, the fixation of the shock absorber and the axis of impulsion

THE PROCESS OF FOUNDRY

- The process begins with the induction furnaces that are fed mainly with new material, material of return and the scrap pieces. These furnaces molt and mix the material with other necessary substances for the casting process (temperature upper than 1400°C). Later, the iron-base is put under a reaction process using magnesium in order to form nodules that allow it to acquire certain physical properties of ductility. It allows to manufacture a piece whose function is associated to diverse efforts and tensions that cause their critical parameters and its meticulous control. Then the casting process is performed

- A casting is a metal part formed by pouring molten metal into a sand mold. The mold is comprised of two halves that form a cavity into which the molten metal is poured. The mold forms the external surface of the casting. In this case, an internal cavity is required in the casting, a core is placed inside the mold cavity.
- After the metal solidifies, the mold is broken, the core removed and the part is ready for finishing operations. The sand is then remolded, prepared and used again in a cyclic process

TRIZ TOOLS USED

- INNOVANT QUESTIONARY
- IDEAL SOLUTION
- ALTSHULLER MATRIX
- S-FIELD ANALYZE

THE MOST IMPORTANT PROBLEMS

- 1. **Slag**
- **2. Non-Adhered Sand on the Return Material**
- **3. Adhered Sand on the Return Material**
- **4. Return of the Sand Too Hot**

1. SLAG

The slag are the impurities detected in the metal before the casting process

This problem is originated mainly in the material of return or the scraps pieces that are impregnated with an important amount of sand, as product of strips, which cannot be easily eliminated.

IDEAL SOLUTION

- The scraps pieces or the material of return do not contain sand at all

ALTSHULLER'S MATRIX

- If we consulted the Altshuller's matrix in line 35 related to **Adaptability** and column 17 referring to **Temperature**, we find the numbers 2, 27, 3, 35 that correspond to the inventive principles suggested by the matrix

2 TAKING OUT

A. Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.

- • *Locate a noisy compressor outside the building where compressed air is used.*
- • *Use fiber optics or a light pipe to separate the hot light source from the location where light is needed.*
- • *Use the sound of a barking dog, without the dog, as a burglar alarm.*

INTERPRETATION

The separation of the polluting elements that are accumulated in the superior part of the hoppers (Slag) must make with some special devices in the same way like takes off the cream from a glass of milk .

27 CHEAP SHORT-LIVING OBJECTS

Replace an inexpensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance).

- *Use disposable paper objects to avoid the cost of cleaning and storing durable objects. Plastic cups in motels, disposable diapers, many kinds of medical supplies.*

INTERPRETATION

The addition of some component could neutralize the injurious effect of the slag, for example the use of salts or saline solutions that have a neutralizer effect and make easier the operation of extraction. This measurement is already considered and practiced in a regular way within the process, obtaining a significant decreasing of the problem.

3. LOCAL QUALITY

A. Change an object's structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.

B. Make each part of an object function in conditions most suitable for its operation.

C. Make each part of an object fulfill a different and useful function.

INTERPRETATION

- This principle suggests to avoid that the sand arrives at the furnaces or at least, it does not arrive in excess or if it arrives, that it is possible some reaction process in order that becomes operational or their effect is unnoticed.

- Perhaps to obtain that some external agent allows avoiding the excess of sand in the furnaces.

35. PARAMETER CHANGES

- **Definition**:
- Change an object's physical state (e.g. to a gas, liquid, or solid).
- Change the concentration or consistency
- Change the degree of flexibility
- Change the temperature.

INTERPRETATION

- To obtain that the undesired material becomes more evident and manipulable in order to eliminate it with more facility. To use the effect of some chemical reaction to cause that all the impurities that cause problems ascend to the surface and make its elimination easier .

RETURN OF THE SAND TOO HOT

- This problem is observed when the sand returns to its reusability area for the manufacture of molds, this one is still too warm (more than 39° C) and according to the parameters it is not acceptable since it can alter its physical properties, its humidity mainly.

ALTSHULLER'S MATRIZ

- A technical contradiction must be eliminated: sand's temperature is needed less hot, and by the other hand, the repair capacity, that is to say, if the sand is hotter of 38° C , the sand will have less capacity to be reused.
- According to the Altshuller's matrix, in column 34, **Capacity of Repair** and in line 17, **Temperature**, we find the numbers that correspond to the following inventive principles.4, 10 and 16. Let us see each of them.

4 ASIMETRY

- A. Change the shape of an object from symmetrical to asymmetrical.

- B. If an object is asymmetrical, increase its degree of asymmetry.

INTERPRETATION

- The band that transports the sand to its reusability area is normally uniform (symmetrical) in its ascending movement. It would be recommendable that this one had an irregular movement (non-symmetrical), it is to say non-uniform but in small impulses in order that the sand undergoes a slight displacement with respect to the band and thus allows to avoid the isolation of the sand that is in internal layers

10. PRELIMINARY ACTION

- A. Perform, before it is needed, the required change of an object (either fully or partially).

- B. Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.

INTERPRETATION

- This principle suggests that the band that transports the sand towards its reusability area be dampened previously with cold water in order to neutralize the temperature that brings after its process of rinding

16. DEFINITION PARTIAL OR EXCESSIVE ACTIONS

- If 100 % of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

INTERPRETATION

- It the methods proposed are not absolutely suitable to achieve the objective to obtain the cooling wished since the sand is very hot and it has the property to keep the temperature. For that reason, it would be recommendable to move it by the band forming thin layers of sand instead of thick ones, so that is greater the amount of sand that is in contact with the air and thus, as much the inferior layer that it is in contact of the humid band like the outer layer will have an own cooling system, This can be obtained increasing the speed of the band

OBSERVATIONS

- Inspired in principle 4 (Asymmetry) we can adapt the following alternative since all the sand could be in contact with the air but with the following adaptation:
- To leave the movement continuous and to adapt it a small helicoidales plates in different points of their route. The objective is to keep the sand in contact with the air the most time possible. These plates would be placed at the external and at the central part of the band.

The solution is the closest to the *ideal solution* and has the advantage that doesn't consumes energy neither requires extra cost nor a change in the design of the band nor in its mechanism of transmission, fulfilling its objective of cooling. This solution was accepted and implemented for the managers of this area. Once implemented the changes proposed referring to the cooling of the sand, we noticed that the reduction of the temperature was in three or four degrees during the route of the sand by the transporting band towards the deposit hopper. This solution is already satisfactory but it is possible to improve it more yet using another TRIZ tool.

ANALYSIS OF THE PROBLEM OF THE NON-ADHERED SAND ON THE RETURN MATERIAL

- Since the problem of the slag is mainly attributed to the high sand content, the problem must be presented in such a way that the possibility that the sand arrives at the furnaces does not exist or it arrives only in a minimal amount

CONTRADICTIONS

- we would like to eliminate the undesired material during the transport process but the amount of material to transport prevents it; that is to say, the parameters are: line 33, **Ease of operation** and column 1, **Weight of a Mobil object**. The precognized inventive principles suggested by the matrix are: 25, 2, 13 and 15. Let us analyze carefully these principles and try to find answers adapted to our problem

25. SELF-SERVICE

A. **An object serve itself by performing auxiliary helpful functions**

B. **Use waste resources, energy, or substances.**

INTERPRETATION

- The own freight elevator must clean the return material during the transportation; that is to say, not only it has to transport but also it has to be able through to clean it. This can be performed some device of suction (aspiration) using its own calorific or electric power energy to avoid extra costs.

2 Taking out

Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.

Interpretation: The extraction of the sand is confirmed with this principle as it was settled down in the previous principle.

13 'THE OTHER WAY ROUND'

A. Invert the action used to solve the problem (e.g. instead of cooling an object, heat it).
B. Make movable parts (or the external environment) fixed, and fixed parts movable).
C. Turn the object (or process) 'upside down'.

INTERPRETATION

- This principle suggests to undo of the leftover sand before the material is unloaded and not later, inverting the deposit, previously covered by a very resistant mesh that can load all the material, so that only the sand drains. Later the material without the protective mesh could be unload in the corresponding area.

15 DYNAMICS

A. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.

B. Divide an object into parts capable of movement relative to each other.

C. If an object (or process) is rigid or inflexible, make it movable or adaptive.

INTERPRETATION

- A double bottom of the return material deposit could be a good solution.
- The first bottom is a solid surface with innumerable perforations so that the sand filters to a second bottom. Once this has happened, a sliding device will cause that the perforations are obstructed so that to the deposited being the material by inverting, the sand remains caught between the two bottoms of the deposit. A system of aspiration using the same energy of the freight elevator (calorific, mechanical or electrical) will drain the even sand content to be taken to the corresponding area or, by inverting.

ANALYSIS OF THE PROBLEM OF THE ADHERED SAND ON THE RETURN MATERIAL

WE WILL POSE THIS PROBLEM LIKE A CONTRADICTION OF THE FOLLOWING WAY

- What we want is to clean to the surface of a movable object that is the material that is transferred to the recovery area. Nevertheless, a resistance exists because the sand is compacted to the material and therefore the cleaning work becomes difficult.

ALTSHULLER'S MATRIX

- Consulting the Altshuller's matrix, in line 18 (Brightness) and in column 14 (Strength) we find the numbers 35 and 19 as the inventive principles to be applied to solve this problem.

  Let us analyze each of them.

35 PARAMETER CHANGES

A. Change an object's physical state (e.g. to a gas, liquid, or solid).
B. Change the concentration or consistency.
C. Change the degree of flexibility.
D. Change the temperature.

INTERPRETATION

- This principle suggests us to make react the sand adhered to the material, submerging it in an acid or an alkaline liquid of a certain concentration so when that reacting, the sand becomes loose in the same way as it happens with greare when reacting with the stoves liquid cleaning, this one acquires a favorable consistency for its cleaning without affecting the surface of the material. This operation can be conducted by those who makes the separation of the pieces with the call " branch" (material of return) without wasting a lot of time or effort.

19 PERIODIC ACTION

A. Instead of continuous action, use periodic or pulsating actions.

B. If an action is already periodic, change the periodic magnitude or frequency.

C. Use pauses between impulses to perform a different action.

INTERPRETATION

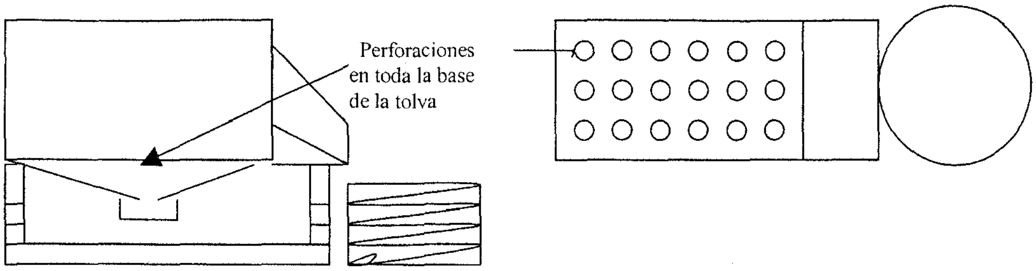
- This principle is complemented with the previous one, because once the cleaning liquid has been applied to the material, a movement of oscillation or periodic impulses can be applied to the deposit in order that the return material is undone of the sand that previously has been already treated. These impulses can be made of more efficient way during their transfer using the same energy of the freight elevator

- This solution is similar to the proposal for the loosen sand, therefore, the two solutions could be conjugated and obtain that any type of sand does not arrive, neither the release nor the adhered one.

THE SOLUTIONS

- To modify the hopper that spills the material to the furnaces adding a great amount of circular perforations in all the base of the hopper. At the moment it has only these perforations in a small area that is not sufficient to collect all the sand that already is loosen in the hopper

- Thus, once the scraps or return material is deposited in the hopper, this one will be vibrated in order to obtain an effect of sifted and eliminate the maximum of sand, a recollector will be adapted, Now this modifications are made with a minimum of investment



Hooper modifed with perforations

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Profile of Lecturer

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Total Product/Process Development System Where Six Sigma Meets TRIZ and QFD

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In a recent iSixSigma.com article the following question was proposed: "*...is Six Sigma enough*[1]*?...*" If an understanding of the Total Product/Process Development System (TP^2DS) is considered and the capabilities of Six Sigma identified, then it becomes obvious that additional analytical capabilities are required. The TP^2DS can be characterized using Axiomatic Design[2]. In this model a societal need is the prime mover for the development of customer requirements. These customer requirements then drive functional requirements that then drive design parameters which finally drive process variables. All of these relationships should be in a one-to-one correspondence[3]. This correspondence will help insure that each customer requirement is satisfied. Also, the idealness[4] of a system is driven by the utilization of only one functional requirement (FR) per customer requirement (CR).[5,6] These development groups identify the major phases of the TP^2DS as indicated in Figure 1.0. An understanding of the necessary functions for each phase will allow us to understand what types of methodological assistance we need for each. This function decomposition is represented in Figure 2.0.

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[1] http://www.isixsigma.com/library/content/c030519a.asp
[2] This is only one method of characterizing the TP^2DS. There are many others that are also valid.
[3] One-to-one correspondence means that for every CR there is one FR, each FR is coupled to one DP, each DP is coupled to one PV, etc.,...also, these couplings are independent of each other.
[4] Idealness is a Theory of Inventive Problem Solving (TRIZ) term characterized by the Ideality (I) value which may be determined subjectively ($I=\Sigma$ Useful functions / (Σ (Harmful functions + Costs))) and objectively. To review an objective rigorous mathematical approach developed by Dr. Slocum please refer to the last section of "Reangularity, Semangularity, and Ideality" published in the July 2003 edition of the TRIZ Journal, www.triz-journal.com.
[5] Suh, N.P., The Principles of Design, Oxford University Press, Inc., 198 Madison Avenue, NY, NY, 10016-4314, 1990.
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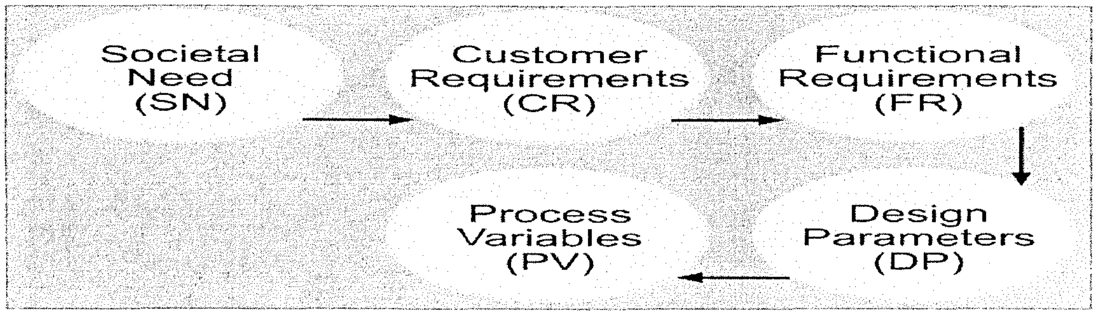

Figure 1.0: The Total Product / Process Development System decomposed into five phases using a modified Axiomatic Design approach (Societal Need (SN) has replaced Customer Attribute (CA))[7].

Societal Need (SN)	Customer Requirements (CR)	Functional Requirements (FR)	Design Parameters (DP)	Process Variables (PV)
	Translate Societal Need to Customer Focus. Identify Customer Capture Articulated and Unarticulated V.O.C. Translate V.O.C. to technical requirements.	Identify functions necessary to satisfy customer requirements	Identify design features that deliver necessary functions	Identify processes and parameters to manufacture/ assemble the design

Figure 2.0: Major functions by Total Product/Process Development Phase. This functional list is not comprehensive but does include major critical functions.

The DMAIC[8] and DMADV[9] (also known as Design for Six Sigma or DFSS) methodologies provide many elements and methods that enable the practitioner to function in the DP and PV phases.

[7] Suh, N.P., Axiomatic Design: Advances and Applications, Oxford University Press, Inc., 198 Madison Avenue, NY, NY, 0-19-513466-4, 2001

[8] Define-Measure-Analyze-Improve-Control

These phases (DP and PV) are the focal points of the Six Sigma methodology but there are also elements of Six Sigma that address CR[10] and FR[11] functions from a secondary perspective. It is also relevant to identify two additional *limitations* of the DMAIC process:

1. In certain scenarios the solution to your problem is not inherent in your process, and

2. The optimization of a process or design only progresses towards the experimental maximum potential driven by the design or process under investigation. The theoretical maximum is not addressed if it is not already available to the design or process in question (*improving to the limits of the system or its' entitlement, not to the theoretical maximum, see Figure 3.0*).

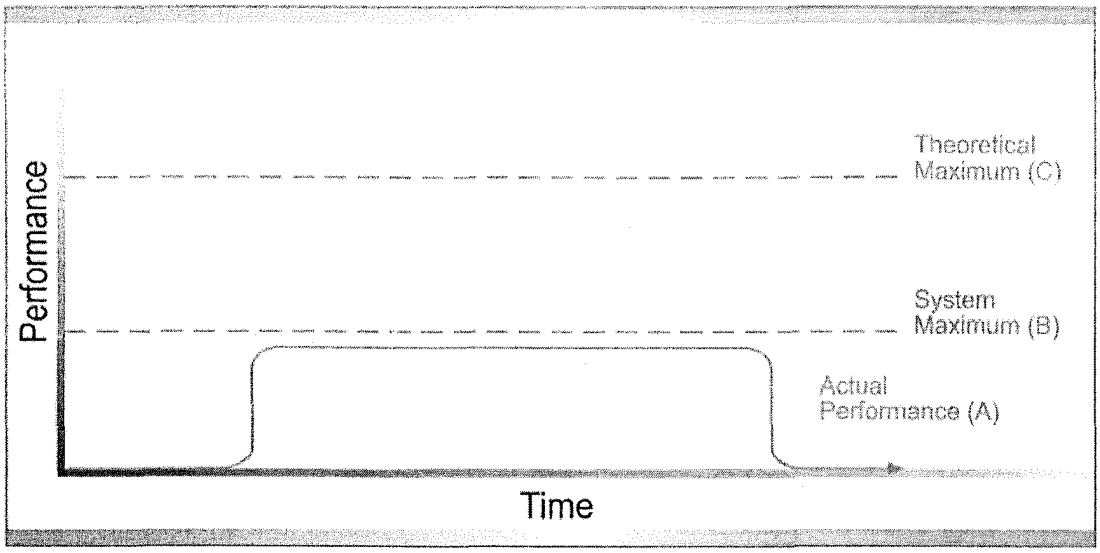

Figure 3.0: The actual performance of a system (A) may be optimized. This optimization will progress towards the maximum level available to the system (B). If (B) and (C)[12] are not the same limit then any optimization progresses towards an ultimately sub-optimum condition. The DMAIC process will not transcend the (B) to (C) barrier but the DMADV process may.

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[9] Define-Measure-Analyze-Design-Validate
[10] Voice of the Customer (VOC) collection
[11] Cause and effect diagramming (C/E)
[12] the theoretical maximum based on scientific laws and principles

The integration of the DMAIC and DMADV with other complementary methodologies in the CR and FR phases would increase the total effectiveness of their application. Incorporating these additional methodologies and analytical elements into the traditional Six Sigma methodology would create a more robust, enhanced Six Sigma methodology that appropriately addresses all of the functional needs of the TP^2DS. Two methodologies that address these functional assistance voids are:

1. Quality Function Deployment (QFD): Provides assistance in the CR phase. The use of various QFD matrices can also provide CR-FR-DP-PV correspondence.

2. Theory of Inventive Problem Solving (TRIZ): Provides assistance in the FR, DP, and PV phases and assistance with the two Six Sigma limitations listed above.

Quality Function Deployment[13] is a quality methodology developed in Japan by Professors Akao and Mizuno that integrates systems thinking and psychology into a structured approach that focuses on the customer. QFD insures that customer needs are linked to technical deliverables throughout the TP^2DS.

The Theory of Inventive Problem Solving (TRIZ)[14] is a Russian methodology developed by Altshuller based on the principle that the resolution of a contradiction is the root of an innovative solution. TRIZ provides algorithms and elements that help to identify and resolve these contradictions. TRIZ provides a structured methodology that facilitates innovation and creativity in an organization and has many advantages over existing emotional and psychologically based creativity methods.

QFD and TRIZ are complementary in nature and are fully integratable with the DMAIC and DMADV methodologies. This integration yields a supported TP^2DS as indicated in Figure 3.0.

[13] an excellent reference for QFD is <u>Quality Function Deployment: Integrating Customer Requirements into Product Design</u> by Dr. Yoji Akao, Productivity Press, P.O. Box 13390, Portland, OR 97213, ISBN 0-915299-441-0.

[14] An excellent TRIZ reference is <u>TRIZ: The Right Solution at the Right Time</u>, by Dr. Yuri Salamtov edited by Drs. Valeri Souchkov and Michael Slocum, Insytec, Hessenweg 55, NL 8051LB Hattem,The Netherlands, ISBN 90-804680-1-0.

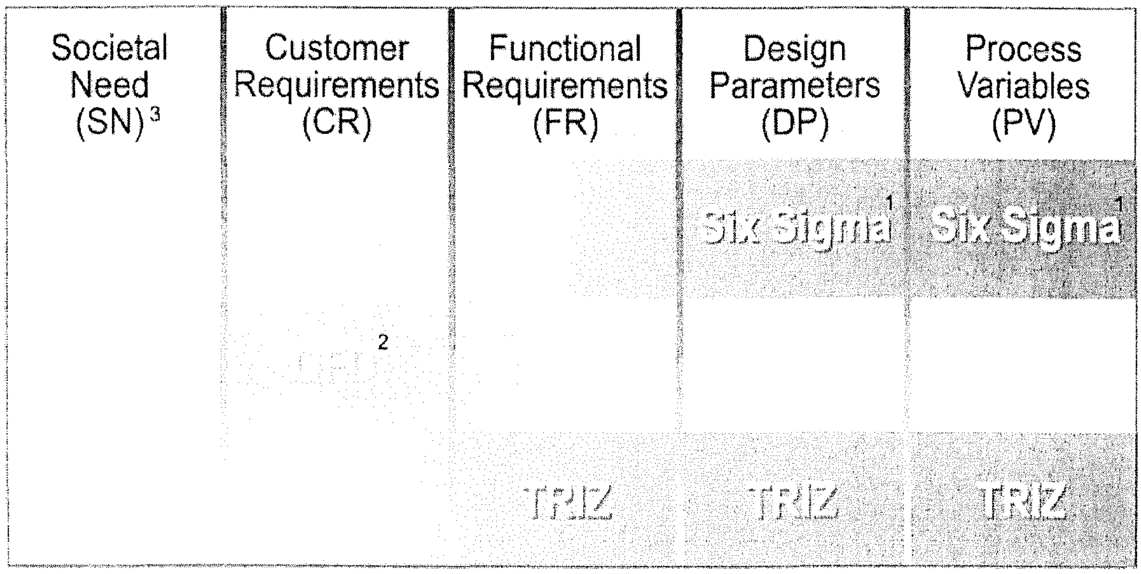


Figure 3.0: The application of Six Sigma, TRIZ, and QFD to the various phases of the TPDS.

1. with the aforementioned limitations
2. also with FR-DP-PV applicability as previously discussed
3. beyond the scope of this paper

The integration of QFD, TRIZ, and Six Sigma yields an enhanced methodology capable of supporting each phase of the TP^2DS. The methodological transitions are driven by the TP^2DS Phases and are delineated in a TP^2DS algorithm. The Six Sigma Black Belt will be equipped with a methodology that is empowering throughout the TP^2DS and this facilities concurrency in engineering, manufacturing, and quality.

Appendix A: Advanced applications of Axiomatic Design to Ideality, Capability, Signal-to-Noise Ratio, and Variance

Combining Ideality and Reangularity

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \end{Bmatrix}$$

$$Ideality = \frac{\sum F_u}{\sum(F_h + \text{cost})} = \frac{(A_{11} + A_{22} + A_{33})}{(A_{12} + A_{13} + A_{21} + A_{23} + A_{31} + A_{32}) + \text{cost}(\text{DP}_1 + DP_2 + DP_3)}$$

Using Axiomatic Design to Calculate Capability

$$Capability$$

$$C_{p_{DP1}} = \frac{USL - LSL}{6\sigma} = \frac{DP_{1a} - DP_{1c}}{6\sigma};$$

$$C_{p_{DP2}} = \frac{USL - LSL}{6\sigma} = \frac{DP_{2a} - DP_{2c}}{6\sigma};$$

$$C_{p_{DP3}} = \frac{USL - LSL}{6\sigma} = \frac{DP_{3a} - DP_{3c}}{6\sigma};$$

$$C_{system} = \min\left(C_{p_{DP1}}, C_{p_{DP2}}, C_{p_{DP3}}\right)$$

$$\sigma^2 = \operatorname{var}iance = \frac{1}{n-1}\sum_{p=1}^{n}\left(FR_j^p - \overline{\overline{FR}}_i\right)^2$$

$$\sigma_{FR1}^2 = \frac{1}{2}\left[\left(A_{11a}DP_1 - \overline{\overline{FR}}_1\right)^2 + \left(A_{11b}DP_1 - \overline{\overline{FR}}_1\right)^2 + \left(A_{11c}DP_1 - \overline{\overline{FR}}_1\right)^2\right]$$

where

$$\overline{\overline{FR}}_1 = \frac{1}{2}\left(FR_{1a} + FR_{1b} + FR_{1c}\right)$$

$$\sigma_{FR2}^2 = \frac{1}{2}\left[\left(A_{22a}DP_2 - \overline{\overline{FR}}_2\right)^2 + \left(A_{22b}DP_2 - \overline{\overline{FR}}_2\right)^2 + \left(A_{22c}DP_2 - \overline{\overline{FR}}_2\right)^2\right]$$

where

$$\overline{\overline{FR}}_2 = \frac{1}{2}\left(FR_{2a} + FR_{2b} + FR_{2c}\right)$$

$$\sigma_{FR3}^2 = \frac{1}{2}\left[\left(A_{33a}DP_3 - \overline{\overline{FR}}_3\right)^2 + \left(A_{33b}DP_3 - \overline{\overline{FR}}_3\right)^2 + \left(A_{33c}DP_3 - \overline{\overline{FR}}_3\right)^2\right]$$

where

$$\overline{\overline{FR}}_3 = \frac{1}{2}\left(FR_{3a} + FR_{3b} + FR_{3c}\right)$$

$$S = \prod_{j=1}^{n}\frac{|A_{jj}|}{\left(\sum_{k=1}^{n}A_{kj}^2\right)} = \left(\frac{|A_{11}|}{\left(A_{11}^2 + A_{21}^2 + A_{31}^2\right)^{1/2}}\right)\left(\frac{|A_{22}|}{\left(A_{21}^2 + A_{22}^2 + A_{23}^2\right)^{1/2}}\right)\left(\frac{|A_{33}|}{\left(A_{31}^2 + A_{32}^2 + A_{33}^2\right)^{1/2}}\right)$$

$$R_{12} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{12}}{A_{22}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{21}}{A_{11}}\right)$$

$$R_{13} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{13}}{A_{33}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{31}}{A_{11}}\right)$$

$$R_{23} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{23}}{A_{33}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{32}}{A_{22}}\right)$$

$$R_{21} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{21}}{A_{22}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{12}}{A_{11}}\right)$$

$$R_{31} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{31}}{A_{33}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{13}}{A_{11}}\right)$$

$$R_{32} = \cos(\alpha - \alpha'); \quad \alpha = \tan^{-1}\left(\frac{-A_{32}}{A_{33}}\right); \quad \alpha' = \tan^{-1}\left(\frac{A_{23}}{A_{22}}\right)$$

$$b_1 = (FR_1)_0 - \frac{1}{2}(FR_{1a} + FR_{1b} + FR_{1c})$$

$$b_2 = (FR_2)_0 - \frac{1}{2}(FR_{2a} + FR_{2b} + FR_{2c})$$

$$b_3 = (FR_3)_0 - \frac{1}{2}(FR_{3a} + FR_{3b} + FR_{3c})$$

$$SNR_1 = \frac{(FR_{1a} + FR_{1b} + FR_{1c})}{\left(A_{11a}DP_1 - \frac{1}{2}(FR_{1a} + FR_{1b} + FR_{1c})\right)^2 + \left(A_{11b}DP_1 - \frac{1}{2}(FR_{1a} + FR_{1b} + FR_{1c})\right)^2 + \left(A_{11c}DP_1 - \frac{1}{2}(FR_{1a} + FR_{1b} + FR_{1c})\right)^2}$$

$$SNR_2 = \frac{(FR_{2a} + FR_{2b} + FR_{2c})}{\left(A_{22a}DP_2 - \frac{1}{2}(FR_{2a} + FR_{2b} + FR_{2c})\right)^2 + \left(A_{22b}DP_2 - \frac{1}{2}(FR_{2a} + FR_{2b} + FR_{2c})\right)^2 + \left(A_{22c}DP_2 - \frac{1}{2}(FR_{3a} + FR_{2b} + FR_{2c})\right)^2}$$

$$SNR_3 = \frac{(FR_{3a} + FR_{3b} + FR_{3c})}{\left(A_{33a}DP_3 - \frac{1}{2}(FR_{3a} + FR_{3b} + FR_{3c})\right)^2 + \left(A_{33b}DP_3 - \frac{1}{2}(FR_{3a} + FR_{3b} + FR_{3c})\right)^2 + \left(A_{33c}DP_3 - \frac{1}{2}(FR_{3a} + FR_{3b} + FR_{3c})\right)^2}$$

Combining Ideality and Reangularity

$$Ideality = \frac{\sum F_u}{\sum (F_h + \text{cost})} = \frac{(A_{11} + A_{22} + A_{33})}{\left(\frac{1}{R_{12}} + \frac{1}{R_{13}} + \frac{1}{R_{21}} + \frac{1}{R_{23}} + \frac{1}{R_{31}} + \frac{1}{R_{32}}\right) + \text{cost}(\text{DP}_1 + DP_2 + DP_3)}$$

"The Integration of QFD, TRIZ, and Six Sigma in an Axiomatically Driven Total Product / Process Development System"

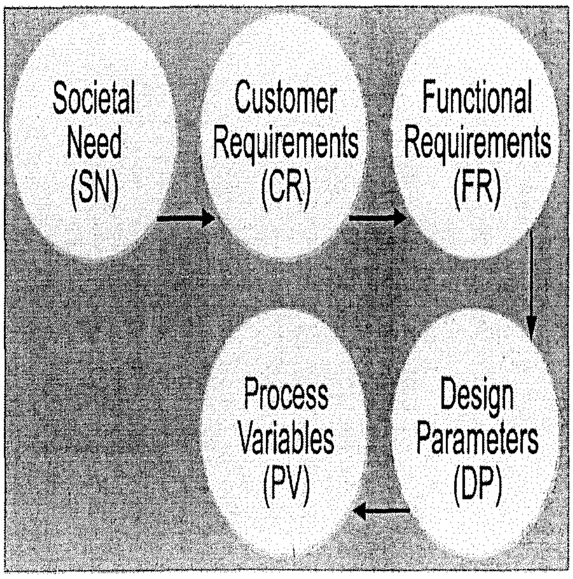
Michael S. Slocum, Ph.D., T.Sc., M.B.B.
Vice President of Innovation and Design

Breakthrough Management Group
Longmont, CO, USA

Aachen, FRG, 13 November 2003

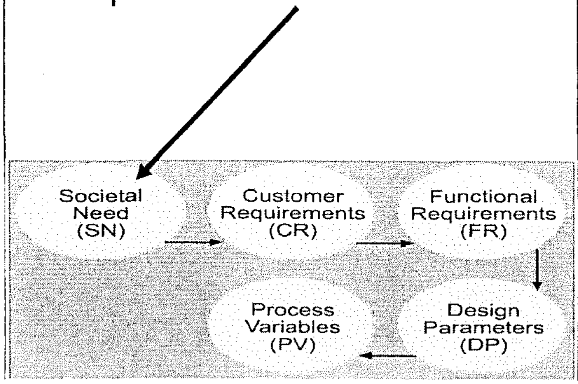
Axiomatic Design as the Structure for the TPPDS

- A **Societal Need** drives the Total Product / Process Development System
- SN is translated to **Customer Requirements**
- CR's are mapped to **Functional Requirements**
- FR's are mapped to **Design Parameters**
- DP's are mapped to **Process Variables**



TPPDS Amplifiers: TRIZ

Identifying an unmet SN is the grain of sand a pearl is built around.

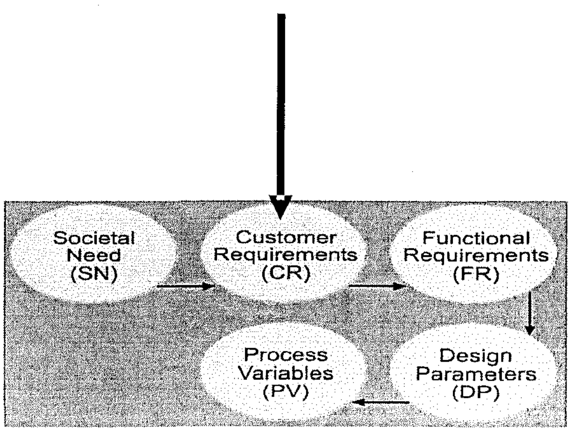


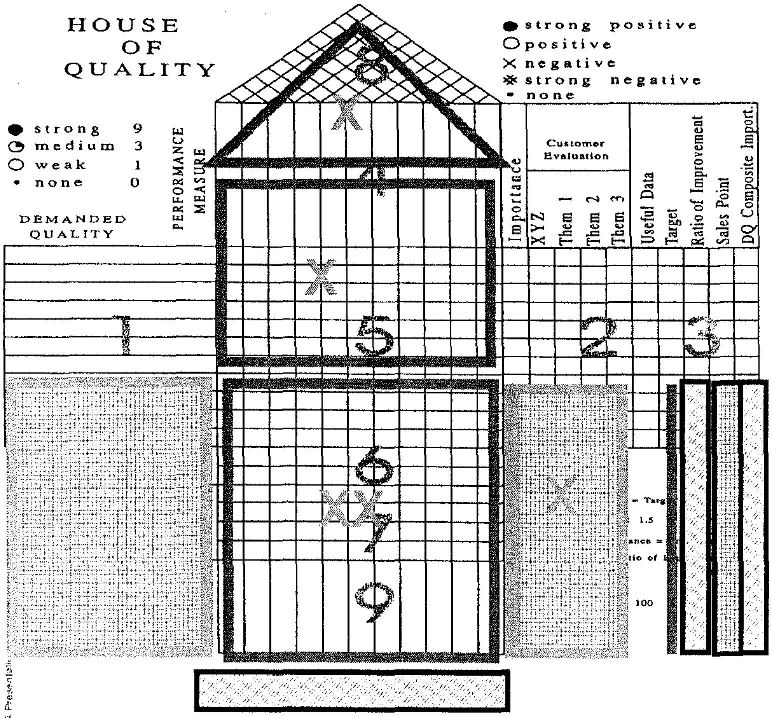
- Where does a SN come from?
  - A SN is the realization of a *contradiction*
    - *Society needs something to improve life* ***but*** *many issues prevent realization*
  - Many models rely on:
    - Fiat, Eureka moments
    - Spontaneous brilliance
  - In this model we use:
    - TRIZ: a methodology that focuses on *contradiction* identification and resolution

TPPDS Amplifiers: cQFD

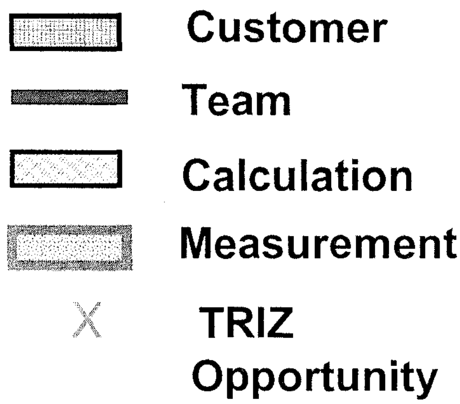
- How do we translate a SN into a set of CR's?
  - Many models rely on:
    - Nothing (the team assumes that they understand the needs of the customer)
    - Partially analytical techniques
  - In this model we use Comprehensive Quality Function Deployment

Understanding the articulated and unarticulated voice-of-the customer is critical for the establishment of CTQ's and FR's





cQFD provides identification and structure to the VOC. cQFD also identifies contradictions in your system– TRIZ indicators.



©1995, John Terninko, *Step by Step QFD*
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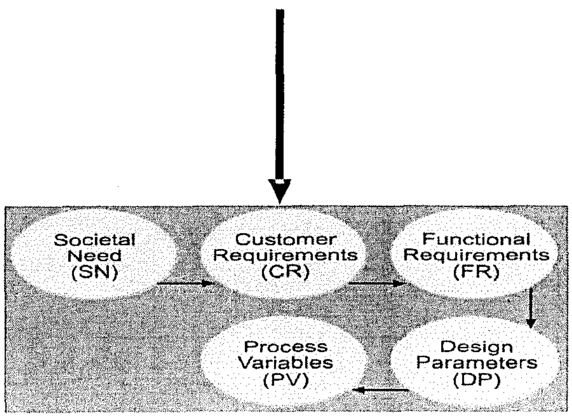
TPPDS Amplifiers: TRIZ

- Where do concepts come from?
  - Many models rely on:
    - Nothing as an amplifier
    - Psychological / Emotional Methods
      - Brainstorming
      - De Bono
  - In this model we use TRIZ
    - Structured approach based on:
      - empirical observations
      - heuristics from patents and technological evolution
      - functional modeling
      - contradiction identification

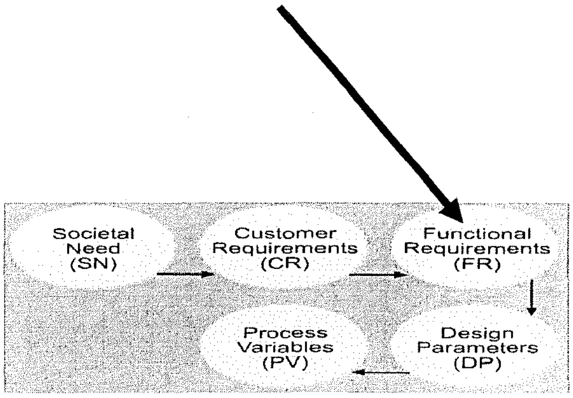
A **concept** drives the TPPDS after a SN and the associated CR's have been identified.



TPPDS Amplifiers: TRIZ, Axiomatic Design, and VE

- Where do functional requirements come from?
  - Many models rely on:
    - Ad hoc design process
  - In this model we use:
    - TRIZ based functional analysis
      - Su-Field Modeling
      - MLP
    - Axiomatic principles
      - Independence Axiom
      - Information Axiom
      - Design Equation
    - VE based function analysis

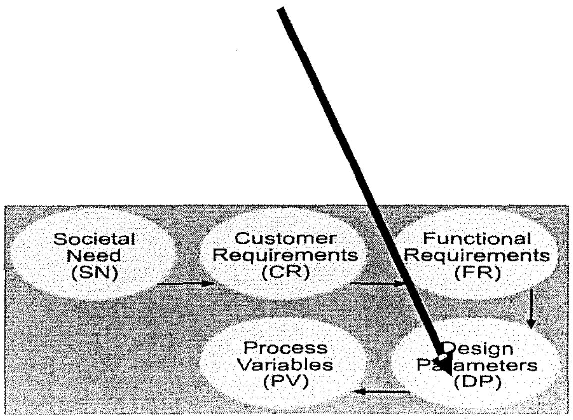
A FR must be identified that achieves each CR (ideally with no interdependences)



TPPDS Amplifiers: DFSS

- Where do design parameters come from?
  - Many models rely on:
    - Ad hoc design process
  - In this model we use:
    - Design for Six Sigma
      - DFSS is the act of designing a product, process or service resulting in a Six Sigma output that satisfies both external customer and internal business CTQ requirements.

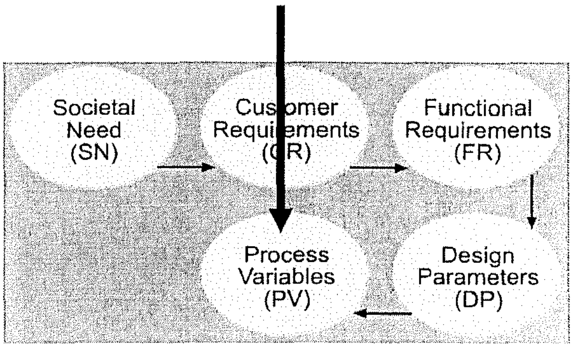
A DP must be identified that achieves each FR (ideally with no interdependences)



TPPDS Amplifiers: DFSS and DMAIC

- Where do process variables come from?
  - Many models rely on:
    - Ad hoc design process
    - Ad hoc process improvement methodologies
  - In this model we use:
    - Design for Six Sigma
      - DFx, PFMEA
    - DMAIC Model
      - Optimization of process variables

A PV must be identified that achieves each DP (ideally with no interdependences)

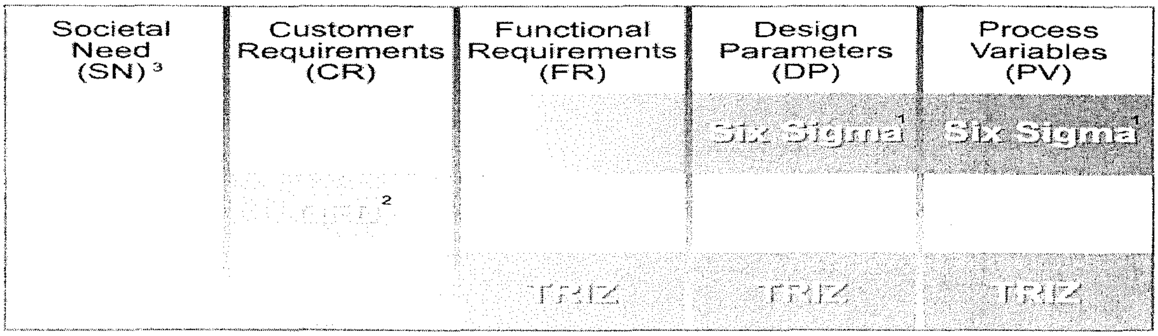


NOTE: Throughout the TPPDS secondary problems will be identified: use <u>TRIZ</u> to solve these.

TPPDS Phases and Key Tasks

Societal Need (SN)	Customer Requirements (CR)	Functional Requirements (FR)	Design Parameters (DP)	Process Variables (PV)
	Translate Societal Need to Customer Focus. Identify Customer Capture Articulated and Unarticulated V.O.C. Translate V.O.C. to technical requirements.	Identify functions necessary to satisfy customer requirements	Identify design features that deliver necessary functions	Identify processes and parameters to manufacture/ assemble the design

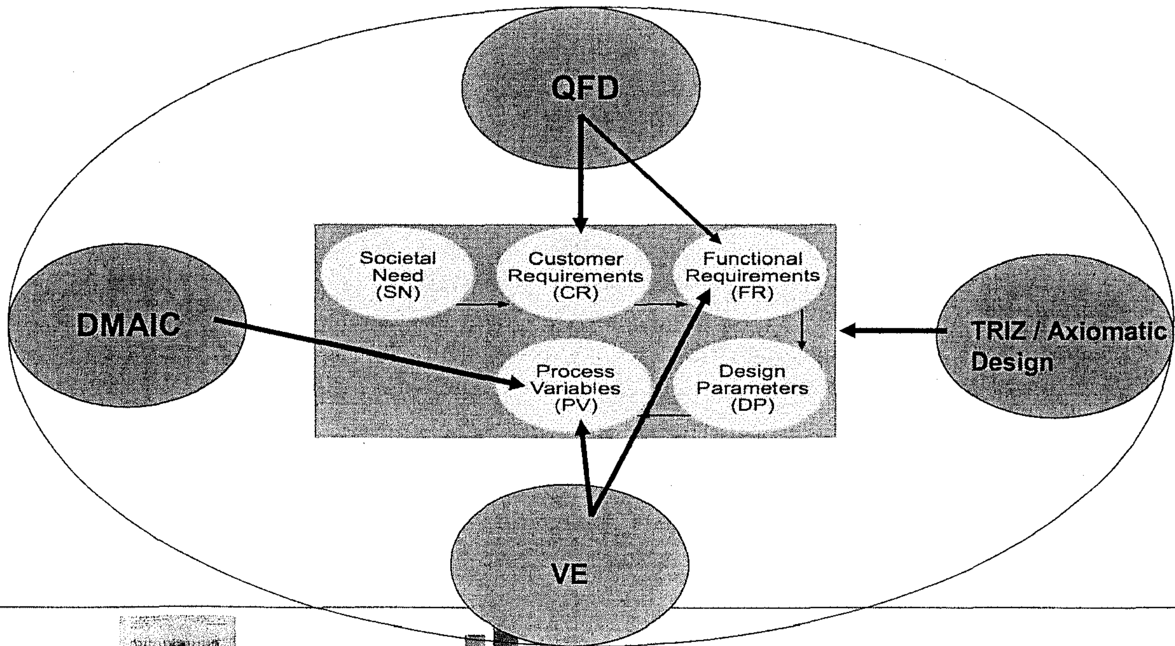
TPPDS Phases and Methodology Integration



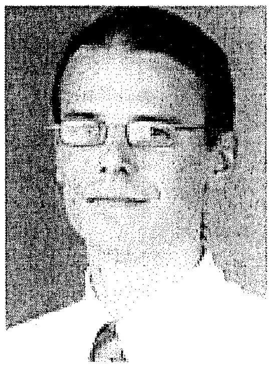
Integration opportunities: QFD with SS, QFD with TRIZ, TRIZ with SS, all with Axiomatic Design

Ideally, integrate all of these methods into a comprehensive DFSS structure.

Comprehensive DFSS



Profile of Lecturer



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1992-1999	Study of Mechanical Engineering at the RWTH Aachen: Graduate Engineer in Mechanical Engineering (Dipl.-Ing.)
1997-1999	Undergraduate research assistant at the Fraunhofer Institute for Production Technology IPT
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INNOVATIVE PROCESS CHAIN OPTIMIZATION - UTILIZING THE TOOLS OF TRIZ AND TOC FOR MANUFACTURING

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Abstract

The enormous potential of process innovation and optimization is often undervalued. In order to stay competitive organizations are forced to adapt quality of products and production to permanently growing requirements. Modern manufacturing processes need to fulfill highest demands on efficiency, flexibility and reliability. Thus, process optimization gains significantly in importance. The increasing complexity and integration of production systems complicate their optimization. Hence, the classical approaches of manufacturing process optimization reach their limits. Depending on the development state of the production system, exponential improvement can only be achieved, using a form of optimization that considers and questions the existing system structure as a whole and enables innovative process design. However, up to now operational practice mostly focuses on the improvement of single process steps and optimizes only within the existing structures. Thus, a large potential for optimization stays unutilized in the manufacturing area.

The objective of the project »Innovative Optimization of Process Chains« which was conducted by the Fraunhofer IPT was to develop a system for the innovative optimization of process chains in manufacturing. The system enables a holistic consideration and optimization of manufacturing processes that results in an innovative process design. To achieve this goal a procedure was developed that integrates classical tools of quality management as well as innovative methods for manufacturing optimization. These are among other things the tools of the so-called »Theory of Inventive Problem Solving (TRIZ/TIPS)« and the »Theory of Constraints (TOC)« which promise a high profit and a relative low effort for qualification. TRIZ and TOC share the assumption that most core problems exist because some underlying conflict or contradiction prevents the straightforward solution of a problem (e.g. improving one characteristic leads to impairment of another). TRIZ especially provides tools to find breakthrough solutions (innovative process design) that overcome these conflicting objectives. TOC is a systems approach to continuous improvement of process chains. It provides a set of five powerful tools, three of them focusing on the safe implementation of solutions found for the problems of optimization, particularly since most great ideas fail in the implementation stage.

The procedure was developed on the basis of the DMAIC (Define-Measure-Analyze-Improve-Control) cycle that originates from the Six Sigma approach. Each stage of the DMAIC process

is supported by one or more tools of an interdisciplinary toolset which combines classical QM-methods with TRIZ- and TOC-tools.

The research project was accompanied by a workgroup that consists of representatives from different industries. The suitability of the systematic for industrial practice was validated in the course of two pilot-applications. The presentation will provide an overview of the research project and give an introduction into the developed system and it's tools. The application of the systematic and the DMAIC cycle will be explained on basis of examples from the pilot applications.

Challenges of Process Optimization in Manufacturing

The competitiveness of modern-day companies is more than ever a direct function of their ability to implement process innovations and optimization. Such optimization, however, is becoming increasingly harder to realize, due to the growing complexity of the ways in which the networks of structures and processes in the manufacturing area are interconnected.

In operational practice, process optimization often means trouble-shooting. People in charge of (continuously) improving production processes strive towards "problem solution in a single stroke". The analysis of the problem frequently gets a raw deal. If any, primarily basic tools for problem solving (e.g. brainstorming) and trial-and-error are applied. The quality of the solution is strongly dependent on the experience and intuition of the problem-solver. Furthermore, many great ideas fail in the implementation stage. When the complexity of the problem is high and no obvious solution is known this approach reaches its limits **/Lit1/**.

Quality management in manufacturing provides several tools to support optimization efforts. FMEA, SPC or test data evaluation can be used to reveal problem areas in a process chain. DoE is a powerful tool that helps to understand an individual process and to simultaneously optimize it for all critical outputs. However, classical QM-tools for manufacturing are mainly focused on the prevention of failures without considering and questioning the existing structures as a whole. The efficiency and the effectiveness of a process chain are not only measures of defects but are multidimensional. This is where classical methods often run into their limits. Technologically mature systems – which serial production facilities invariably are – can only be improved on a profound level by integrated system analyses and holistic optimization efforts that may result in innovative process design. This means that a large part of the optimization potential in the production sector and neighboring fields remains untapped so far. A holistic approach for innovative process chain optimization is required. This approach needs to utilize classical and innovative methods that can cover the integrated analysis of the process chain, the systematical generation of innovative solutions and their safe implementation.

The Project »Innovative Process Chain Optimization«

The objective of the research project (duration: Dec. 1st 2000 until Dec. 31st 2002) was the development of a system which allows the holistic optimization of process chains in the manufacturing area with a view to increasing quality and performance **(see slide 4)**. For practical purposes, a pertinent procedure was developed which successfully combines conventional quality management methods with new and integrated approaches. These incorporate the Theory of Inventive Problem Solving (TRIZ/TIPS) and the Theory of Constraints (TOC), both of which provide high-performance tools for process optimization. The palpable results of the project include an advanced tool kit for quality management operations in manufacturing business environments. The contained tools support the individual stages of the optimization process to which they can be clearly and easily assigned. The internal experts are supported in learning and applying both the procedure and the integrated tools by a (as yet unfinished) guidebook and a corresponding qualification module.

The project »Innovative Optimization of Process Chains« was sponsored by the German Federation of Industrial Cooperative Research Associations (AiF) and was funded by the Federal Ministry of Economics and Technology (BMWi). It was administrated by the Federation for Quality Research and Science (FQS). To ensure the suitability for industrial practice, the project was supervised by a working group that consisted of companies from various industries. The developed system (procedure and toolset) has been successfully validated in the course of two pilot applications in different companies.

TRIZ - Systematically to Innovative Solutions

In the optimization of a process chain the project team has to face a problem which is usually characterized by many requirements and objectives, some of which are conflicting. The team may have to solve a problem with no known solution. This is called an inventive problem and may contain contradictory requirements. Knowledge and creativity are two essential conditions for a successful solution. However, there is often a lack of both **/Lit2/**.

Even though the composition of the team is interdisciplinary, it is virtually impossible to integrate universal knowledge of all specialized areas into a team. Independent studies have shown that creativity diminishes steadily throughout the work phase of life **/Lit 3/**. Many people hesitate to be creative, because they fear that they lack the essential skills. In general humans solve problems by analogical thinking. That is, we try to relate the problem we are facing to some standard class of problems (analogs) we are familiar with, and for which a known solution exists. If we can draw the right analogy, we can find the right solution. Our knowledge of such analogous problems, however, is the result of our educational, professional, and life experiences. Ideally, all potential directions for solutions should be equally regarded. In reality however, only solutions within one's own experience are considered while the consideration of alternative technologies to develop new concepts is ignored **/Lit4/**. This results in what is called psychological inertia which defeats randomness and leads only into those areas of personal experience.

For process optimization it would be a decisive advantage if the team had an extensive knowledge base and was capable of generating innovative concepts purposefully and systematically, rather than more or less at random. The TRIZ method provides some suitable tools. TRIZ expands the knowledge horizon of the developer by using a scientific-engineering knowledge base and supports the user systematically throughout the process of creative problem solving. The method ensures an effective and efficient search for innovative solutions, focusing on the so-called Ideal Final Result. It limits the search field considerably, but fosters creativity within that search field. TRIZ also helps the user to detach himself from the psychological inertia vector, i.e. from his usual thought patterns and structures **/Lit5/**.

TOC - From Concept to Implementation

With the Theory of Constraints (TOC) another powerful methodology for process chain optimization was identified. TOC offers a lot of promising synergy to TRIZ. Both share the assumption that most core problems exist because some underlying conflict or contradiction prevents straightforward solution of a problem. Each approach is capable to analyze the problem situation and to identify the conflict. TRIZ is especially strong in generating innovative concepts to overcome these conflicts. TOC additionally provides tools to answer the question »How do we implement the change?«.

The Theory of Constraints is a systems approach to continuous improvement that has its basis in the manufacturing environment. TOC was developed by Eliyahu M. Goldratt in 1984 which he presented in his first book 'The Goal'. Goldratt likens (production) systems as chains, or networks of chains. A process chain in manufacturing can be thought of as a chain of dependent events that are linked together. The activities that go on in one "link" are dependent upon the activities that occur in the preceding "link". Since »a chain is only as strong as its weakest link«, optimization efforts should focus on "chain strength" by working to strengthen the weakest link – the constraint. TOC is based on several principles that are very important for successful improvement. The crucial principle is *»Systems as Chains«* that has already been mentioned **/Lit6/**. Other vital ones are:

»Cause and Effect«: All systems operate in an environment of cause and effect. One particular event acts as a cause for another event, while the particular cause leads to a specific effect. This relationship between cause and effect can be very complex.

»Undesirable Effects and Core Problems«: The indication of the existence of a problem is brought out by undesirable effects (symptoms). Eliminating undesirable effects gives a false sense of security. The elimination of the core problem, however, not only eliminates the symptoms but prevents them from happening again.

»Solution Deterioration«: The solution to any problem deteriorates with time, because the environment changes. Hence, a process of continuous improvement is required to maintain the same levels of efficiency at all times.

»Ideas are not Solutions«: Mere the idea on how to solve a problem does not result in improvement, rather, the effective implementation of this idea that results in real improvement. However, in many cases ideas fail in their implementation stage.

The TOC thinking process focuses on the answer to three fundamental questions: »What to change?«, »What to change to?« and »How to cause the change?«. This thinking process is supported by specific thinking tools, the five logical trees **(see slide 6)**. *The Current Reality Tree (CRT)* is designed to analyze the current condition of a system and to gain a better understanding for the problem. It identifies the core problem(s) that lead(s) to observed undesired effects which decrease(s) the performance of the system. Solving these core problems becomes the objective. This often requires the elimination of an underlying conflict, that prevents straightforward solution. The *Conflict Resolution Diagram (CRD)*, also referred to as "Evaporating Cloud", helps to resolve these conflicts and strives to create a breakthrough solution to the problem that avoids compromise. Being armed with the tools of TRIZ is here particularly useful. Once a proper improvement measure has been found, the *Future Reality Tree (FRT)* serves to check if it will in fact produce the desired effect without introducing new and unexpected side effects. The FRT can also effectively test alternative solutions before allocating expensive resources to them.

Once the realization of an appropriate solution has become the objective the *Prerequisite Tree (PT)* comes into operation. The PT is designed to find all obstacles and the responses needed to overcome them in realizing the objective. It identifies minimum necessary conditions and requirements without which the objective cannot be achieved. The result of the PT is a sequence of intermediate objectives to be followed to neutralize all obstacles. The TOC thinking process is completed by the *Transition Tree (TT)*. The TT provides a detailed step-by-step instruction for implementing a course of action. It shows all the steps necessary in achieving a specific objective, providing a so called 'road map' to the entire implementation effort. The construction and review of the trees is governed by so-called *Categories of Legitimate Reservation (CLR)*. These are eight rules, or tests of logic that are applied for building, scrutinizing and improving the trees. They also serve to communicate effectively disagreements related to the construction of relationships. The CLRs are clarity, entity existence, causality existence, cause sufficiency, additional cause, cause-effect reversal, predicted effect existence and tautology **/Lit 5/**.

Both approaches, TRIZ and TOC, provide tools for analyzing the initial situation and for identifying core problems. TRIZ is extremely powerful in generating innovative solutions that overcome underlying conflicts/contradictions and bring the system closer to ideality. The solutions found with TRIZ can be successfully scrutinized and implemented by applying the last three tools of the TOC thinking process (FRT, PT and TT). The combined use of classical QM-tools, TRIZ and TOC promises a holistic optimization of process chains in manufacturing, without giving in to compromise. However, to achieve this, two steps were essential. On the one hand some of the individual tools had to be redesigned in order to fit them together. On the other hand a procedure was developed that sets the individual tools into context.

DMAIC – Step-by-Step to Success

The system for innovative process chain optimization that was developed in the research project consists of two major elements. A procedure describing the course of an optimization project and an interdisciplinary toolset that supports each stage of the model. The toolset contains TRIZ-, TOC- as well as classical QM-tools **(see slide 5)**. The procedure was developed on the basis of the DMAIC cycle (Define-Measure-Analyze-Improve-Control) that originates from the Six Sigma approach **/Lit7/**.

In *Define* the team has to identify and define the problem, the objective, customer requirements (internal and external) and important boundary conditions. The process chain to be investigated needs to be understood. To support this stage the Define-Checklist was developed, based on the Innovative Situation Questionnaire of TRIZ. The objective of *Measure* is to determine the current performance of the process and the extent of the problem. The current state of the process is recorded which is essential to rate the achieved success at the end of the optimization project. The Measure phase also prepares the analyze step of the DMAIC cycle by gathering key data that helps to identify the process constraint. Usually a lot of data (test data, MTM, ...) is already available in the manufacturing area. The gathered data is scrutinized in the *Analyze* phase. This stage can be classified into data analysis and process analysis. The common objective is to identify the root causes of the problem and the constraint. As a result of Analyze, optimization priorities are set up. Classical QM-tools (Capability studies, 7 tools, ...) may serve for data acquisition and evaluation. The process analysis can be effectively supported by the CRT.

The optimization problem is solved in the *Improve* phase. The constraint in the process chain is examined carefully in order to find out how to elevate it. Sub-problems, conflicts and/or contradictions are systematically revealed by applying several powerful TRIZ-based tools (e.g. Function-Effect-Modeling). Innovative concepts for solutions are generated, structured and compared. The solutions to be implemented are selected. This can be done by portfolio analysis (e.g. chance/risk; cost/time) or the application of the Future Reality Tree, for instance. The implementation of these solution is methodical safeguarded by the Prerequisite Tree and Transition Tree. The first 4 steps of DMAIC were dedicated to identifying, measuring and implementing change. However, without sustaining the gain, the initial enthusiasm for improvement can easily be lost. The *Control* phase serves for confirming the fact that the improvement measures selected have achieved the goal set up in Define. Therefore, compiled result data has to be reviewed. A second important objective of Control is to select ongoing measures to monitor performance of the process and continued effectiveness of the implemented solutions.

Conclusion

Classical methods of quality management in manufacturing already do a good job in the prevention of failures and can optimize the output of an individual process. However, improvement efforts normally focus on individual elements of a process chain and do not question the existing structures. When it comes to improving a process chain with a holistic view to increasing efficiency and effectiveness, the conventional QM-methods often reach their limits. Especially, when the complexity of the system is high, support is needed.

Core problems that prevent straightforward solution are often caused by an underlying conflict or contradiction. For example, from the current point of view, improving one characteristic of the process will result in impairing another characteristic. Hence, a trade-off seems to be necessary. TRIZ provides powerful tools for overcoming conflicts and contradictions without the need for compromise. TRIZ expands the knowledge horizon by providing a knowledge basis that represents the combined experience of over 2.5 million patents. It also helps users to detach themselves from their usual thought patterns and structures.

Armed with TRIZ, the optimization team can generate innovative concepts for breakthrough solutions. However, ideas or concepts are not solutions. Not until they have been successfully implemented. The implementation stage needs to be methodically safeguarded as well. This is where TRIZ and TOC can complement one another. TOC provides tools that enable the user to evaluate alternative concepts for solutions and ensure successful realization. TOC also supports the analysis of the process chain in order to identify the "weakest link", the constraint, that needs to be strengthened.

The DMAIC cycle as a proven procedure for process optimization sets the individual tools into context. It emphasizes the measurement of the current performance of the process chain, which is essential to evaluate the achieved improvement. The concerted application of classical QM-tools, TRIZ and TOC in the DMAIC cycle results in a holistic optimization of process chains with innovative design. Even if the maturity of the system is high, improvements in quantum leaps are possible. The system for innovative process chain optimization enables enterprises to tap substantial innovation-based optimization potentials and contributes to improving both their quality standards and their competitiveness.

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Fraunhofer Institut Produktionstechnologie

Innovative Process Chain Optimization (IPO) –

Combining the Tools of TRIZ and TOC for Manufacturing Innovative

ETRIA World Conference - TRIZ Future 2003
Aachen, November 13th, 2003

Martin Tillmann, Fraunhofer IPT, Aachen

Structure of Presentation

IPO - Motivation and Objectives

IPO - Systematics

IPO - Application and Implementation

Production Process Optimization

Importance

»Future competition is increasingly between processes!«

78% of more than 440 surveyed companies rated the importance of production process optimization as »high« to »very high«.

70% of those companies said, that present methods of process optimization need to be improved.

3% use innovative methods like TRIZ for process optimization.

[*QM-Study Fraunhofer IPT 2002*]

Trend

Complexity and integration of modern production systems increasingly complicate their optimization.
Classical approaches are reaching their limits.

[*D. Steins, Dissertation RWTH Aachen 2000*]

The Project IPO – Motivation and Objectives

Present Proceeding

- Acute problems are still the most frequent trigger
- Focus on single elements of the process chain
- Strive towards „problem solution in a single stroke“
- If any, primarily application of basic QM-tools (e.g. 7 tools)

Present Results

- If maturity is high, only small improvements are possible
- Many good ideas fail during implementation

⇒ **Substantial potential for optimization is not utilized yet**

Objectives of IPO

- Holistic optimization of process chains in manufacturing
- Utilizing innovative methods for process optimization
- Concerted application of classical and innovative tools

⇒ **Breakthrough solutions for process optimization**

IPO- Innovative Process Chain Optimization

Approved cycle of process optimization

D Define → **M** Measure → **A** Analyze → **I** Improve → **C** Control

Interdisciplinary tool kit with

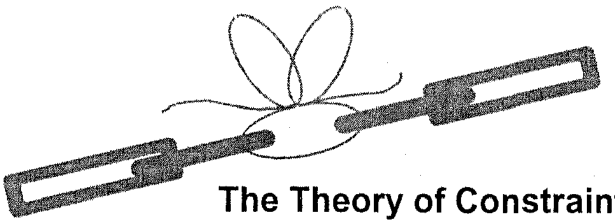
Classical QM-Methods ⟷ **TRIZ** ⟷ **TOC**

methods and techniques of process optimization

Supporting the implementation

Qualification Module ⟷ User Manual

The Theory of Constraints (TOC)



The Theory of Constraints

Production systems consist of process chains, whose quality depends on the weakest link!

The Principles:

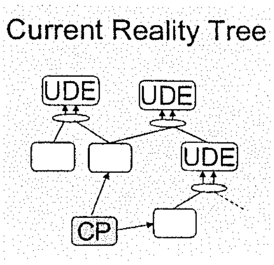
- Systems as Chains
- Local vs. System optima
- Cause and Effect
- Undesired Effects and Core Problems
- Solution Deterioration
- Ideas are NOT solutions!

Thinking Process and Tools

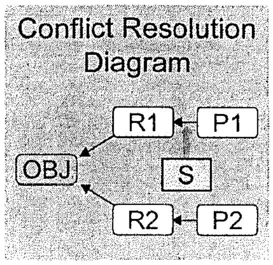
What to change?	What to change to?	How to cause the change?
Analysis of the current situation *Current Reality Tree*	Analysis of „real causes“ *Conflict Resolution Diagram* Projection of the future *Future Reality Tree*	Analysis of obstacles *Prerequisite Tree* Planning the detailed implementation *Transition Tree*

TOC – Five Logic Trees

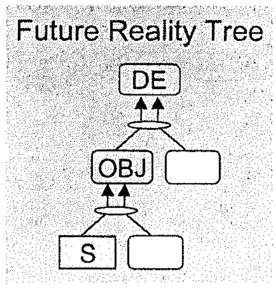
- Information about process chain
- Undesired Effects [UDE]



- Cause-and-effect relationships
- Core Problems [CP] or constraint
- Objective [OBJ] of optimization

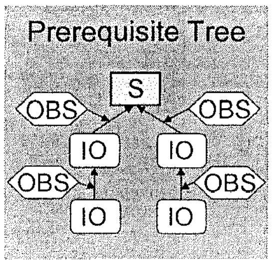


- Breakthrough Solutions [S] for resolving conflicts
- Desired Effects [DE]

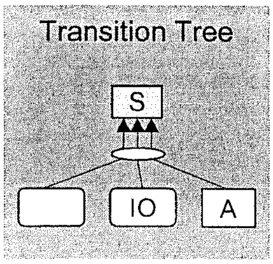


- Simulation model of the future
- Verification of solutions

How to cause the change?



- Obstacles [OBS]
- Intermediate Objectives [IO]
- Milestones of implementation



Step-by-step Actions [A] for successful implementation

Intermediate Conclusion

TRIZ

+ Analysis of initial situation
+ Extensive knowledge-base
+ Powerful tools for generating breakthrough solutions
■ Support by other methods of Systematic Innovation possible

TOC

+ Evaluation and selection of solutions
+ Identification and elimination of implementation-obstacles
+ Step-by-step instructions for implementation

Both

+ Problem analysis and identification of core problems
+ Resolving hidden conflicts/contradictions
+ Highly effective and easy to learn

Combined application of QM-, TRIZ- and TOC-tools results in holistic optimization, without compromise!

Product and Process Chain

Information of the Product and the Process Chain

Product

Window regulator for a cabriolet.

Key characteristic:

- Operation time
- Force
- Stroke
- ...

Process Chain

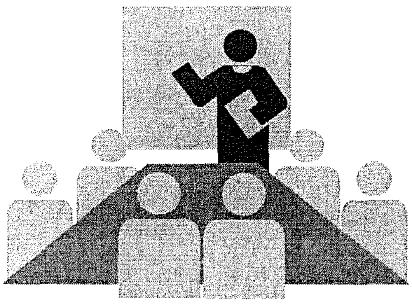
Strengths:

- Experienced employees
- U-Shape
- Kanban
- Poka Yoke
- ...

Potential of optimization:

- Handling
- Fault liability
- Clamping system

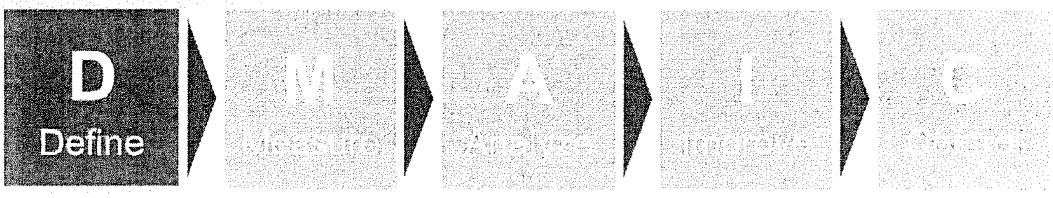
The Project Team



- Employee of Service Team Assembly
- Employee of Production Scheduling
- Shop Floor Personnel
- Employee of Quality Management
- Employee of Engineering
- Employee of Continuous Improvement Process (CIP)
- Consultant (IPT)

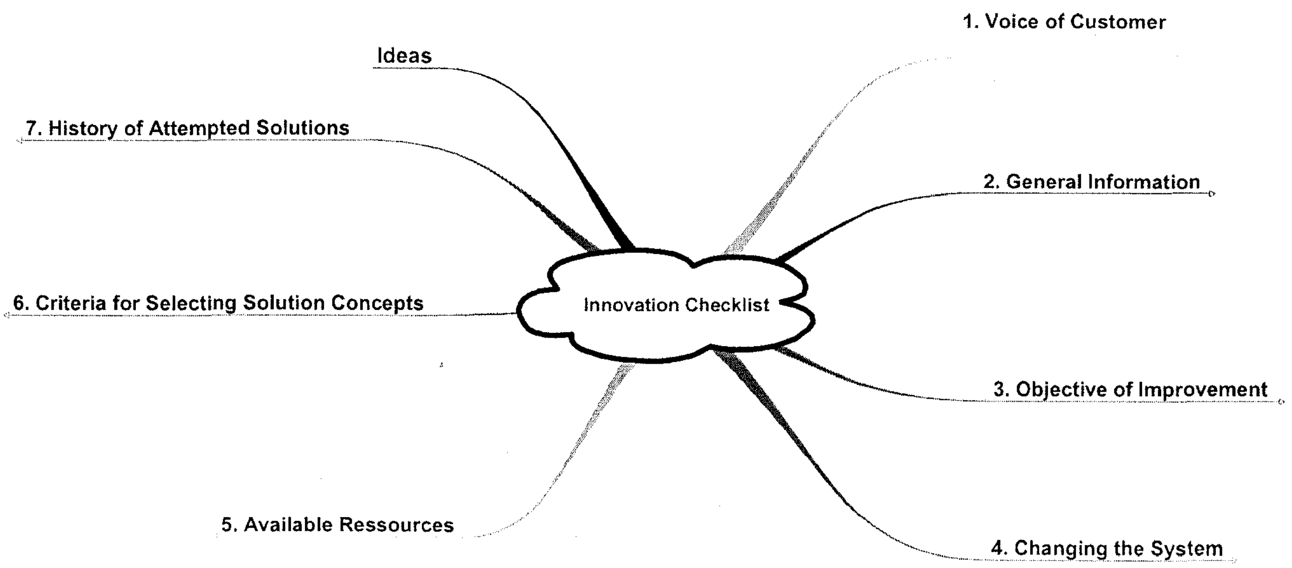
Define Phase

Purpose and Objectives	Definition of the project Relevant boundary conditions Description of the process chain Objective of optimization



Proceeding	Define-Checklist for the definition of project and objective Process-charts to characterize the process chain Appreciation of existing structures (What should be retained?)

Define Checklist



Measure Phase

Purpose and Objectives

- Acquisition of metrological data of the current situation
- Determine the degree of the achievement of objectives
- Basis for the identification of main problems
- Basis for the measurability of success

D Define ▶ **M Measure** ▶ A Analyze ▶ I Improve ▶ C Control

Proceeding

- Ensure actuality in case of using already available data
- Get clarity about the definition of the measurand
- Ensure capability of the measuring equipment (e.g. R&R)

Analyze Phase

Purpose and Objectives

- Analysis of acquired and available data
- Identification of cause-effect relationships
- Identification of the core problem
- Localize the constraint of the process chain

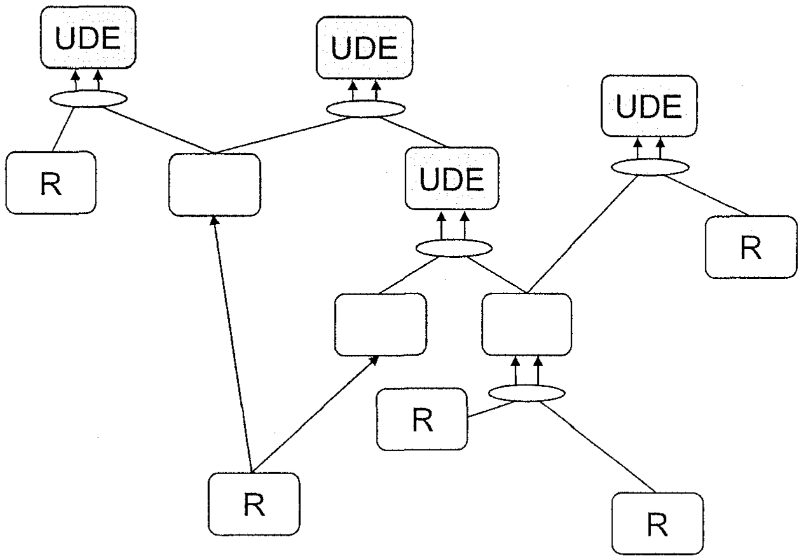
D Define ▶ M Measure ▶ **A Analyze** ▶ I Improve ▶ C Control

Proceeding

- Current Reality Tree for root cause analysis within the process chain
- Reliable determination of the constraint only by combined analysis of data **and** analysis of process

TOC- Current Reality Tree (CRT)

- Undesired effects [UDE] are symptoms of the optimization problem
- Roots [R] are the starting point of a cause-effect relationship

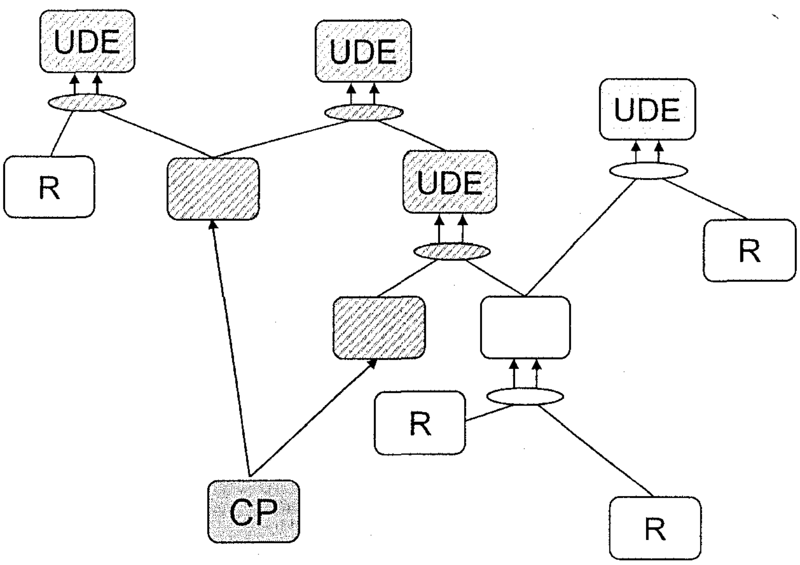


Keep »8 rules of legitimate reservation« in your mind!

TOC- Current Reality Tree (CRT)

- Undesired effects [UDE] are symptoms of the optimization problem
- Roots [R] are the starting point of a cause-effect relationship

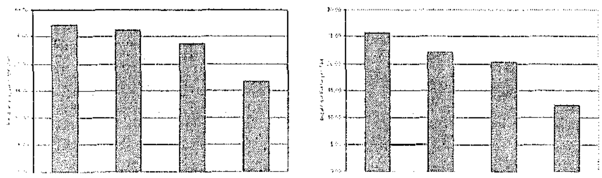
- The core problem [CP] is the origin of a substantial number of UDEs and determines the constraint



Keep »8 rules of legitimate reservation« in your mind!

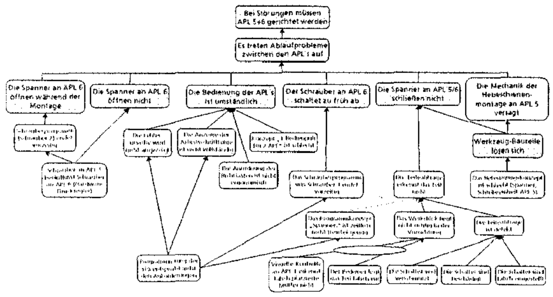
Identification of the Constraint

Pareto-Analysis of Malfunctions



Frequency — Duration

Current Reality Tree



Constraint: Workplace 5

Improve Phase

Purpose and Objectives

- Developing innovative solutions
- Evaluation of solutions and selection of best solution(s)
- Identification and overcoming obstacles of implementation
- Implementation plan for the best solution(s)

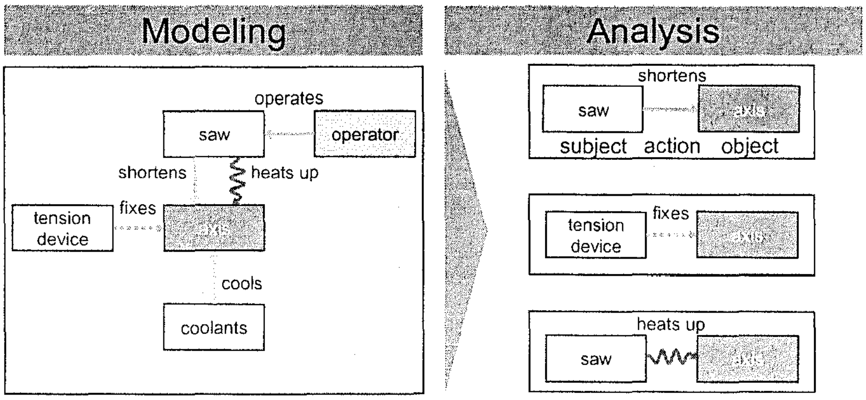
D Define ▶ M Measure ▶ A Analyze ▶ I Improve ▶ C Control

Proceeding

- Improve roadmap guides through the optimization process
- TRIZ tools help to detect and to overcome underlying contradictions and conflicts in objectives
- TOC tools safeguard the successful implementation

Modeling

- Define objects
  - Components
  - Supersystem
  - Products
- Connect Objects through defined interactions
- Identify
  - Primary useful function
  - Harmful function
  - Undesired effects
  - Conflicts/ Contradictions



product	Object of the main function of the engineering system	normal arrow	normal arrow: desired, satisfying interaction
component	An object that is a constituent part of an engineering system	broken arrow	broken arrow: desired interaction which is not satisfying in characteristic, intensity or quality
super-system	An engineering system, personnel, or an environment that interacts with the system to be analyzed	winding arrow	winding arrow: undesired interaction

Improve Phase – Modeling

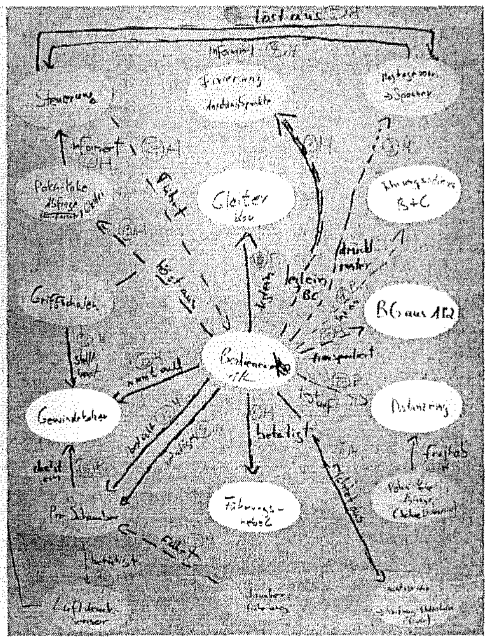
Definition of Sub-Process and Modeling: Workplace 5

Pre-assembly and deposition of distance bolt

Bolt the glider together

Preparation of the regulator's track for screw connection

Bolt the track together



Fraunhofer Institut Produktionstechnologie
FQS Forschungsgemeinschaft Qualität e.V.
TRIZ

Dealing with contradictions and sub problems

Developing Solutions

Identified Contradictions

Contradiction Analysis

Conflict:
Improving one characteristic results in impairing another characteristics.

Contradiction:
Two conditions excluding each other.

→ Contradiction Matrix 40 Principles
→ 4 Separation-principles

Prioritized Sub-Problems

Trimming

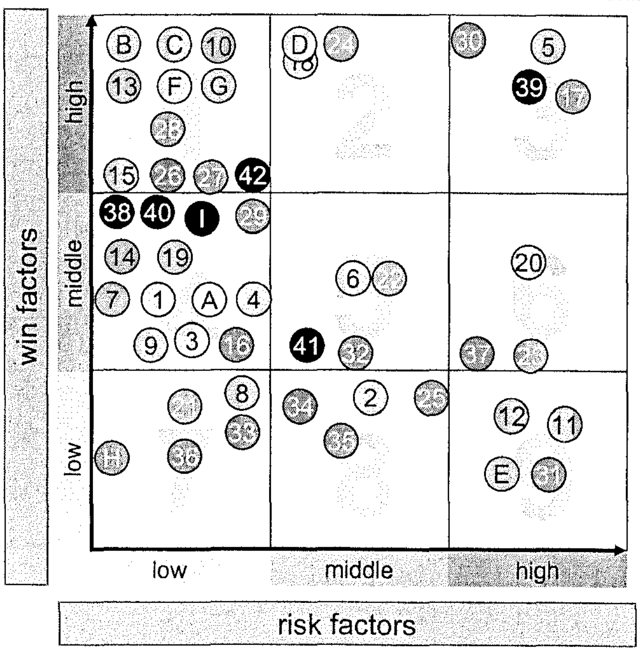
1. Can another object perform the function?
2. Can the object, that is affected by the action perform the function itself?
3. Can the action be dropped out?
4. Can a part be replaced or be eliminated?
5. Can the functional principle be changed?
6. Can further resources be used?

→ Substance-Field-Analysis
→ 76 Standard Solutions

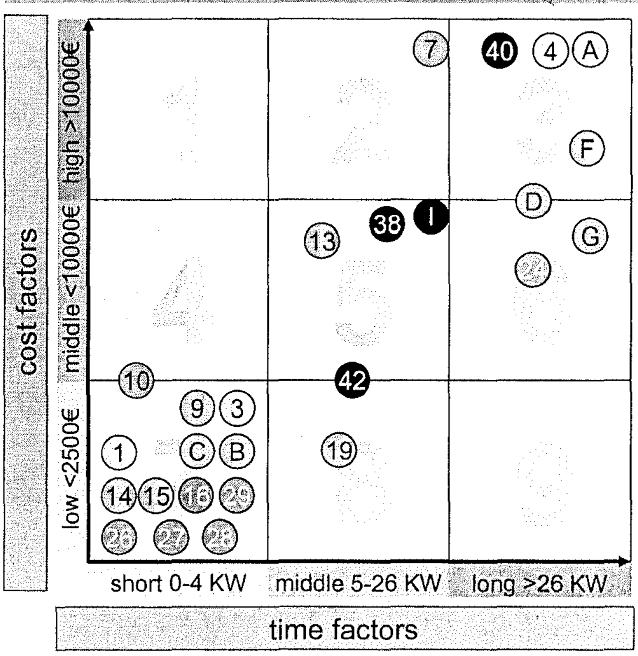
→ Solution concepts/ideas

Choosing the right Solution(s)

Chance-Risk-Portfolio



Cost-Time-Portfolio



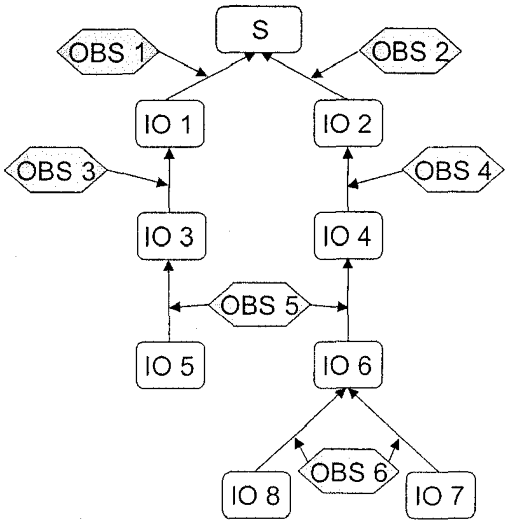
Safeguarding the Implementation

Prerequisite Tree (PT)

Purpose and Objective

- Answers the question:
  How can the solution concept be implemented?
- Starting-point:
  Solution [S]
  (e.g. from TRIZ-Application)
- Identification of obstacles [OBS] to implementation of solutions.
- Deduction of intermediate objectives [IO] in order to overcome these obstacles.

Result

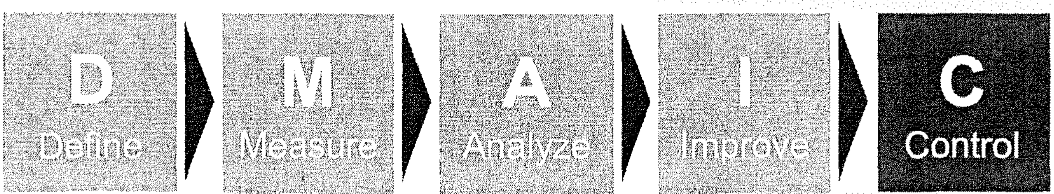


Obstacles are solely to overcome, not to eliminate!

Control Rase

Purpose and Objectives

- Surveillance of effectiveness
- Observation/measurement of long-time behavior
- Reaction on changes
- Documentation of project and process chain



Proceeding

- Consideration of higher level monitoring instruments
- Preservation of solutions as example of success
- Lessons-Learned analysis
- Dignify and celebrate success!

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Constraint-Dominated Breakthrough Innovation in a Manufacturing Process Situation

(A Case Study From the Photographic Paper Manufacture Industry)

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Abstract

All systems hit limits. All attempts to try and improve a system that has hit its fundamental limit are destined to fail. In such situations, additional improvement can only be achieved by making changes to the system. Changing a system – particularly a manufacture process that may have commissioning costs measured in millions of Euros – can imply significant risk and expense. In the paper we discuss strategies designed to help engineers to ensure that effective change can be made with the minimum impact on both parameters. The paper uses a real industrial situation from the photographic paper and film manufacture sector, and concludes by showing quantifiably significant bottom-line improvements to the manufacturing process under investigation

Introduction

One of the philosophical pillars of TRIZ is the idea that all systems will evolve in the direction of an ideal final result. In this ideal final result, the desired functions will be achieved with zero cost or harm. Although there are many instances where this end goal has been attained (Reference 1), it is generally used as an *attractor* for innovative efforts; successful innovations should deliver a more ideal solution than the solution they are going to replace.

The dynamics of evolution further dictate that the route from an existing system to the ideal final result state is a non-linear one. Evolution occurs through a series of disruptive shifts as one system hits its fundamental limits in the form of a conflict or contradiction, and then another one emerges which successfully challenges those conflicts.

As illustrated in Figure 1, TRIZ gives us three principle mechanisms for accelerating this evolution dynamic – we can solve contradictions, find other ways of delivering functions, or we can use the trends of evolution.

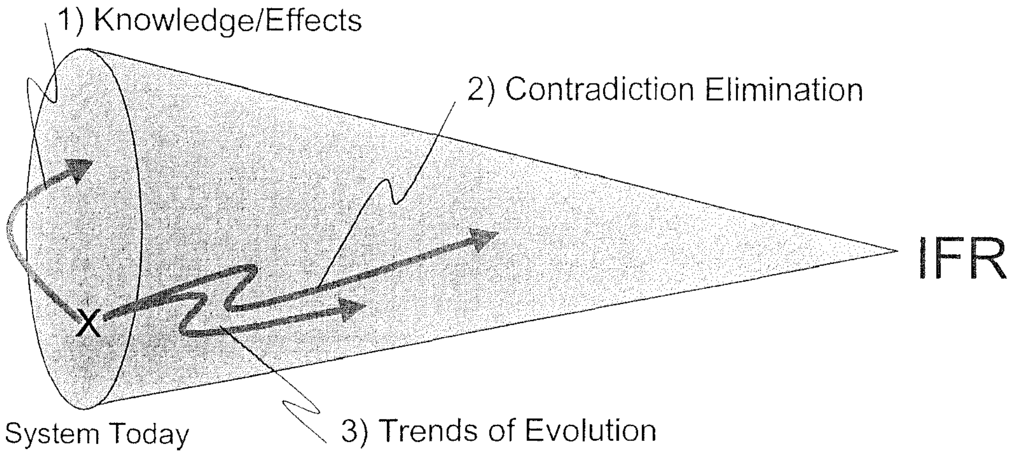

Figure 1: Three Principle System Evolution Mechanisms

Any successful breakthrough strategy must, of course, fit within the real-life constraints imposed on the prevailing situation. Constraints can very easily transform a solvable problem into one which is not. This is especially evident when we take into account the implication from the conical image presented in Figure 1 that the evolution process is convergent.

If we imagine that it is possible to define a space within which all solutions lay (for example the dotted box illustrated in Figure 2), then we may see the constraints as the things defining regions of that solution space where we can and cannot go. As suggested in the Figure, the constraints can be either technical in nature (e.g. 'the energy consumption must be less than x') or they may be 'business' (time, money, people, ethical, etc).

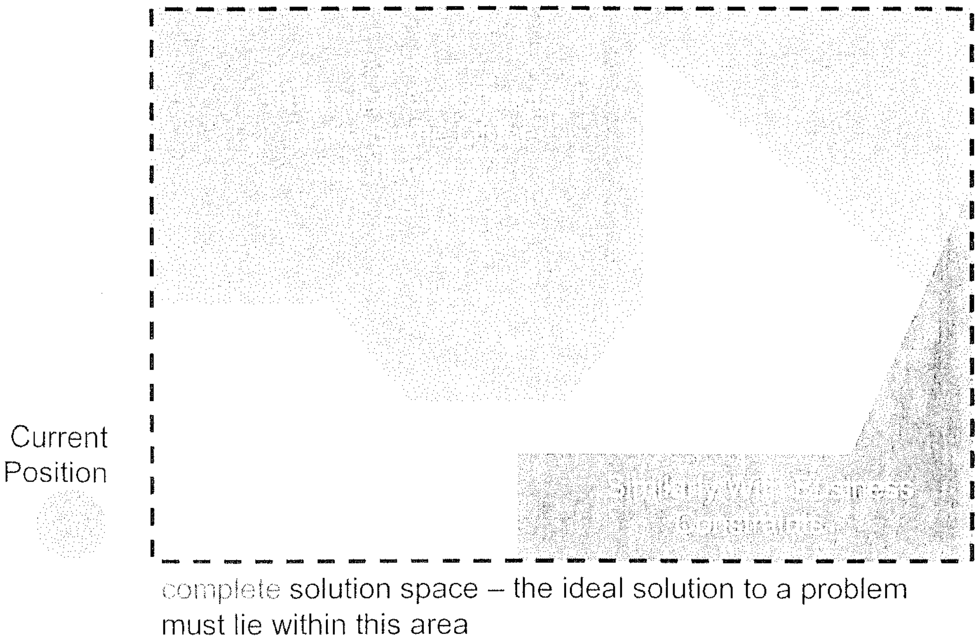

Figure 2: Constrained Evolution

What this image suggests is that if our evolution path from the current position to Ideal Final Result is blocked by our constraints, then advancement of the system will be prevented.

As reported in Reference 2, in manufacture processes the constraints are often very heavily dominated by the amount of investment sunk into the procurement of expensive machinery. Reference 3 also goes on to report that this is a major reason why so many innovations come from newcomers and not incumbents – the newcomer simply has no previous investment to write-off. What this should tell us is that smart process industries will manage their constraints well and will be planning for disruptive jumps in their capital equipment.

Reference 3 provides a demonstration of how the idea of constraint management can be used in conjunction with the trends of evolution part of the TRIZ toolkit. In this paper we will focus on the management of constraints in relation to the function database and contradictions parts of the toolkit.

Background

A process for manufacturing a chemical in the photographic process has always been used in considerable quantities. During the past 5-6years the demand for photo products has reduced as the digital imaging market has rapidly grown in size. This has meant that previous batch sizes are too large and new ways of manufacturing must be found in order to keep the manufacturing process economic. There is also the issue of inventory and product shelf life with the original size batches. An approach from the production department was made to ask for a manufacturing process that reduced the batch size from 106kg to 50kg. A small group of engineers and production technologists were brought together to investigate ways to achieve the production requirements, with only one person in that group having used TRIZ.

Initial Investigation

An initial investigation revealed a number of other issues that were of a consequence in the manufacture of this chemical.

1	Batch size	106kg
2	Chilling time	2hours
3	Mixing time	30mins.

The operators felt that the chilling time and cooling time were also excessive and that if there were a reduction in these parts of the process it would free up the vessel for other work.

The ideal final result for each of the three critical process parameters, was readily seen as, respectively, 0kg, 0seconds and 0seconds. The ideal final result (IFR) idea forces us to put constraints to one side. In some instances, we can use the IFR to force ourselves to develop some very effective solutions. In this case – like many others – however, the constraint of having a large amount of existing equipment and lack of capital budget to replace them prevented us from using the IFR definition as anything other than an attractor. In situations like this – where the constraint prevents a big change – we are forced to analyse the existing system.

The System

The whole system was sketched and the question asked as to whether the various components contributed to the reason for the long chill time, the extended mixing time or the need for such a large batch. This approach allowed us to reduce the components that were to be analysed and a function diagram was produced. Figure 3 illustrates a simplified version of the resulting function analysis model.

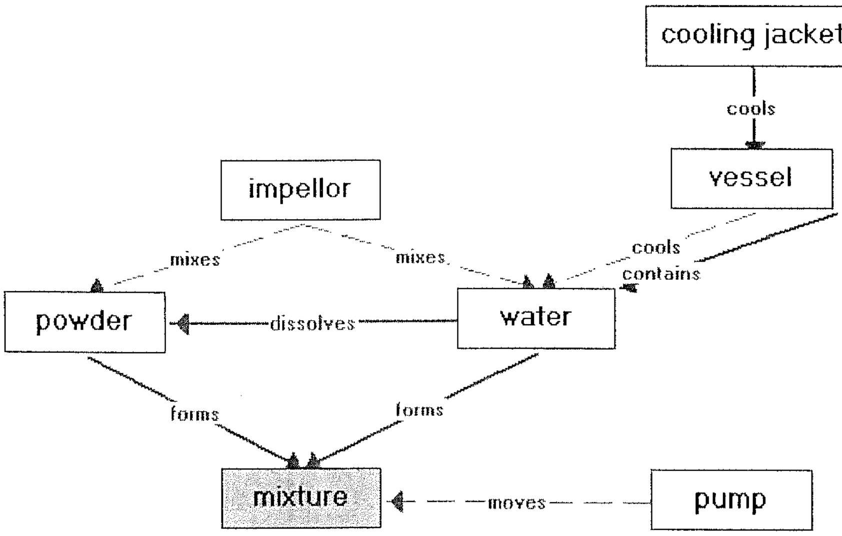

Figure 3: Simplified Function Analysis Model For System

Manufacturing Process

The manufacturing process was relatively straight forward consisting of the following steps:

1	Add water to vessel	
2	Allow water to cool	2 hours
3	Add powder to water	
4	Mix with Impellor	30 minutes
5	Open bottom outlet valve	
6	Pump away mixture	

The group now asked three questions

1 Why could the batch size not be reduced?
2 Why did the cooling take so long in a jacketed vessel?
3 Why did the mixing take so long?

The following answers were given or found out during the investigation:
The batch size was actually less than it should have been. When viewed from the additions box on top of the vessel it was clear that the 106kg only just came into contact with the bottom of the impellor. The operators then explained that the impellor required the water to be above the impellor as it was used as a lubricant of for the bearing supporting the impellor on its shaft.

The second answer that became very clear was that because the batch size had been reduced to its 106kg it was now below the level of the cooling jacket. It was only by the fact that the steel shell gradually cooled down that the water that it contained also cooled down.

The third and final answer showed that due to previous attempts to reduce batch size it was now so low in the vessel that much of the rotation of the impellor was completely wasted as only air was being entrained into the fluid and not the powder.

The group were keen to forge ahead with the purchase of a new impellor suited to the size of batch but after some discussion it became clear that this would not answer the greatest bottleneck in the process which was the initial cooling of the water from its ambient temperature down to the temperature required by the process.

More detailed questions were now asked as to what was stopping the various problem areas from being improved.

What is stopping the operator from reducing the batch size?
The bearing will no longer get any lubrication and therefore overheat and fail
What is stopping the operator from reducing the chilling time?
The fluid is not in contact with the part of the vessel that is very effective at chilling
What is stopping the operator from reducing the mixing time?
The fluid does not adequately cover the impellor

Contradictions

This kind of 'what would I like to improve/what stops me from making the improvement?' questioning is a very simple and effective way of identifying the contradictions within an existing system. From the above knowledge it was easy to begin to list a set of conflict pairs:-

I want to reduce the batch size but bearing overheats
I want to reduce the batch size but mixing does not occur
I want to reduce the batch size but chilling time is increased
I want to reduce the batch size but air is introduced into the solution

The conflict pairs could also be transformed into physical contradictions:

The water level must be low for a good batch size but must be high for efficient chilling
The water level must be low for good batch size but high for good lubrication
The water level must be low for good batch size but high for good mixing

In other words we really want the water to be at the top of the vessel for one operation and at the bottom of the vessel for another operation.

Having identified conflicts, the matrix was consulted to see what inventive principles might be used. We decided to use the new 2003 version of the Contradiction Matrix (Reference 4). As there were several contradictions present, we also used the CREAX Innovation Suite to allow us to examine multiple contradictions simultaneously. The software will automatically identify and prioritise the sequence of Inventive Principle suggestions.

Note that we used the parameter 'volume of stationary object' rather than 'moving object' because the focus of the contradictions was on the static part of the system – the vessel. The positions of all of the functional elements contained within the vessel were fixed, and only the fluid was capable of relative movement.

Improving Factor	Worsening Factor	Principles
Volume of Stationary Object (8)	Function Efficiency (24)	1 7 28 5 2 19 12 37
I want to reduce the batch size but mixing does not occur		
Volume of Stationary Object (8)	Temperature (22)	3 26 4 35 15 6 19
I want to reduce the batch size but bearing overheats		
Volume of Stationary Object (8)	Duration of Action of Stationary Object (13)	35 38 15 31 3 1 34
I want to reduce the batch size but chilling time is increased		
Volume of Stationary Object (8)	Amount of Substance (10)	35 3 31 40 5 13 17
I want to reduce the batch size but air is introduced into the solution		

Figure 4: Conflicts Mapped To New Matrix

For the physical contradictions a series of questions about the process were asked to decide which separation principles should be used.

Where do I want the water to be high?	On the inside of the vessel
Where do I want the water to be low?	On the inside of the vessel
When do I want the water to be high?	For chilling
When do I want the water to be low?	For mixing
I want the water to be big if?	I'm chilling
I want the water to be small if?	I'm mixing

This suggests that either the separation in time or separation upon condition principles could be used. This in turn leads us to a selection of Inventive Principles that could be used to challenge the contradictions present.

* there should be no possibility of affecting the quality of the product – several downstream processes had been optimised around the product in precisely its current form.

Both resources and constraints were then used as a means of down-selecting the Inventive Principles that could and could not be used to help generate solution directions.

Resource/Constraint	**Principles Eliminated**
Product must not be affected	35 – Parameter Changes 38 – Enriched Atmosphere 34 – Discard & Recover 40 – Composite Materials
Existing Hardware	26 – Copying 37 – Thermal Expansion 6 – Universality 40 – Composite Materials 7 – Nesting
Energy consumption	36 – Phase Transition

Care was taken to only 'eliminate' Principles that were clearly outside the scope of the boundary conditions. Thus, although Principle 13 – recommended by one of the conflict pairs – appeared to be inconsistent with the constraint about not changing hardware, we could see several places where it could potentially be used by elements within the system. Principle selection, in other words, was made on the basis of zooming-in and zooming-out on the system, and examining it from different perspectives.

At the end of this 'constraint management' analysis, we were left with the following remaining Inventive Principles (in descending order of likelihood – as determined by the sequence present in the Matrix):

3, 1, 31, 15, 28, 4, 5, 19, 2, 29, 13 and 17

With this information to hand a brain storm on the Inventive Principles and resources available was carried out. Initial focus was placed on the pump since this was felt to be the most under utilised item in the plant: The pump was only used at the end of the cycle for emptying the vessel and sat stationary for more that 90% of the manufacturing process and it would also answer the question of how do you raise the water to be at the top of the vessel for chilling. The pump thus looked like a possible untapped resource capable of offering an answer to the Other Way Around direction suggested by the conflict analysis.

Implementation

A valve was fitted into the pipeline from the pump and a bypass line fed back through the inlet port on top of the vessel and directed towards the wall of the chilling jacket.

A test was conducted with a 106kg batch of water and found to chill the water in 45mins which was a major step forward in reducing cooling time. However, it still did not answer the issue of batch size.

The group went back to the resources and reviewed what could be done for mixing and batch size. Again the pump operation came to light as a source for mixing so the impellor was turned off during a trial and the re-circulation of the fluid was carried on after the chilling phase of the process.

The mixing process still took as long with this method.

At this point the groups hand was forced somewhat as the bearing on the existing impellor failed and we were faced with a £3500 bill to replace the unit. We took the recommendation of Principle 28, Mechanics Substitution as a prompt to see if it were possible to achieve the mixing function delivered (albeit not very well) by the impellor with a non-mechanical means. (Note that if the impellor bearing had not failed, the chances are we would not have thought so much about this Principle as it appeared to be offering a highly non-instinctive solution direction.)

Further analysis suggested the segmentation principle (1) for the fluid flow and also using the pneumatic/hydraulic principle (29) in mixing.

This now presented a further physical contradiction of wanting the feed pipe to be high for the chilling and low for the mixing. A solution to this contradiction was achieved by splitting the feed pipe into the top of the vessel into two parts. One fed to the sidewalls and the other went down to the bottom of the vessel. Another example of Principle 1, but also elements of Principles 3, 4, and 17 were incorporated into the eventual solution.

With these solutions, we now found that by having the pipe feeding to the bottom of the vessel we could reduce batch size considerably.

Next, the feed pipe for the chilling part of the process had a spray device added to its end – yet another interpretation of the segmentation Principle. This allowed the surface area of the water hitting the sides of the vessel to be greatly increased.

Further analysis of Principle 17, Another Dimension, guided us to turn the bottom of the pipe by 90^{o}. This generated a rotating motion of the fluid in the bottom of the vessel. Judicious positioning of a simple fixed plate against which the fluid would be forced impinge further increased the mixing capability. We noted for future use the possibility of further improving mixing by adding holes to this plate – as was suggested by Principle 31.

Results

After incorporation of all of the recommended solutions, the following results were obtained:

Chill time with the spray nozzle system now	less than 15 minutes
Mix time with pump and pipe system	less than 15 minutes
Batch size reduced to	less than 50kg

The benefits corresponded to a doubling of batch size flexibility, a five-fold reduction in overall process time, and the complete elimination of a difficult and expensive maintenance operation.

Conclusions

This case study showed that it is possible to introduce the techniques of TRIZ into an inexperienced group and obtain excellent results.

TRIZ forces users to focus on untapped resources in systems. Like nearly all systems, the one involved in this case study was seen to contain a lot of untapped potential. This happens because TRIZ has examined all areas of technology, and thus accelerates the possibility of transferring the good ideas that have been developed in one sector to others. As such, we might see TRIZ as offering a global benchmarking capability.

The case study demonstrates how the contradictions part of TRIZ can be used to alleviate bottlenecks in manufacturing processes. All systems eventually hit limits. Exceeding these limits fundamentally requires some form of change to the system.

What we have demonstrated here is a process of using resources and constraints to determine which of the TRIZ solution generation components are more likely than others to help generate real solutions. That process is designed to be flexible. Its essence is described in Figure 5. According to the Figure, we can use the Contradiction parts of TRIZ to generate a list of Inventive Principle suggestions. We can then use our resources and constraints to determine which of these Principles is likely to point us towards solutions consistent with those constraints. There is no absolute 'need' to do this of course, but when the range of contradictions is broad – as it was here – and the number of Inventive Principles recommended is high, a constraint management process can do much to reduce the time required to generate viable solutions.

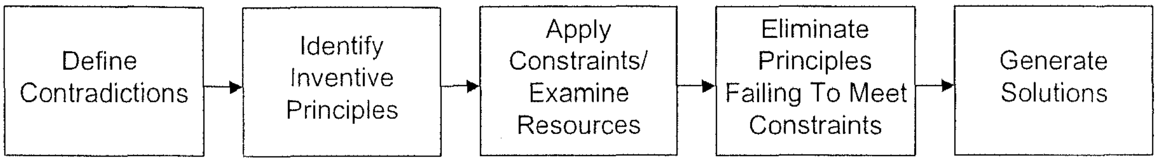

Figure 5: Constraint Management Process

Exactly the same process applies during the use of other TRIZ tools; constraints and resources will dictate which of the solution directions suggested by Trends, Effects/Knowledge, etc will or will not offer viable solutions.

As we could see in this case study, very often the resolution of one contradiction generates others. This is fundamental to the idea of Contradiction Chains (Reference 5). One of the main ideas behind the contradiction chain idea is that system evolution takes place through resolution of a succession of conflicts and contradictions. Very often we will hear things like 'ah, but, I can't implement that solution because of x'. TRIZ is trying to suggest to us that whatever x might be, someone, somewhere has already solved that problem. In other words, do not give up after the first attempt to solve a problem has hit an obstacle. In this regard, we also note that there are still Inventive Principles recommended for our contradictions that have not as yet been implemented in the solution. This suggests that we still have significant untapped potential to evolve and advance the new process.

A strong evolution driver in most process operations is reduction of the cost and harm aspects of the ideality equation. Both of these drivers will influence which of the TRIZ solution generation triggers can be deployed. Principles and trends associated with reducing part count are thus particularly relevant in these types of problems. In all processes we are aiming to produce more with less. The IFR attractor says that ultimately we want everything from nothing.

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4) Mann, D.L., Dewulf, S., Zlotin, B., Zusman, A., 'Matrix 2003: Updating the TRIZ Contradiction Matrix', CREAX Press, July 2003.
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Constraint-Dominated Breakthrough Innovation in a Manufacturing Process Situation

Ian Mitchell
Darrell Mann

ETRIA Conference, Aachen, 12-14 November 2003

Manufacturing process

- Reduction in chemical useage requires a reduction in batch size (currently 106kg)
- Production required a 50% reduction

- Other consequences
  - ƒchilling time 2 hours
  - ƒmixing time 30 minutes
- Chilling time excessive
- Mixing time too long

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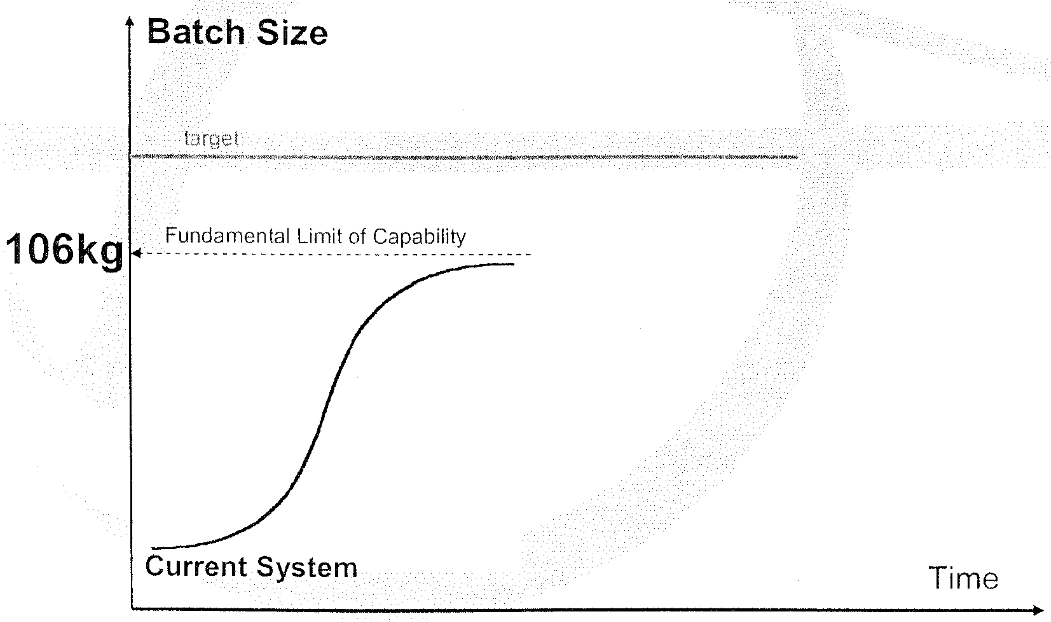
The Overriding Importance of Evolutionary S-Curves



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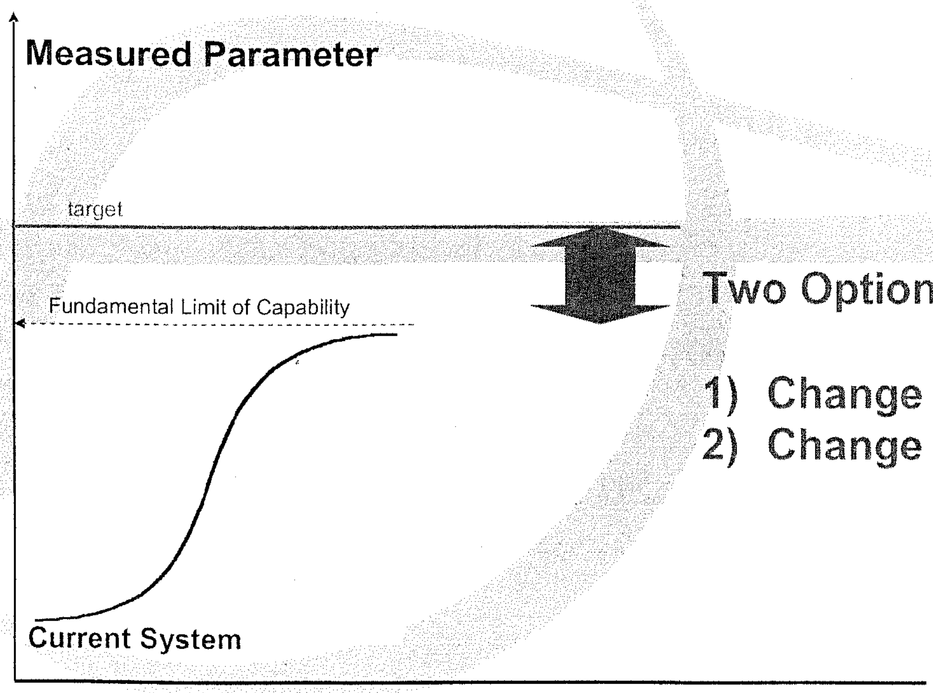
The Overriding Importance of Evolutionary S-Curves



Two Options

1) Change the target
2) Change the System

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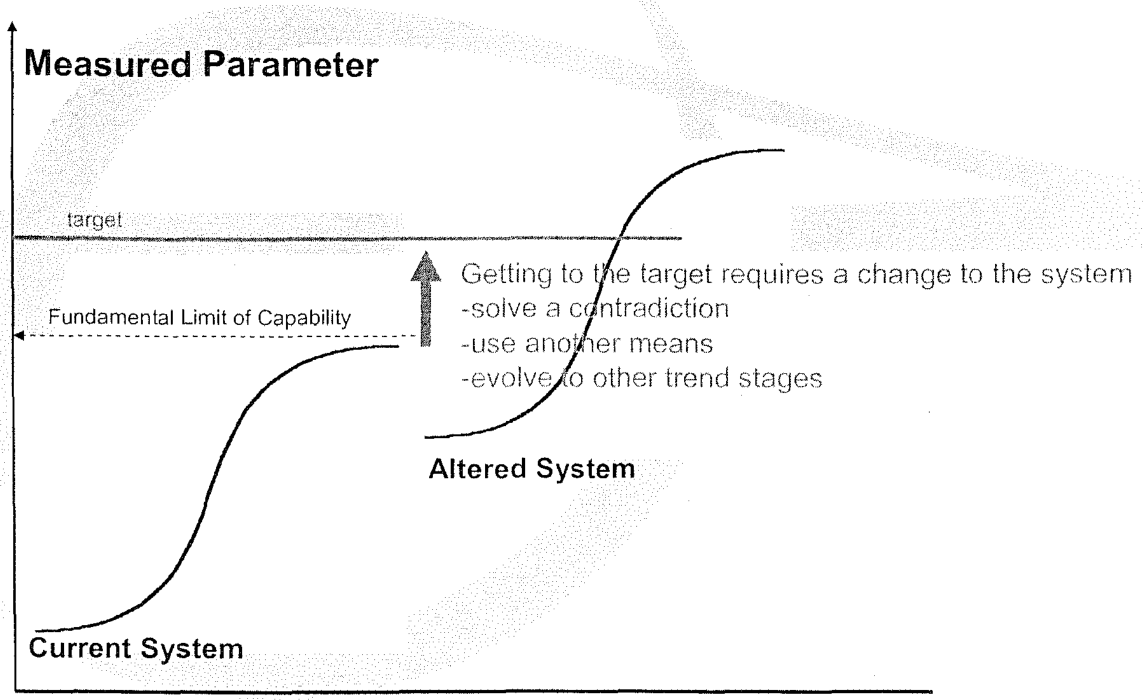
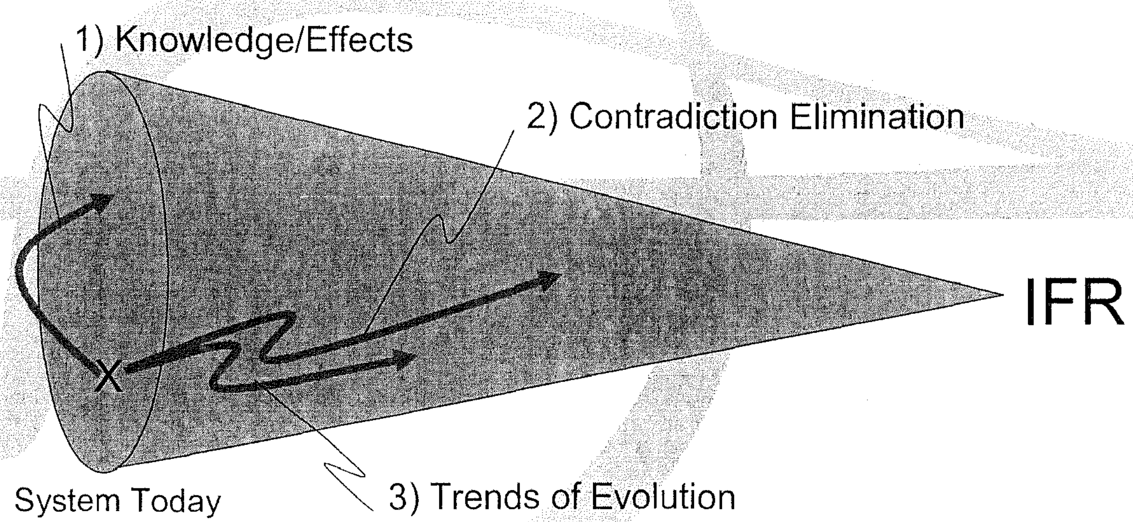
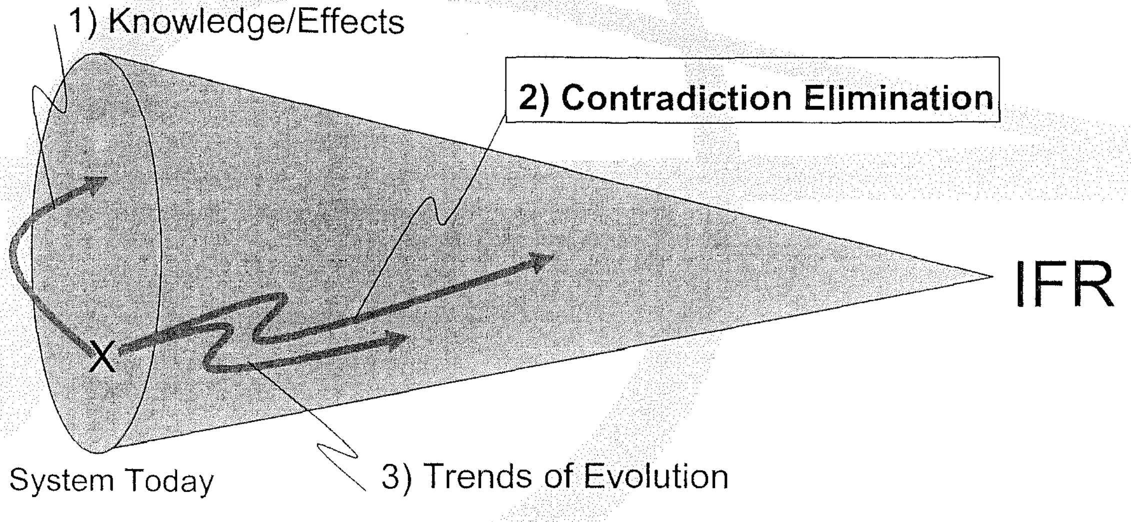
The Overriding Importance of Evolutionary S-Curves



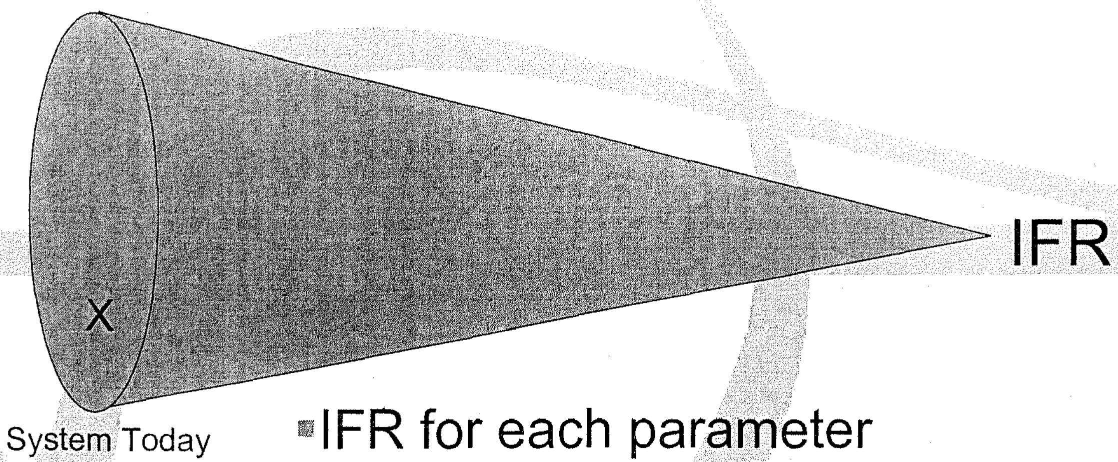
Three Means of Changing a System



Three Means of Changing a System



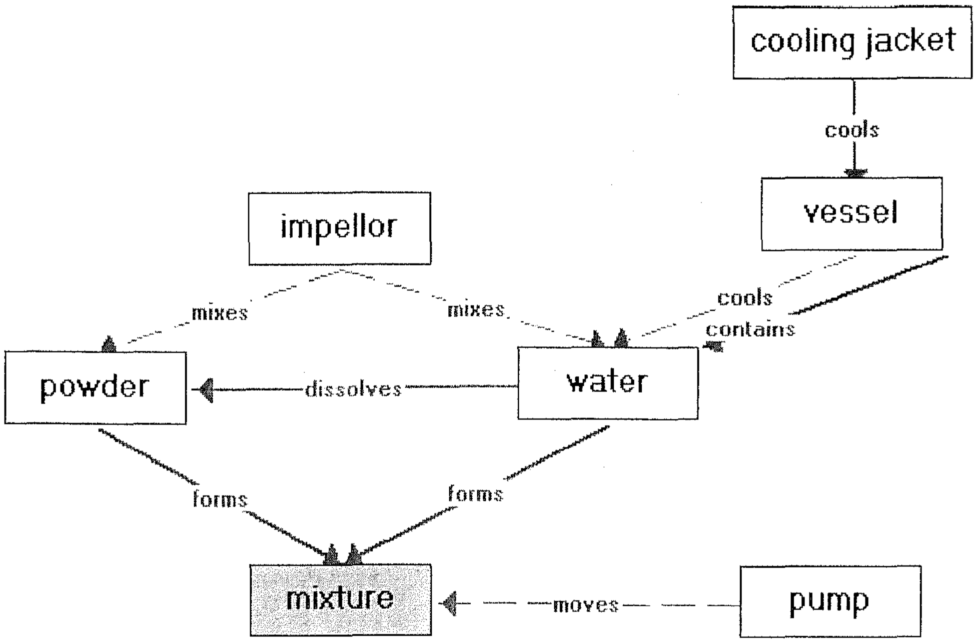
Defining The Problem 1) IFR



- IFR for each parameter

* Minimum batch size	0kgs
* Chilling time	0 seconds
* Mixing time	0 seconds

The System



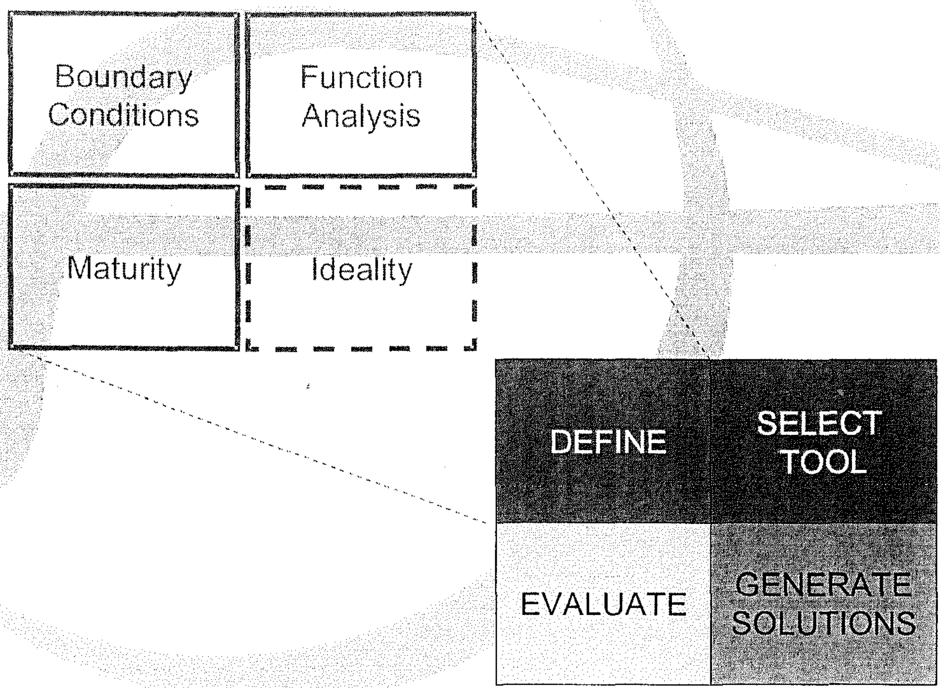
Whats stopping?

- Why could the batch size not be reduced?
- Why did the cooling take so long in a jacketed vessel?
- Why did mixing take so long?

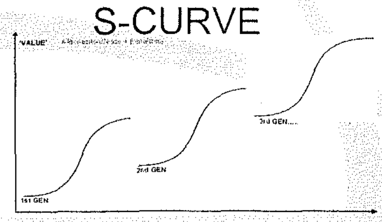
Whats stopping?

- Batch size is already too small
  - Impellor is not fully covered
  - Bearing can over heat
- Batch below the level of the cooling jacket
  - Very slow process reducing the unjacketed shell
- More air entrained than mixed
  - Impellor only partially submerged

Ideality Within the Systematic Innovation Context



3 Essentials of Problem Definition:

BOUNDARY CONDITIONS - Benefits - Resources - Constraints - ('Sore Point')	S-CURVE 	FUNCTION ANALYSIS

+ 1 'Highly Recommended'

Ideality/ Ideal Final Result

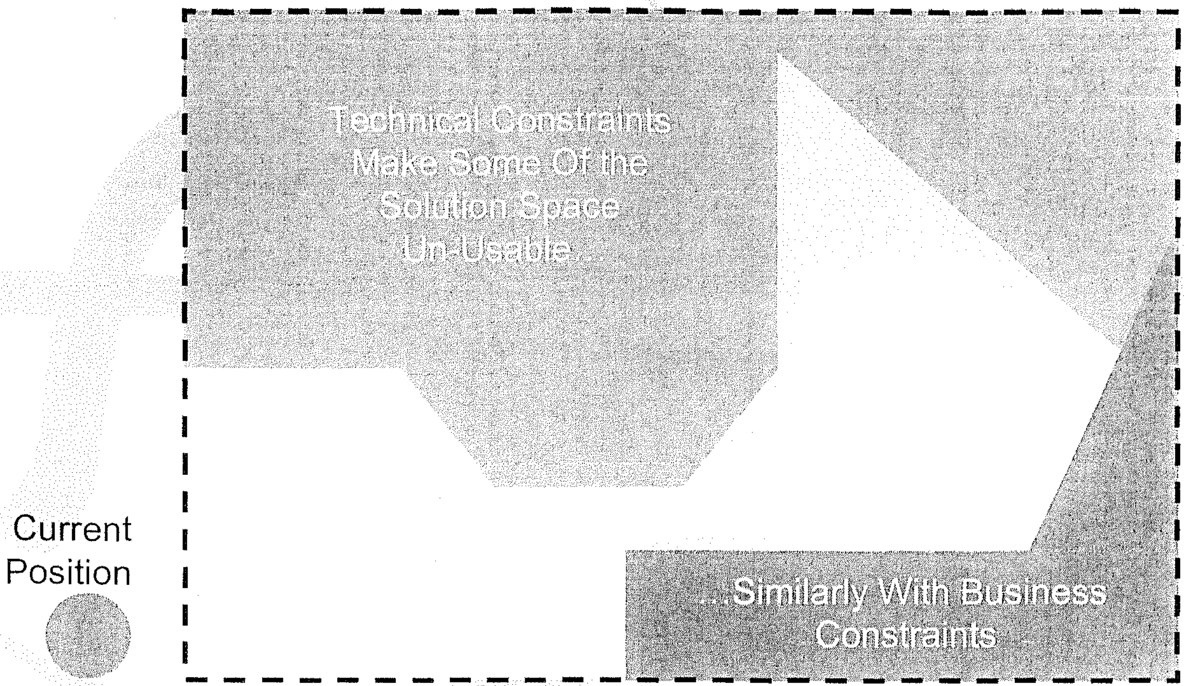
Constraints?

Primary constraint present in and around the system relates to money
Financial limitations precluded the construction of complete new design.

Other constraints present were:-

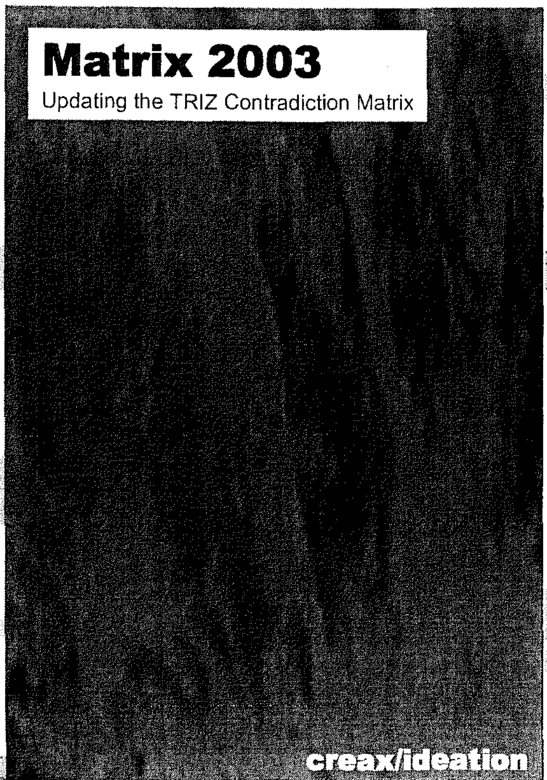
* **physical size should not be increased since available space outside the vessel was limited**
* **energy consumption should not increase**
* **there should be no possibility of affecting the quality of the product** (several downstream processes had been optimised around the product in precisely its current form)

'Solution Spaces' and Constraints



complete solution space – the ideal solution to a problem must lie within this area

Matrix 2003



Update of the contradiction matrix from Classical TRIZ

Based on research of patents and other best practice conflict resolution solutions from across the world 1985-2003

150,000 patents

TRIZ- Contradiction Matrix Elements

1. Weight of moving object
2. Weight of stationary object
3. Length of moving object
4. Length of stationary object
5. Area of moving object
6. Area of stationary object
7. Volume of moving object
8. Volume of stationary object
9. Shape
10. Amount of Substance
11. Amount of Information
12. Duration of action - moving object
13. Duration of action - stationary object
14. Speed
15. Force/Torque
16. Use of energy by moving object
17. Use of energy by stationary object
18. Power
19. Stress/Pressure
20. Strength
21. Stability
22. Temperature
23. Illumination Intensity
24. Function Efficiency
25. Loss of Substance
26. Loss of Time
27. Loss of Energy
28. Loss of Information
29. Noise
30. Harmful Emissions
31. Object Generated Side Effects
32. Adaptability/Versatility
33. Compatibility/Connectability
34. Ease of Operation
35. Reliability
36. Repairability
37. Security
38. Safety/Vulnerabilty
39. Aesthetics
40. Object affected harmful effects
41. Manufacturability
42. Accuracy of manufacturing
43. Automation
44. Productivity
45. System Complexity
46. Control Complexity
47. Ability to Detect/Measure
48. Measurement Precision

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Conflict pairs

- I want to reduce batch size but the bearing overheats
- I want to reduce batch size but mixing does not occur
- I want to reduce batch size but chilling time is increased
- I want to reduce batch size but air is introduced into the solution

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Looking Up The Contradictions

Improving Factor	Worsening Factor	Principles
Volume of Stationary Object (8)	Function Efficiency (24)	1, 7, 28, 5, 2, 19, 12, 37
I want to reduce the batch size but mixing does not occur		
Volume of Stationary Object (8)	Temperature (22)	3, 26, 4, 35, 15, 6, 19
I want to reduce the batch size but bearing overheats		
Volume of Stationary Object (8)	Duration of Action of Stationary Object (13)	35, 38, 15, 31, 3, 1, 34
I want to reduce the batch size but chilling time is increased		
Volume of Stationary Object (8)	Amount of Substance (10)	35, 3, 31, 40, 5, 13, 17
I want to reduce the batch size but air is introduced into the solution		

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Deciding which separation principles should be used

- Where do I want the water to be high?
  - On the inside of the vessel
- Where do I want the water to be low?
  - On the inside of the vessel
- When do I want the water to be high?
  - For chilling
- When do I want the water to be low?
  - For mixing
- I want the water to be big if?
  - I'm chilling
- I want the water to be small if?
  - I'm mixing

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Contradiction Solution Route	Inventive Principles Used To Tackle This Type of Contradiction
Separation in Space	1. Segmentation 2. Taking out 3. Local Quality 17. Another Dimension 13. Other Way Around 14. Curvature 7. Nested Doll 30. Flexible Shells/Thin Films 4. Asymmetry 24. Intermediary 26. Copying
Separation in Time	15. Dynamics 10. Prior Action 19. Periodic Action 11. Beforehand Cushioning 16. Partial or Excessive Action 21. Skipping 26. Copying 18. Mechanical Vibration 37. Thermal Expansion 34. Discarding & Recovering 9. Prior Counter-Action 20. Continuity of Useful Action
Separation on Condition	35. Parameter Changes 32. Colour Changes 36. Phase Transition 31. Porous Materials 38. Strong Oxidants 39. Inert Atmosphere 28. Mechanics Substitution 29. Pneumatics & Hydraulics
Transition to Alternative System 1. Transition to Sub-System	 1. Segmentation 25. Self-Service 40. Composite Materials 33. Homogeneity 12. Equi-Potentiality
2. Transition to Super-System	5. Merging 6. Universality 23. Feedback 22. Blessing In Disguise

possible

possible

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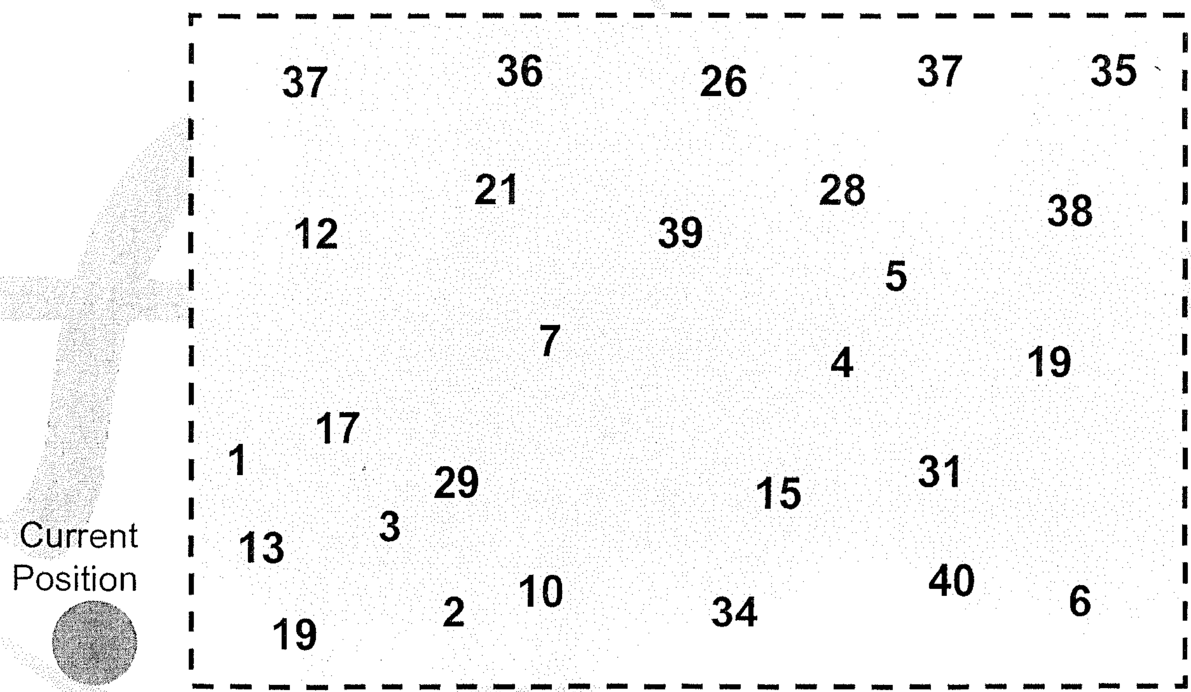
'Solution Spaces' and Constraints



complete solution space – the ideal solution to a problem must lie within this area

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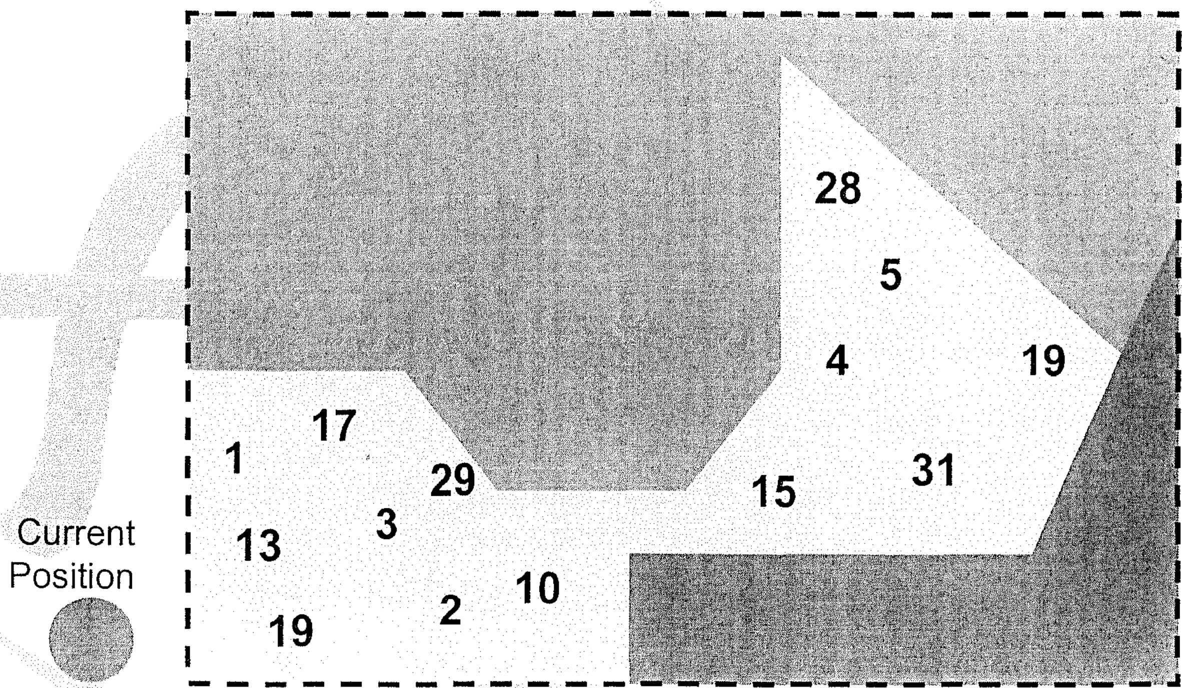
Using Constraints To Eliminate Principles Which Cannot Be Used

Resource/Constraint	Principles Eliminated
Product must not be affected	35 – Parameter Changes 38 – Enriched Atmosphere 34 – Discard & Recover 40 – Composite Materials
Existing Hardware	26 – Copying 37 – Thermal Expansion 6 – Universality 40 – Composite Materials 7 – Nesting
Energy consumption	36 – Phase Transition

'Solution Spaces' and Constraints



complete solution space – the ideal solution to a problem must lie within this area

Brainstorm and review of resources

- Pump came out to be the most under utilised item of plant at less than 10% of time
- Could also be used to raise the water to top of vessel for chilling

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Implementation

- Modification to pipework
  - incorporate a return pipe
  - directing fluid to vessel side
  - introducing a spray nozzle as suggested by principle1 reduced chilling time
- Pump could be used to mix instead of impellor
- Pipe extended to bottom of vessel
  - batch size now considerably reduced
  - principle 17 used to change the angle of the bottom of the pipe improved mixing
  - Adding a baffle plate improved mixing even more

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Results

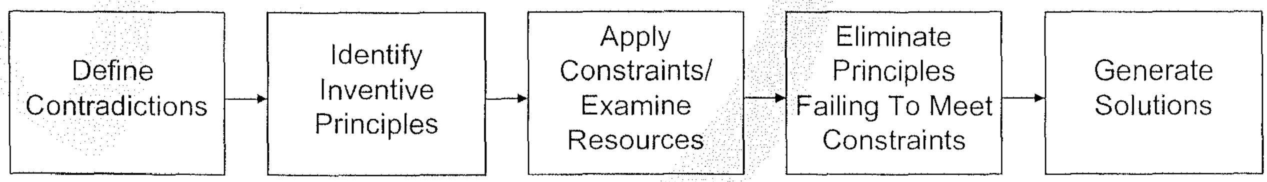
- After incorporation of all solutions
  - chill time reduced to less than 15 minutes with spray nozzle
  - mix time with pump and pipe system to less than 15minutes (Overall Factor > 5)
  - Batch size reduced to 50kg without detriment to product quality. (Factor >2)
- Elimination of expensive and difficult maintenance

Conclusion

- Introduction of TRIZ to an inexperienced group and obtain excellent results
- This case study shows how it is possible to alleviate bottlenecks in the manufacturing process using TRIZ

Conclusion

- A constraint management process has been demonstrated



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Towards a management of problems formulation within the framework of lean manufacturing implementation

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Abstract:

The manufacturing system is a complex system which is composed by a unit of interdependent resources to transform, to move, to store the products. Recent results (Womack 1996) indicate that one of the responses to perform the manufacturing systems is the implementation of Lean Manufacturing. In order to implement the Lean Manufacturing, a detailed manufacturing system modelling is necessary. This modelling generates a complex network of relations between the resources and activities whose it is difficult to obtain an immediate understanding. This interlacing of relations contains a whole of contradictions which it is difficult to extract. In order to provide an explanation for better comprehension of Lean Manufacturing implementation, we propose a method for formalize the contradictions. For greater clarity, we implement this method within the framework of description of specific contradictions network to the lead manufacturing time reduction. Finally, we propose a manner to operate this contradictions network within a manufacturing workshop study.

Key words: manufacturing system, lean manufacturing, problems and contradictions network.

1. Introduction

In order to implement Lean Manufacturing, a detailed modelling of the manufacturing system is necessary. This modelling generates a complex network of relations between the resources and the activities whose an immediate comprehension is difficult. Messaoudene (2002) discovered that this interlacing of relations contains a whole of contradictions which sometimes may be difficult to identify. A contradiction is expressed by the dilemma to solve in order to achieve two goals like the very frequent example following within the Lean Manufacturing implementation framework: *the transfer lot size must be raised to reduce displacement costs of products, but the transfer lot size must be weak to reduce post-operative storing costs.* The most frequently used approach concerning a system of contradictions as shown before is to model that problem in form of a whole of unavoidable constraints and to find the least bad

solution by optimizing an objective function. The general approach we explore in our research relies on one principal assumption. This is that if we are unable to eliminate constraints for it is due to physical or scientists laws, we can take account on the specificities of the problem to put ourselves in a situation where constraints which first appear as insurmountable may be circumvented by techniques and approaches belonging to the inventive design. This type of approach already proved its effectiveness in products design. The most important character making the difference between the design problems of manufacturing systems and products design that we are used to treat in practice is the number of contradictions. We first have to identify these contradictions before trying to solve them. The contradictions and design problems are very often discovered only after specification or even implementation of the system about to be design. The resolution of these contradictions and problems is rarely optimized for at the moment of discovery of these problems the firm already has invested too much money to propose solution different from those already used but which would resolve these same problems at minor cost. A study on manufacturing system design (Messaoudene 2001) indicates that identifying these problems earlier, we give more latitude to the designers for the system realization and increase the chances to find a "good" solution. The difficulty to formalize these contradictions lies in the lack of information's structuring to implement Lean Manufacturing and the judicious choice of model. This model must be in coherence with Lean Manufacturing. The consequence of this lack of formalization is that the problems to be solved are not identified at the beginning and are often discovered only when the system is carried out. In this article, we use taxonomies and the formalism of TRIZ1 to describe these forms of contradictions. TRIZ is a whole of assistance tool to the inventive design. These tools and methods are integrated within a theory developed by Altshuller (1988).
In order to provide an explanation for better comprehension of Lean Manufacturing implementation, we propose a method for formalize the contradictions.
The construction of this method is done in three stages as figure 1 shows it:

1. acquisition of the elements which is necessary to build the problem space;
2. formulation of the problem space structure;
3. formalization of the problem using the principle of contradiction.

[1] Russian acronym of Theory of Inventive Problem Solving

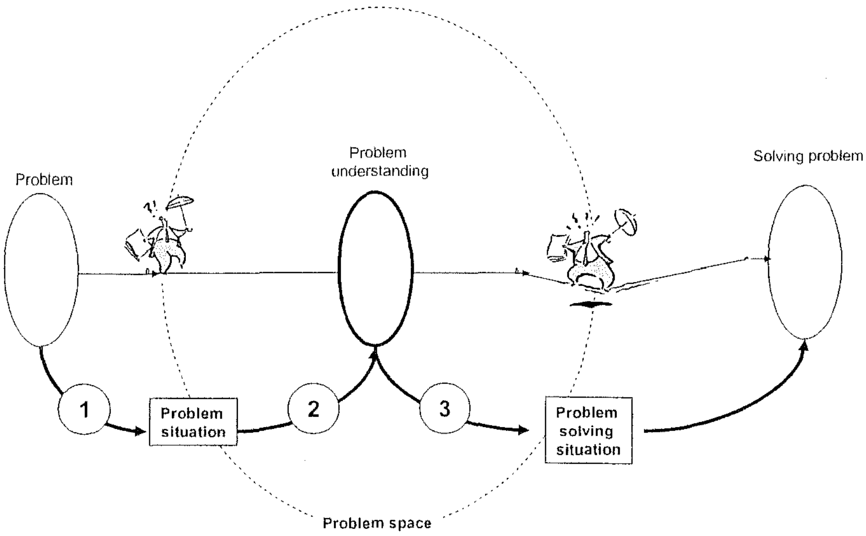

Figure 1: level of method contribution

In our application, the design goal indicates the lead manufacturing time reduction according to the control of lean manufacturing principles. The mechanisms used are the axiomatic design and the principle of contradiction. The objective of this application is to obtain a contradictions network specific to the lead manufacturing time reduction. In addition, we will develop a step allowing exploiting this network within the framework of a manufacturing workshop analysis. The objective of this analysis will be to observe the propagation of the contradictions extracted within the network. This will have like consequence to better control the new specifications of the initial problem.

2. Construction of problem space structure: reduction of the lead manufacturing times.

This part leads to the development of the axiomatic process and the realization of the relations tables between:

- functional needs and design parameters;
- design parameters and activities of the system;
- activities and performance indicators;
- performance indicators and needs functional.

This part makes up of two stages: selection of the data elements and development **of the relational structure of problem space**.

2.1 First stage: selection of the data elements:

This stage consists in collecting information necessary to the construction of different spaces. These spaces are:

- space of the **initial state**;
- space of the **functional needs** and
- space of the **design parameters**.

2.1.1. Information necessary for the construction of initial state space

It is a question of identifying the generic activities, the reference components used in the problem of lead manufacturing time reduction in order to extract activities with their associated performance indicators. It is to recall here, that we study the manufacturing system according to a systemic point of view which is the activity "to produce". The generic activities selected are the processing, the displacement and the storage (work-in-process); the indicators of performances are indicated in time and costs term.

2.1.2. Information necessary for the construction of functional needs space and associated design parameters space

It acts here to build spaces of the functional needs and the design parameters using the axiomatic process developed by Suh (1990). This stage begins with the statement from the design goal and the means allowing to carry it out.

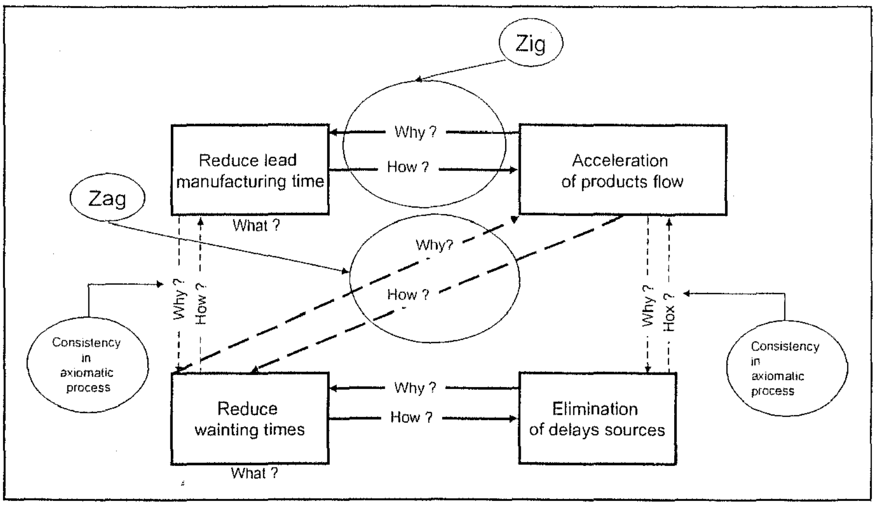

Figure 2.1: axiomatic process between functional needs and design parameters

This stage is completed since the decomposition arrives at the elementary level (in our case, it is about the level of activities). On the level of activities, the functional needs characterize the whole of the delays types which one wishes to reduce. These delays are:

- lot delay,
- run size delay,
- process delay,
- transportation delay,
- systematic operational delay.

The design parameters associated with these delays are:

- size of the transfer batches (or lot size)
- size of the manufacturing batches (or run size)
- the production rate
- the degree of coordination of the activities to support and activities to processing

2.2. Second stage: development of the relational structure between the different spaces

This stage consists in implementing four relations tables. The relations are:

- relations between the functional needs and the associated design parameters;
- relations between the design parameters and associated activities;
- relations between activities and associated performance indicators;
- relations between performance indicators and functional needs.

These relations are identified using the teleological laws which connect the functional needs with the design parameters and the performance indicators with the functional needs. The relations between the design parameters and the performance indicators result from the behavioural laws of the system. The relations between activities and the performance indicators correspond to correspondence relations.

The following example[2] treats various relations.

<u>2.2.1. Relations between the functional needs and the parameters of design.</u>

- suppose FR1, a functional need to satisfy: **to reduce the delays[3] resulting from the manufacturing batch** (resulting from the decomposition from the goal: to reduce the lead manufacturing times).
- suppose DP1 and DP2; two design parameters being able to satisfy FR1 mutually;
  - DP1: manufacturing run size
  - DP2: production rate

[2] For reasons of comprehension facility, the example results from the problems "reduction of the lead manufacturing times".
[3] Also call run size delay.

One of the laws[4] gives the following relation:

$$FR1 = (a-1) * \left[\frac{DP1}{Q} - 1 \right] * \frac{1}{DP2}$$

With
- a = number of the components type to be transformed;
- Q = total quantity of articles to be treated.

The following table gives the relations between the functional needs and the design parameters.

1	Run size
1	Production rate
Reduce run size delay	

Table 2.2.1: relations between functional needs and design parameters

2.2.2. Relations between the parameters of design and under activities of reference

- suppose activities, PV1, PV2....., and PV12 under influence of the design parameter DP1:
- These bonds are identified using the behavioural relations.

PV(i)	activities	Designation
PV1	PPR-D-ART	Personnel of production moves article.
PV2	PPR-S-ART	Personnel of production supports article.
PV3	PPR-D-MCO	Personnel of production moves average container.
PV4	MDM-D-MCO	Mobile means of displacement moves average container.
PV5	MDM-S-MCO	Mobile means of displacement supports average container.
PV6	MDM-S-ART	Mobile means of displacement supports article.
PV7	MDF-D-ART	Fixed means of displacement moves article.
PV8	ZPO-S-ART	Zone of station supports article.
PV9	ZPO-S-MCO	Zone of station supports average container.
PV10	ZCI-S-ART	Zone of circulation supports article.
PV11	ZCI-S-MCO	Zone of circulation supports average container.
PV12	ZCD-S-MCO	Zone of unloading supports average container.

Table 2.2.2.1

[4] This law is given by the lean manufacturing principles.

The following table gives the relations between these activities PV(i) and the design parameter DP1.

	PPR-D-ART	PPR-S-ART	PPR-D-MCO	MDM-D-MCO	MDM-S-MCO	MDM-S-ART	MDF-D-ART	ZPO-S-ART	ZPO-S-MCO	ZCI-S-ART	ZCI-S-MCO	ZCI-S-ART
Production rate	1	1	1	1	1	1	1	1	1	1	1	1

Table 2.2.2: relations between design parameters and activities

2.2.3. Relations between under activities of reference and their associated indicators of performance

- suppose the performance indicators EV1, EV2, EV3 and EV4 associated with each activity. - EV1: cost of displacement;

- EV2: operational post storage cost;
- EV3: operational pre storage cost;
- EV4: quantity on standby before transport.

The following table gives the relations between these performance indicators and the activities associated.

	PPR-D-ART	PPR-S-ART	PPR-D-MCO	MDM-D-MCO	MDM-S-MCO	MDM-S-ART	MDF-D-ART	ZPO-S-ART	ZPO-S-MCO	ZCI-S-ART	ZCI-S-MCO	ZCI-S-ART
Displacement costs	1	1	1									
Costs of post operative storage									1	1		
Costs of pre operative storage											1	1
Quantity on standby before transport				1	1	1	1					

Table 2.2.3: relations between activities and performance indicators

2.2.4. Relations between the performance indicators and the functional needs

They exists relations between the improvement of the system parameters in the form of performance indicators and the satisfaction of certain functional needs which can improve these parameters. In our example, the relations are given by the following table:

Reduce transportation delays	Reduce lot delay	Reduce run size delay	
1	1		Displacement costs
1	1		Costs of post operative storage
		1	Costs of pre operative storage
1	1		Quantity on standby before transport

Table 2.2.4: relations between performance indicators and functional needs

In the example, the relational structure between the different spaces is as follows:

1	1	1	Run size	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	Production rate	1	1	1	1	1	1	1	1	1	1	1	1
Reduce transportation delays	Reduce lot delay	Reduce run size delay		PPR-D-ART	PPR-S-ART	PPR-D-MCO	MDM-D-MCO	MDM-S-MCO	MDM-S-ART	MDF-D-ART	ZPO-S-ART	ZPO-S-MCO	ZCI-S-ART	ZCI-S-MCO	ZCI-S-ART
1	1		Displacement costs	1	1	1									
1	1		Costs of post operative storage									1	1		
		1	Costs of pre operative storage											1	1
1	1		Quantity on standby before transport				1	1	1	1					

Table 2.2.5: relational structure of problem space

3. Formalization of the design problem in the form of contradictions network

The manufacturing system is a complex network of relations between the components, the activities whose is difficult to obtain an immediate comprehension. In the case of the complex systems like the manufacturing systems, contradictions do not represent isolated relations, emerging in the analysis. But these contradictions represent relations organized and associated in networks of variable scale according to the studied system. In the problem of the lead manufacturing time reduction resulting from a logic of the lean manufacturing implementation; our **network of contradictions is a circumscribed whole of data**

elements[5] dependent between them by elementary contradictions which constitute a whole of related arcs[6] whose nodes are the design parameters. As an example, we present a portion of the contradictions network specific at the lead manufacturing time reduction.

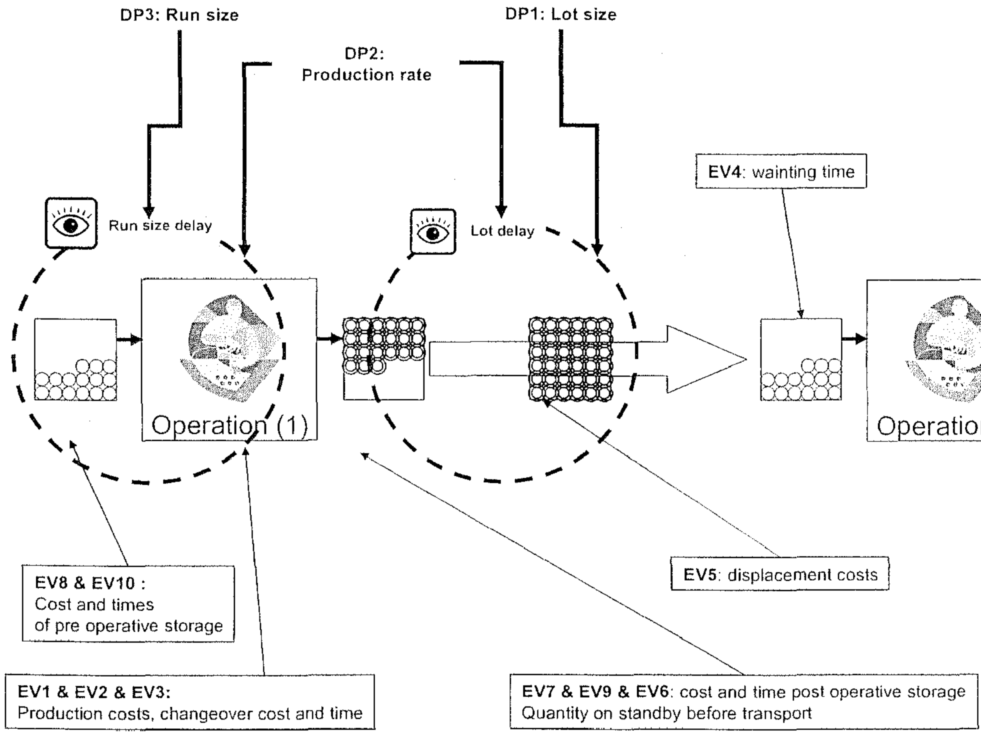

Figure 3.1: localisation of different data elements

- suppose functional FR1 and FR2, two needs to satisfy simultaneously
  - FR1: To reduce the delays resulting from the batch of transfer (lot delay)
  - FR2: To reduce the delays resulting from the manufacturing batch (run size delay)
- suppose DP1, DP2 and DP3, three design parameters being able to satisfy these functional needs
  - DP1: lot transfer size
  - DP2: run size delay
- DP3: Production rate

[5] The data elements are: functional needs, design parameters, activities and associated performance indicators.

[6] We call "related arcs" the relations between the parameters of design and the needs functional like with the indicators for performance.

- suppose EV(i), the whole of the performance indicators which are influenced by the design parameters DP1, DP2 and DP3

- EV1: Production cost
- EV2: Cost of series changeover
- EV3: Cost of displacement
- EV4: Operational post storage cost
- EV5: Operational pre storage cost
- EV6: Time of series changeover
- EV7: Time in waiting (stop)
- EV8: Time makes an attempt post operational
- EV9: Time makes an attempt pre operational
- EV10: Quantity on standby before transport
-

The following figure represents the contradictions elementary network which is representing the simultaneous satisfaction of functional needs FR1 and FR2.

Needs to satisfy simultaneously	Associated design parameters		Performance indicators									
			Production costs	Changeover times	Changeover costs	Wainting times	Displacements costs	Quantity on standby before transport	Costs of post operative storage	Costs of pre operative storage	Post operative wainting time	Pre operative wainting time
Reduce Lot delays	DP1 Lot size	↘					-	+	+		+	
	DP2 Production rate	↗	+				+	-	-	+	-	+
Reduce Run size delays	DP2 Production rate	↗	+				+	-	-	+	-	+
	DP3 Run size	↗	-	-	-	-	-		+	-	+	-

Figure 3.2: contradictions network example

4. Manufacturing workshop study

4.1. General context of the industrial case study

The company in which we carried out our investigation is a company centred on the manufacture of rope drives for the car, mechanized farming, and cycle industry. Opened in the increasingly competing world with a distribution in more than 30 countries, the company has the preoccupation with an increase in the service rate and mainly in the lead manufacturing times reduction by an optimal use of the manufacturing system (figure 4.1).

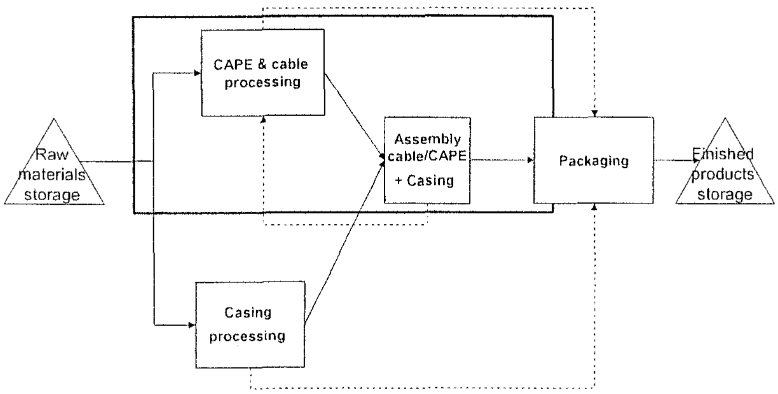

Figure 4.1: manufacturing system

In this study we focus our attention, on the processing and manufacture: cables, CAPE (piano wire), assembly cables/CAPE with casing, conditioning of the cables assembled with casings and the activities of displacement intra and inter processing. Our attention will be more particularly centred on the reduction of displacement costs and the simultaneous reduction of the delays resulting from the transfer batches and the delays due to displacements of the articles and the average containers. Indeed, a preceding analysis carried out during a flows analysis showed that 30% of the costs within the system are costs of displacements of the articles. Moreover 65% of total production times are latencies in post or pre operational storage.

This problem situation can raise several interrogations like:

- Is it necessary to make evolve the system parameters?
- If so, which are the parameters to be modified?
- Which will be the impacts of the evolution of these parameters within activities of the studied system?
- Which are the problems which will be generated by the simultaneous satisfaction of the functional needs?
- How identified all problems due to the lead manufacturing time reduction?

Our mission consisted in bringing brief replies to these questions in a formal way. We discount to clarify the perception of the designers by analyzing the system using our network of contradiction specific to the lead manufacturing time reduction.

4.2. Our method[7] of project management of research in the company

The method of project[8] management that we applied presents as follows (figure xxxx).

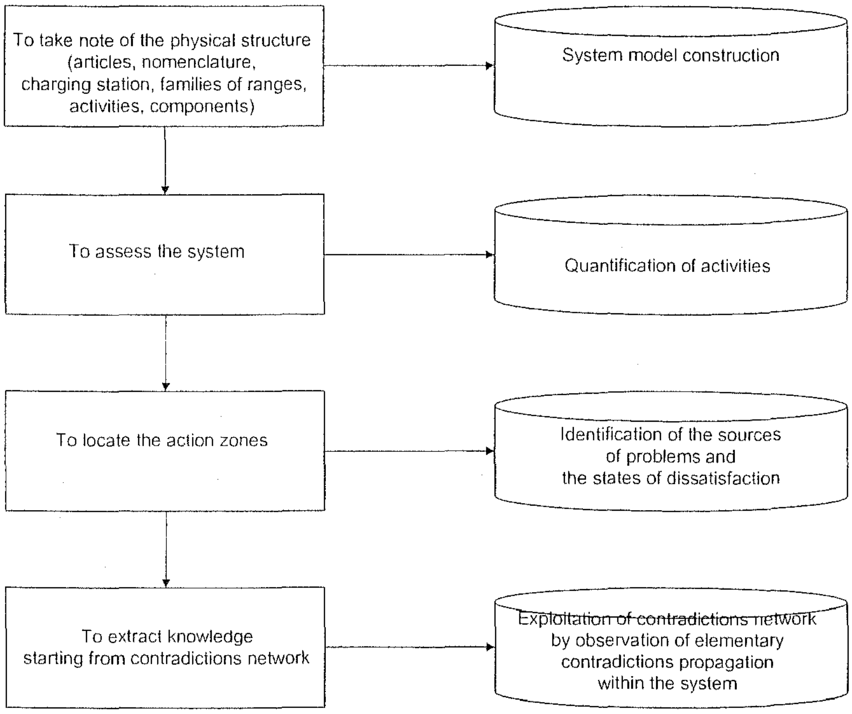

Figure 4.2: Our method of project management

4.3. Implementation of the network of contradictions and exploitation of this network

We located the problem sources for the lead manufacturing time reduction during the phases of evaluation and awareness of the system. The company consequently wishes to reduce the delays resulting from the batches of transfer and the delays resulting from displacements of articles which generate important costs. The following figures give the localization of problems source responsible for certain delays within the workshop as well as the localization of dissatisfaction state responsible for the high costs of displacement.

[7] In this industrial case, the sources of problems were identified like the whole of the delays resulting from the batches of transfer, and the displacements of the articles. The state of dissatisfaction is the value of the costs of article and average containers displacement.

[8] We recall here that the exploitation of contradictions network has two objective in this study case, (1) to better determine the complexity of the system and (2) to discover the problems before the system is not carried out.

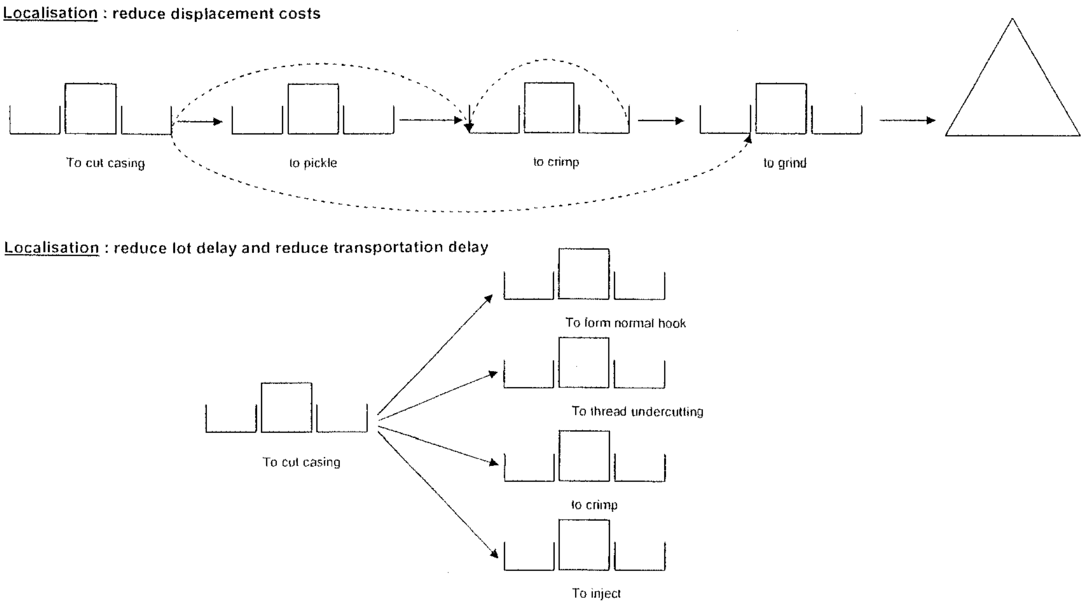

Figure 4.3: Localisation of action zones

We also extracted the contradictions network specific to this case from study by applying our method. The construction and the exploitation of this network are formulated this way:

- To reduce the costs of displacement, which are the design parameters which intervene and which direction of variation must one give them?
- Then which are the negative effects and the positive effects within the studied system (level activities) and how are propagated contradictions within the preset network?
- To satisfy the two functional needs simultaneously (to reduce the delays resulting from the batch of transfer and displacements), which are the associated design parameters and which directions of variation must one give them?
- Then which are the negative effects and the positive effects within the studied system (level under activities) and how are propagated these contradictions inside the network?

The appearance of the negative effects (**sign [-]** within the network) symbolizes the emergence of new problems to be solved. We arrive at an explosion of contradictions that one identifies in order to solve these discovered contradictions.

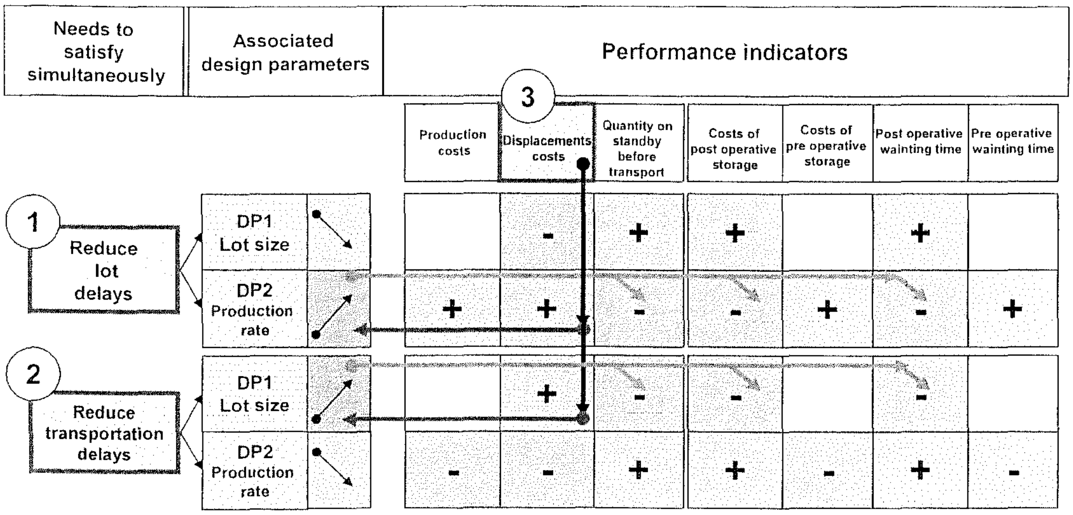

Figure 4.4: exploitation and exploration of contradictions network

Indeed, the observation of contradictions network above shows us that the simultaneous satisfaction of the two functional needs (1 and 2) can generate 121 contradictions articulated around the design parameters "DP1 and DP2". Moreover if one wishes to reduce the costs of displacement (3), it is primary important initially to take into account the resolution of 6 contradictions articulated around the parameter "cost of displacement" which rises from contradiction network.

5. Conclusion

The identification and the formalization of contradictions before the implementation of the manufacturing system have a double interest. The first interest is that the identification of contradictions makes it possible to better apprehend and to control the complexity of manufacturing system studied. The second interest is to give sufficient latitude to the designers to position in order to be in problem solving situation without compromise. Thereafter we wish to solve these contradictions using the techniques of the inventive design, in particular using the tools of TRIZ. An action of contradictions elementary quantification is being studied in order to accentuate the direction of problem solving.

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Solving Technical Problems in Manufacturing Processes by Using Embedded-TRIZ

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Introduction

Due to the increasing global stress of competition, the ability to solve technical problems efficiently not only comes to the fore in terms of managing product-oriented innovation-processes, but also will become a core competence for engineers by coping with manufacturing challenges (figure 3, 4). However, today's industrial practice shows that this claim can not be fulfilled satisfactorily (figure 5, 6). Unfortunately, engineers dealing with technical problems in manufacturing processes, which might be characterized by criteria like complex cause-and-effect chains or dynamical behavior, often have to act single-handedly without appropriate systematic and methodical assistance. Furthermore, time- and financial-limitations determined by management decisions affect their actions. That is why a systematic approach including different methods and techniques for solving problems in production- and manufacturing-surroundings is necessary (figure 7). But, even the application of these approaches may lead to several new problems (figure 8).

Problem and Problem-Solving

Before developing a new approach for solving technical problems in manufacturing- and production-processes it should be quite precisely mentioned what is meant by talking about manufacturing- and production-processes (figure 10, 11) and how problems can be characterized (figure 12, 13, 14) The number and diversity of available techniques to support a systematic and methodical problem-solving-process is nearly unmanageable (figure 15, 16, 17). For example, TRIZ – the Theory of Inventive Problem-Solving – is an important and even powerful framework, in which several single techniques are provided in order to handle a wide range of technical problems (figure 18). But, on the one hand there are still miscellaneous technical problems especially in kinds of manufacturing engineering, which require alternative or additional tools beyond TRIZ and on the other hand, working with problems can become a challenging job because of all the defiencies which might come to the fore (figure 19).

Approach "Embedded-TRIZ"

For that reason, a holistic approach for the systematic and methodical solving of technical problems in manufacturing processes most efficiently by using a suitable problem-solving-process including techniques like TRIZ and additional ones has to be developed and established in manufacturing companies in order to support engineers (figure 21). Hence, the Institute for Manufacturing Engineering and Production Management at the University of Kaiserslautern – FBK – is currently developing a holistic concept of a systematic problem-solving-management for solving technical problems in manufacturing processes. Core of the concept is the systematic problem-solving-process embedding TRIZ as major element with interfaces to several complementary tools. Starting with the individual problem the problem-solving-process is generated step by step, based on connectable modules containing specific tools out of the TRIZ-Toolbox or different techniques (figures 22, 23, 24, 25, 26). Besides that, organizational aspects as well as strategies for implementing the concept in companies by considering the engineers' competences or competence-requirements will also be covered later on.

Conclusions

Engineers have to face several multifarious technical problems during a product's life-cycle, especially in terms of production and manufacturing. In the scientific world as well as in industrial practice a large number of approaches and techniques for solving technical problems do exist. For example Brainstorming, Synectics or TRIZ. Nevertheless, solving problems is a very difficult process. That is why at the FBK an approach is developed which shall help solving technical problems most efficiently by integrating TRIZ in combination with different tools in a common problem-solving-process. Later on, this approach can be adapted to different areas of applications outside production and manufacturing. Furthermore, new techniques can be easily added so that it might become an important tool for solving not even technical problems in terms of holistic production-systems.

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Solving Technical Problems in Manufacturing Processes by Using Embedded-TRIZ

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Aachen, November 12-14, 2003

Figure 1

Agenda

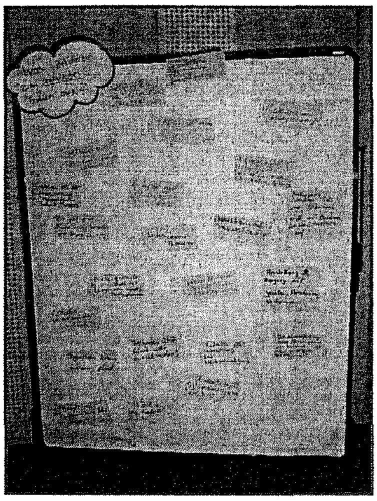
- Introduction
- Problem and Problem-Solving
- Approach „Embedded-TRIZ“
- Conclusions

- Discussion

Figure 2

How can we define a <u>technical</u> problem?

- Solution is **far away** from an **ideal final result**
- **Physical** Background
- Strongly related to **Interfaces**
- Does exist for a **while without** having been **solved**
- The solution is a **contradiction** or a **conflict** to another solution
- Solution is **not trivial**
- Occurs during the **implementation** of **technologies** in **products/ processes**
- Several **default-requirements**, but **no solution**
- Costs/ restricted **resources**
- Related to **products/ machines/ processes**
- **Discrepancy** between actual-state and target-state.
- Solution lies **out of range**
- No solution **on impulse**
- Requirements in **Quality, Time, Costs** can not be fulfilled
- **Barrier** for **improving** resp. further development
- **Variation** of specification-factors
- **Lack** of Information resp. **Knowledge**
- A **technical system** (product) does not work
- **Material, Time, Costs** are to high and have to be reduced



[FBK, TRIZ-AK, 2003]

„Technische Probleme seien verstanden als durch Einsatz von Technologie bzw. Technik lösbar, bei technisch-wirtschaftlichen Problemen müssen zusätzlich wirtschaftliche Gesichtspunkte berücksichtigt werden. Mit anderen Worten: Eine bestimmte Funktion ist gewünscht, und eine technische Lösung wird gesucht."
[Pannenbäcker, 2001]

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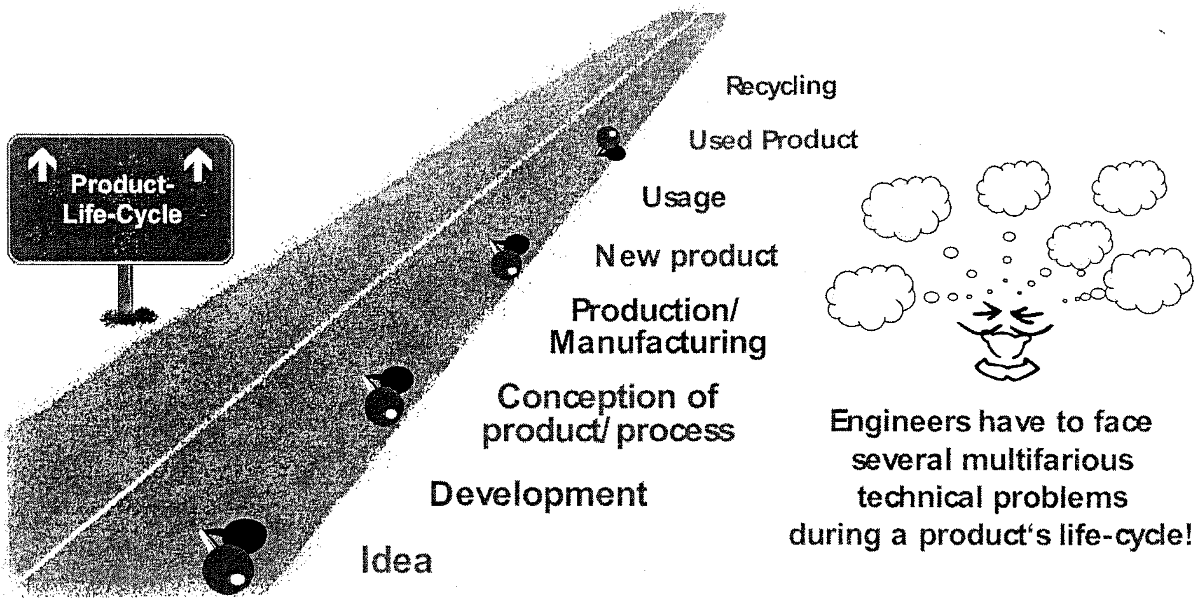
Figure 3

Problems occuring during PLC



Engineers have to face several multifarious technical problems during a product's life-cycle!

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Figure 4

Divisions of (Technical) Problems

Production/Manufacturing (15 hits):
- **Process-Planning**
- **Operation of of Facilities and Machines**
- **Shop-floor**
- **Final assembly**

Development (15 hits)

Research (10 hits)

Engineering (10 Nennungen):

Interfaces (10 hits) :
- **Sales <-> Development**
- **Costumer <-> Supplier**
- **Divisions/Departments**

Maintenance internal/external (3 hits):
- **Maintenance and Repair**
- **Service**

Logistics / Stock-Management (2 hits)

Change Management (2 hits)

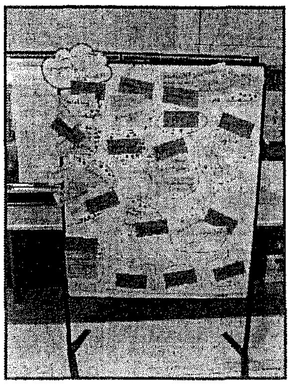
Project-Management (2 hits)
- **Planning of Dates and Costs**
- **Project-Planning and -control**

IT (2 hits)

Management in Generaö (1 hit):
- **Operational Management**
- **Strategic Management**

Purchasing (1 hit):
- **Material**
- **Supplier**

Waste-Management (1 hit)



[FBK, TRIZ-AK, 2003]

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Figure 5

Technical Problems in Production

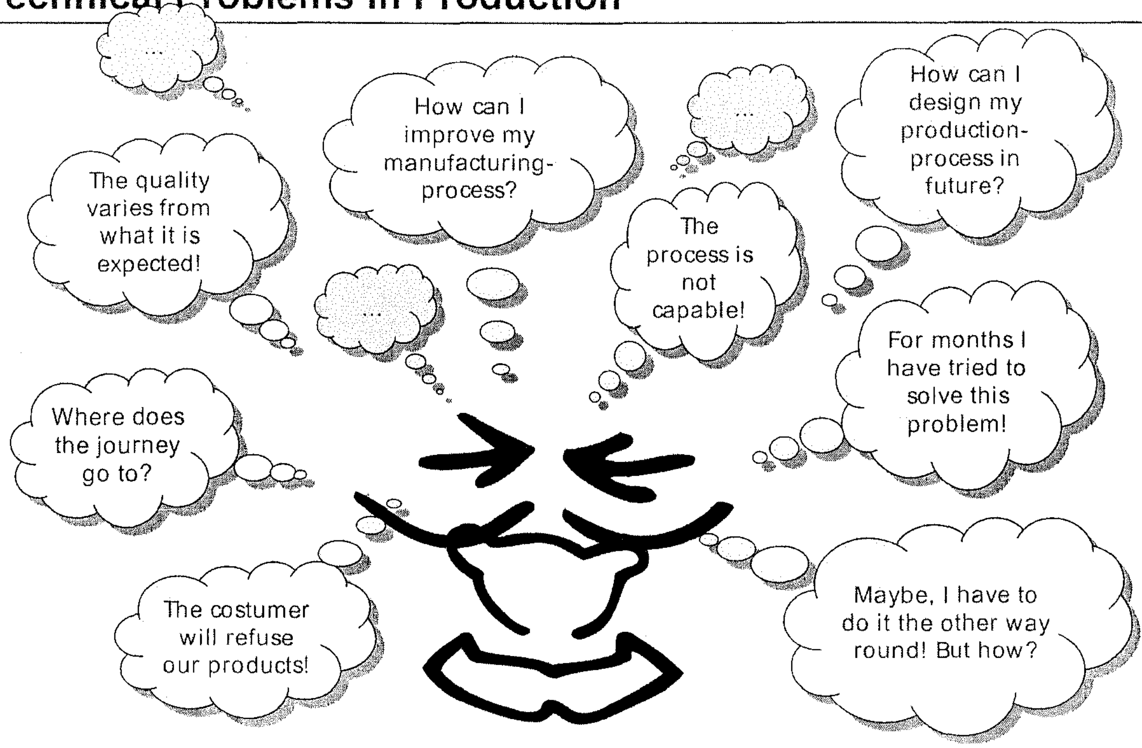

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Figure 6

Systematic Problem-Solving

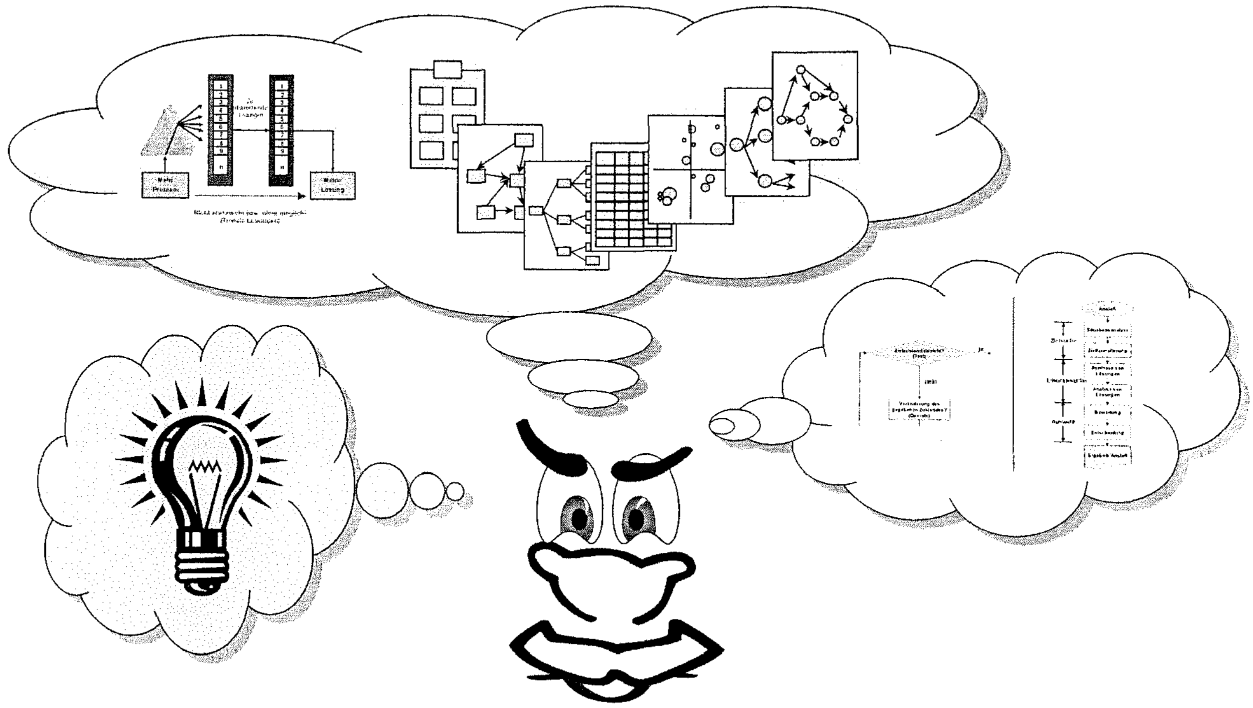

Figure 7

Typical Problems by Solving Problems

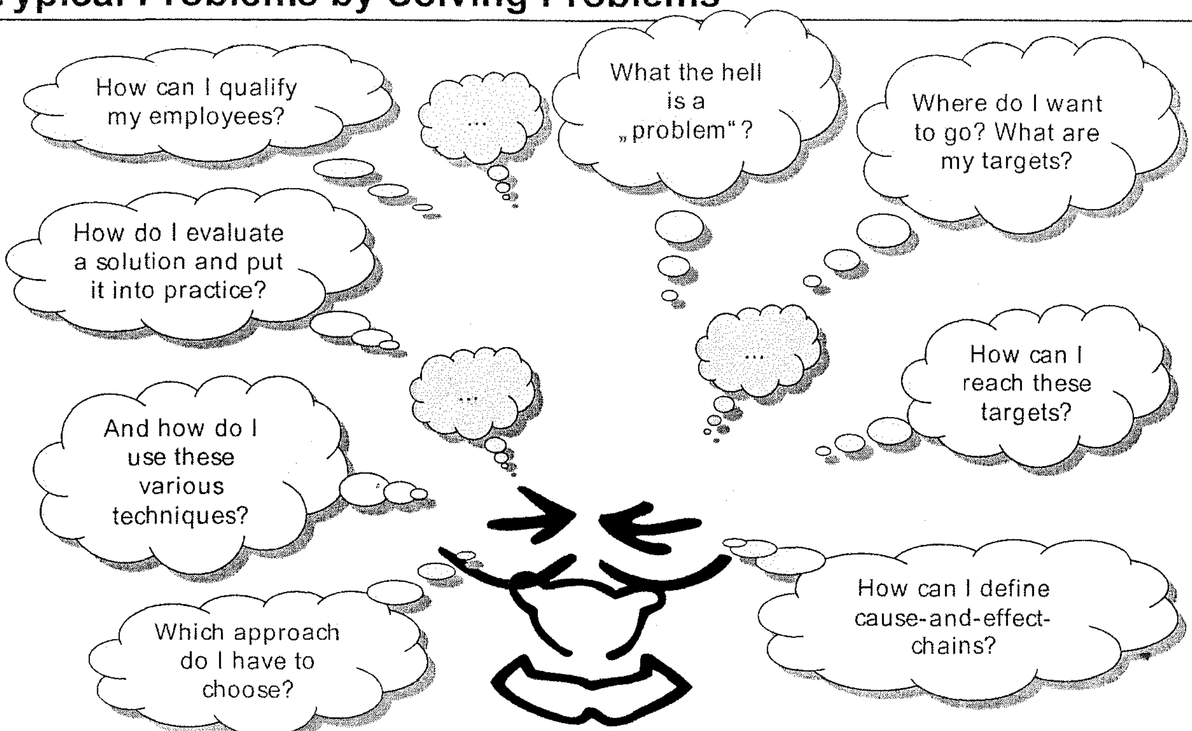

Figure 8

Agenda

- Introduction ✓
- Problem and Problem-Solving
- Approach „Embedded-TRIZ“
- Conclusions
- Discussion

Figure 9

Organizational Structure of Production

- **System of Manufacturing and Assembly:**
  - Facilities,
  - Machines,
  - Tools,
  - Measuring-Equipment and test-control-units
- **System of Material-Flow:**
  Covers all kinds of devices and utilities for storing, conveying, handling and providing of workpieces, tools, measuring-equipment, chips as well as raw-materials and supplies.
- **Information-System:**
  All devices which are necessary to store, administrate, edit, receive and send of data resp. information during production-process.

[REFA, 1990; Eversheim, 1996; Steins, 2000]

Figure 10

Workflow-Management in Production

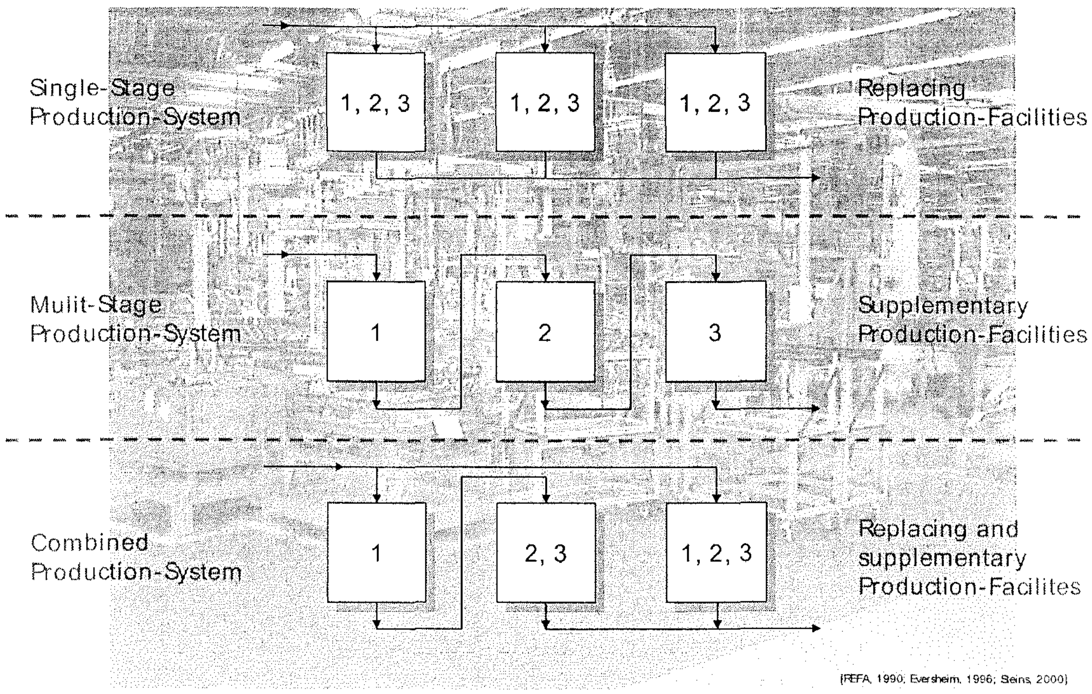

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Figure 11

What is a „Problem"?

- „Ein **Problem** unterscheidet sich von einer einfachen **Aufgabe** dadurch, dass der Bearbeiter kein **Standardverfahren** zu dessen Bewältigung kennt. Die **Lösung** eines Problems ist also immer mit einem **schöpferischen Moment** verbunden und wird daher dem **produktiven Denken** zugeordnet."
  [Brockhaus, 2001]

- „Ein **Problem** ist eine **ungeklärte bzw. widerspruchsvolle Situation**, die durch eine qualitativ und quantitativ bestimmbare **Differenz** zwischen einem vorhandenen **Ist-Zustand** und einem notwendigen oder wünschenswerten **Soll-Zustand** (Ziel) charakterisiert wird."
  [Heyde, 1991 und Reschak/Sabisch, 1996]

- „Zur **Überwindung** dieser Differenz reichen die vorhandenen Erkenntnisse, die bisher angewandten **Methoden, Prozesse, Organisationsstrukturen** usw. nicht aus."
  [Reschak/Sabisch, 1996]

- „Die **Lösung** eines **Problems** erfordert deshalb immer neue **Erkenntnisse** und **Erfahrungen**, neue wissenschaftlich-technische Ergebnisse und technische, wirtschaftliche und soziale Veränderungen im **Unternehmen**. Kern einer **Problemlösung** ist in der Regel die Lösung von Widersprüchen."
  [Reschak/Sabisch, 1996]

„A problem is anything that could be made different or better through some change. [...] A problem [...] has two aspects: it can involve a difficulty (or danger), or it can represent an opportunity (or challenge)."
[Lumsdaine/Lumsdaine, 1995]

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Figure 12

Type ...

Actual-State → Transformation → Target-State

- **Problem of Analysis:**

  The definition of the problem is closed, which means the criteria of the actual- and target-state are clear stated. The solution of the problem covers several steps by using well-known operations (e.g. mathematics).

- **Problem of Synthesis:**

  The criteria of the actual- and target-state are clear stated. The solution of the problem covers several steps by searching for unknown operations (e.g. "Brainteaser").

- **Dialectical Problem:**

  The definition of the problem is open. That means, that either the criteria of the actual state or the criteria of the target-state are incomplete defined. The solution covers several steps of known and unknown operations (e.g. team-work in coping with engineering-tasks).

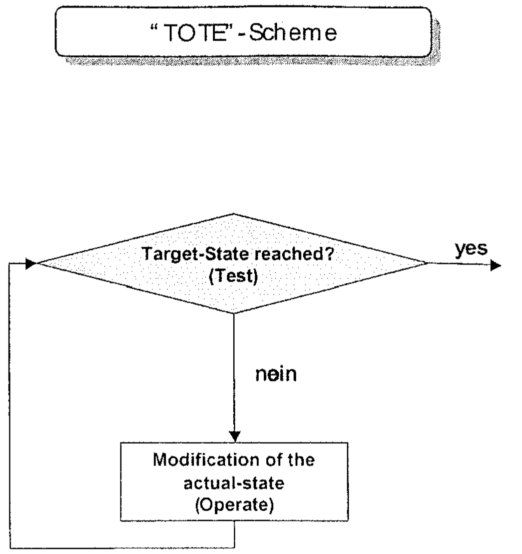
[nach Dömer, 1976; Sell/Schimweg, 2002]

... and Structure of Problems

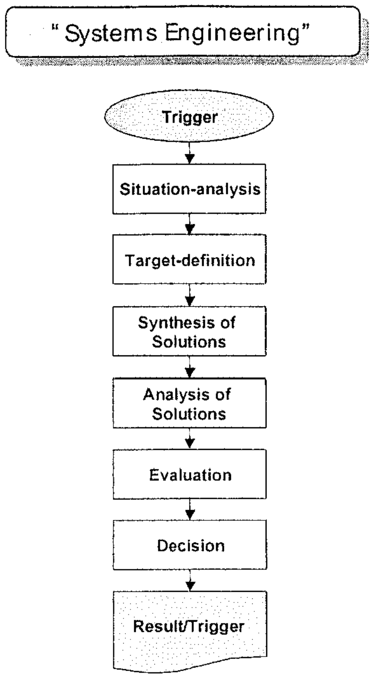
Well-structured Problems	Badly-structured Problems
Problem can be described in numerical terms (Scalar- or Vector-Terms). Targets are well-defined. A suitable algorithm exists, so that a solution can be found and expressed in kinds of numerical terms	At least one of these criteria can not be fulfilled!

[According to Pohl, 1981]

Basic Aproaches of Problem-Solving-Processes



[Humpert, 1995, according to Dörner, 1976 and Rutz, 1985]



[Daenzer, 2002]

Figure 15

Examples of Problem-Solving-Processes

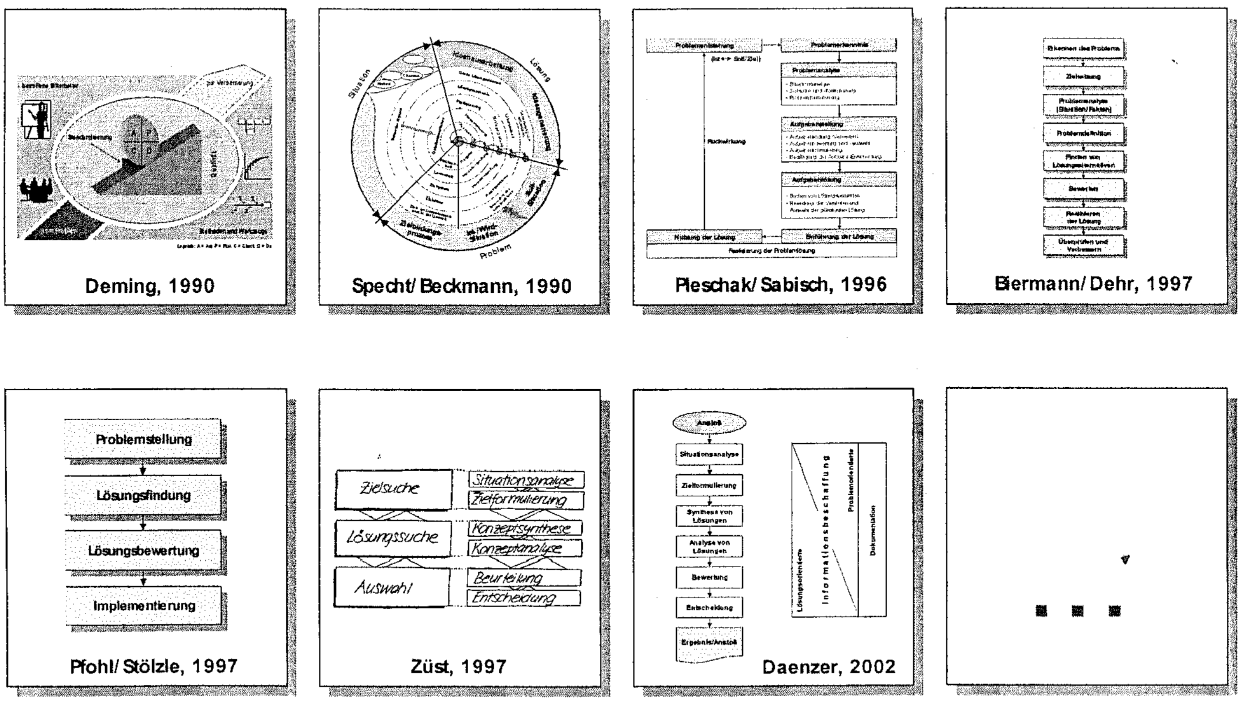
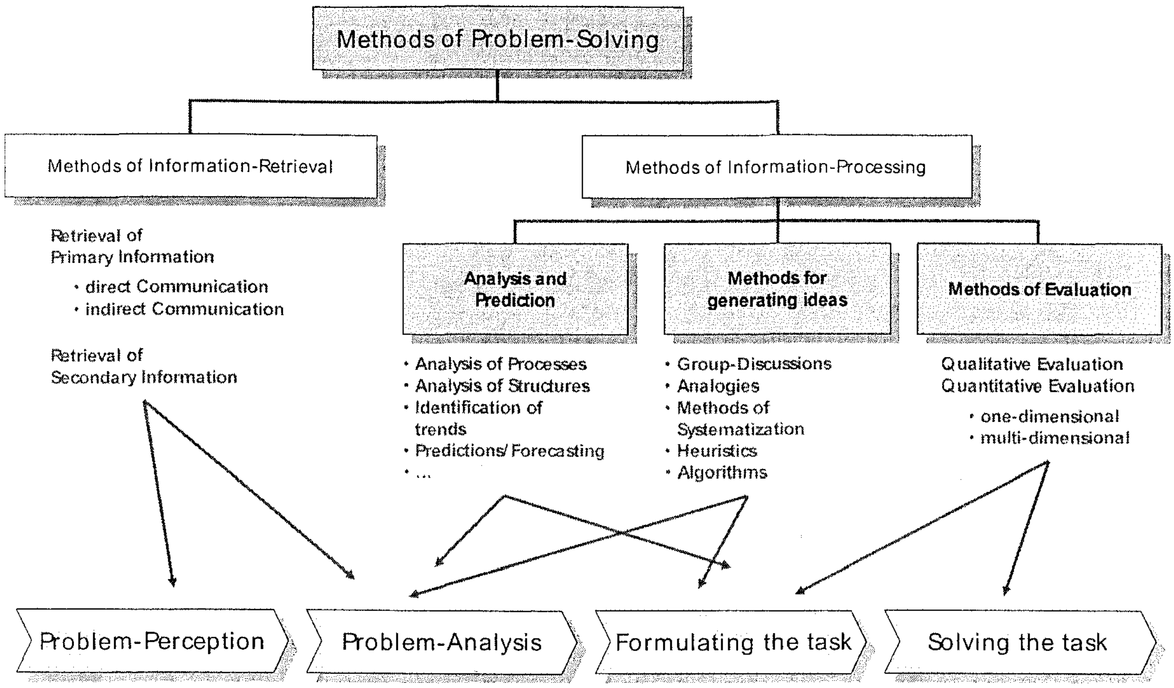


Figure 16

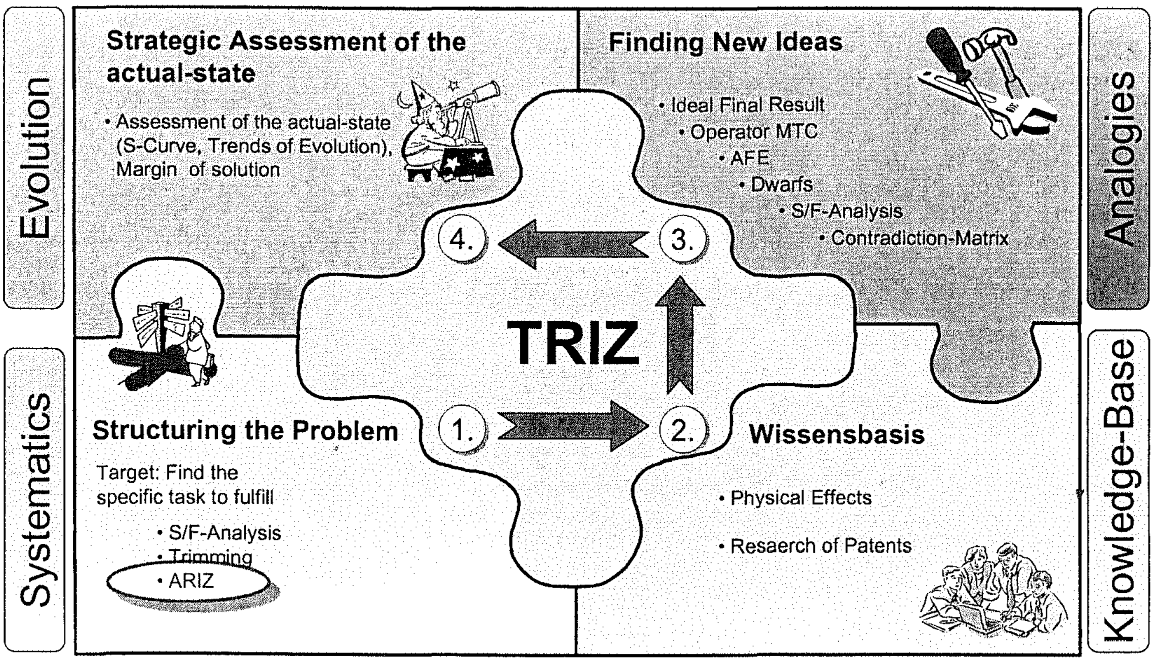
Methods of Problem-Solving – In a nutshell



[Reschak/Sabisch, 1996]

Figure 17

TRIZ – Theory of Inventive Problem-Solving



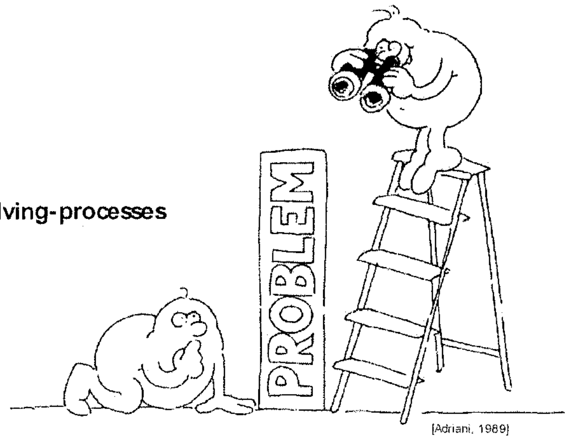
[FBK, 2003, ref. to Gimpel, 1998]

Figure 18

Defiencies in Working with Problems

Problem:

- Missing **traits**
- Subjective **Problem-Cognition**
- **Multiplicity** and **variety** of problems



[Adriani, 1989]

Problem-Solving-Process:

- **Multiplicity** and **variety** of existing **problem-solving-processes**
- **Selection** of suitable problem-solving-processes
- Missing **Guidance** by **choosing** the **methods**
- Many **Compromises**, inefficient solutions
- New **solutions** produce new **problems**

Problem-Solving-Methods:

- **Multiplicity** and **variety** of different methods, techniques and approaches
- Diverse **Thinking-processes** necessary
- Missing **possibilities** for **connecting** different methods
- Huge **effort**, in particular using **TRIZ**
- **Lack of integration** in existing problem-solving-processes
- Frequently missing **evaluation** of the results

Figure 19

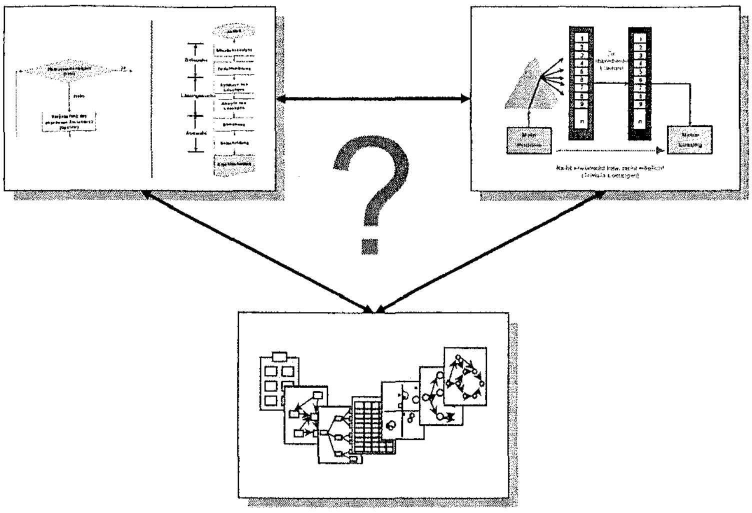
Agenda

- **Introduction** ✓
- **Problem and Problem-Solving** ✓
- **Approach „Embedded-TRIZ“**
- **Conclusions**

- **Discussion**

Figure 20

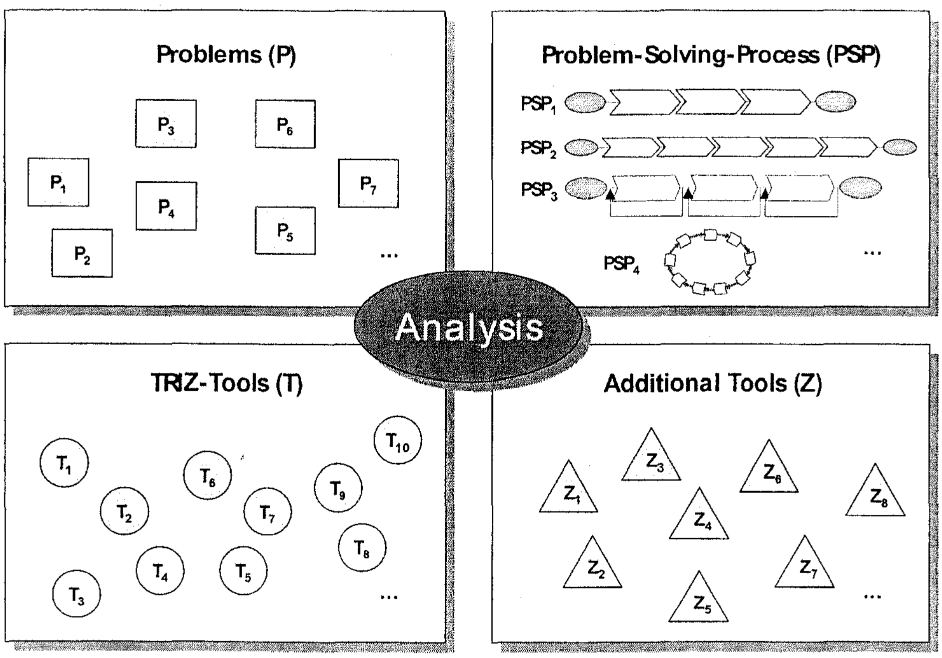
A huge „Question-Mark“ ...



„How can we integrate TRIZ combined with different problem-solving- and evaluation-techniques into an existing problem-solving-process in order to solve technical problems in production and manufacturing most efficiently and problem-oriented?“

Figure 21

Objects of Interest



| Jenke/ Benedix, 2002 |

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Figure 22

First Ideas of „Embedded TRIZ“

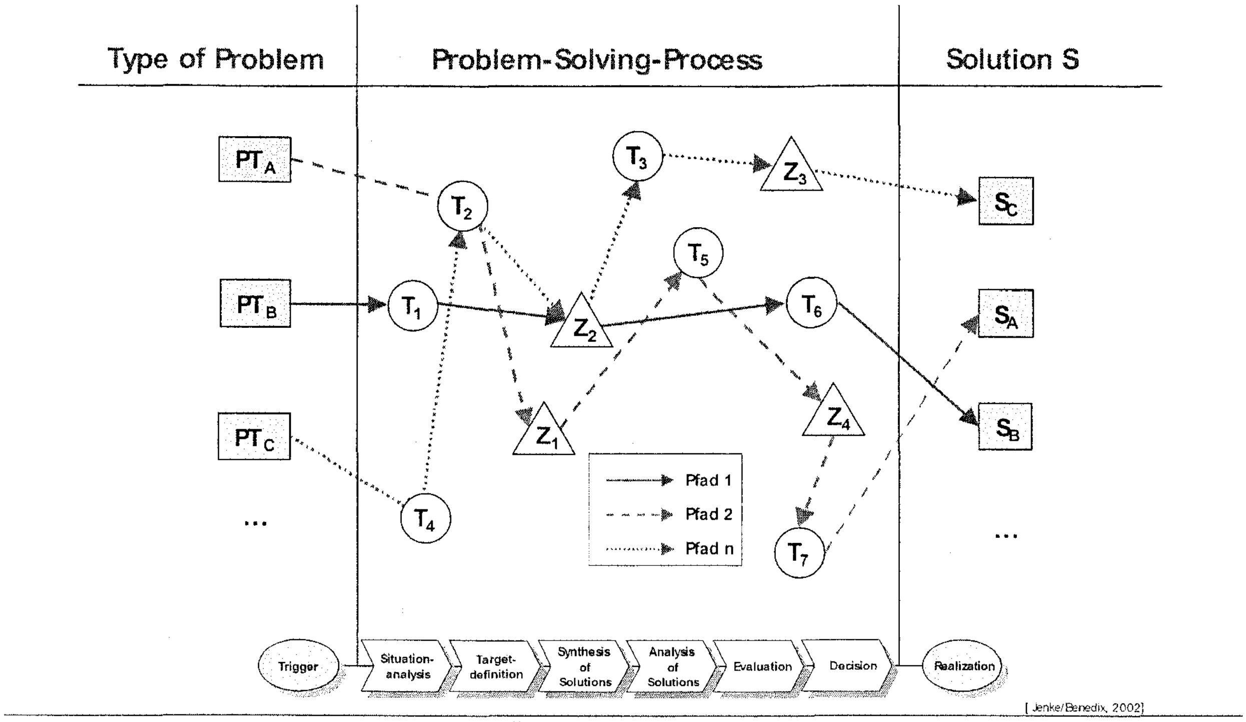

Figure 23

TRIZ-Tools in the Problem-Solving-Process

Trigger → Situation-analysis → Target-definition → Synthesis of Solutions → Analysis of Solutions → Evaluation → Decision → Realization

	Situation-analysis	Target-definition	Synthesis of Solutions	Analysis of Solutions	Evaluation	Decision	Realization
Innovation-Checklist	●	•					
Problem-Modelling	●	•					
S-Curve	●	•			•		
Ressource-Checklist	●		•				
AFTER-96	●	•	●				
S/F-Analysis	●		●				
Tool-Object -Product -Analysis	●		●				
Dwarfs	•		●				
Ideal Final Result	•	●	●	•	•		
Trends of Evolution	●	●	●				
AFE	•	•	●	●			
Operator MTC			●				
Effects/ Knowledge-Base			●				
Physical Contradictions			●				
Technical Contradictions			●				
Trimming			●	●			
ARIZ	●	●	●	●			

● suitable • less suitable

[Jenke/Benedix, 2002]

Figure 24

Continous Development

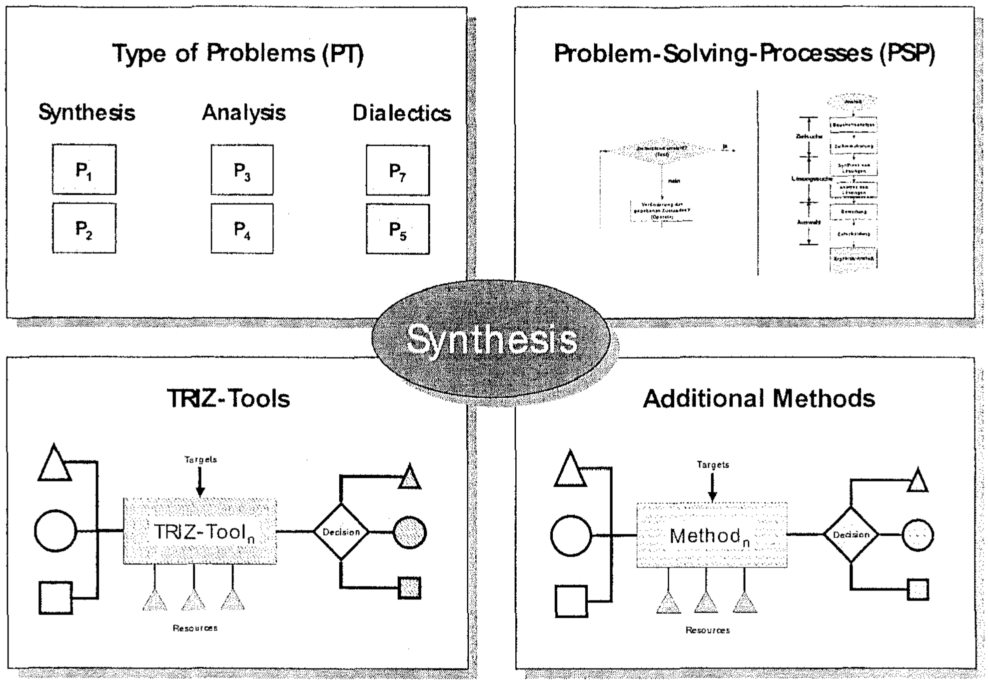

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Figure 25

Generative and module-based Problem-Solving-Process

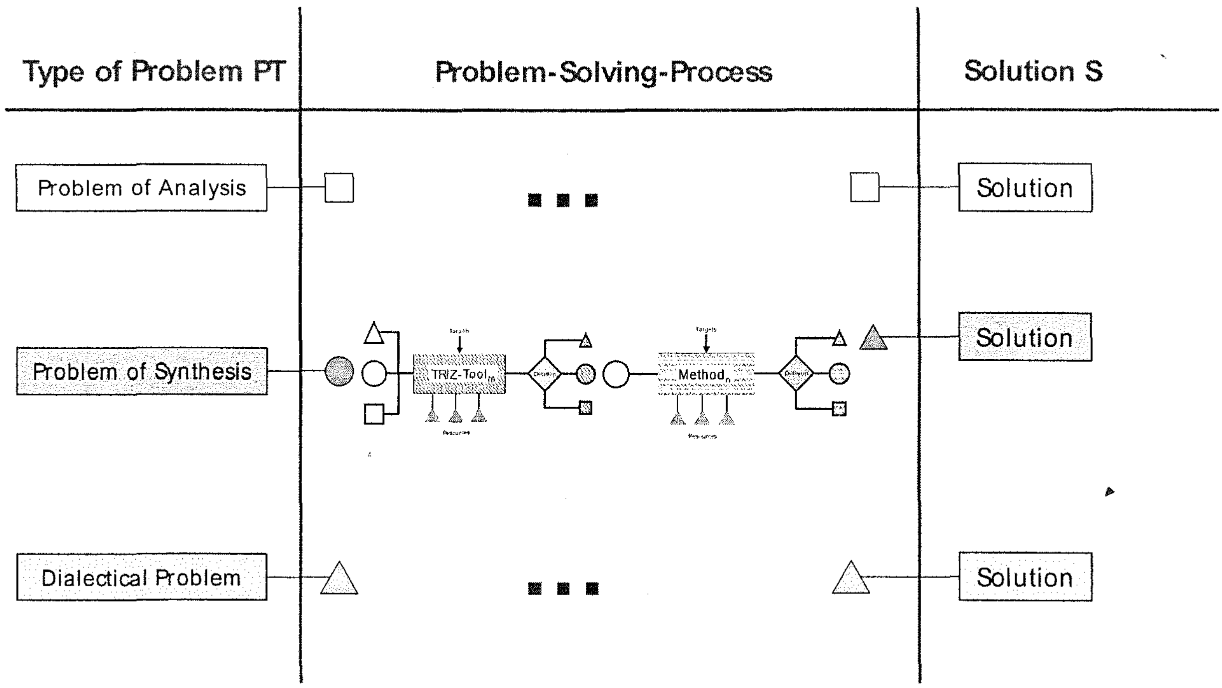

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Figure 26

Agenda

- Introduction
- Problem and Problem-Solving
- Approach „Embedded-TRIZ“
- Conclusions
- Discussion

Figure 27

Conclusions

- **Engineers** have to face several multifarious **technical problems** during a product's life-cycle, especially in terms of **production and manufacturing**.
- In the scientific world as well as in industrial practice a large numer of **approaches** and **techniques** for **solving** technical problems do exist. For example Brainstorming, Synectics or **TRIZ**.
- Nevertheless, solving problems is a very **difficult process**.
- At the **FBK** an **approach** is developed which shall help solving **technical problems** most efficiently by **integrating** TRIZ in combination with different tools in a **common problem-solving-process**.
- Later on, this approach can be **adapted** to different **areas of applications** outside production and manufacturing. Furthermore, **new** techniques can be easily added so that it might become an important tool in terms of **holistic production-systems**.

Figure 28

Agenda

- Introduction ✓
- Problem and Problem-Solving ✓
- Approach „Embedded-TRIZ“ ✓
- Conclusions ✓

- Discussion

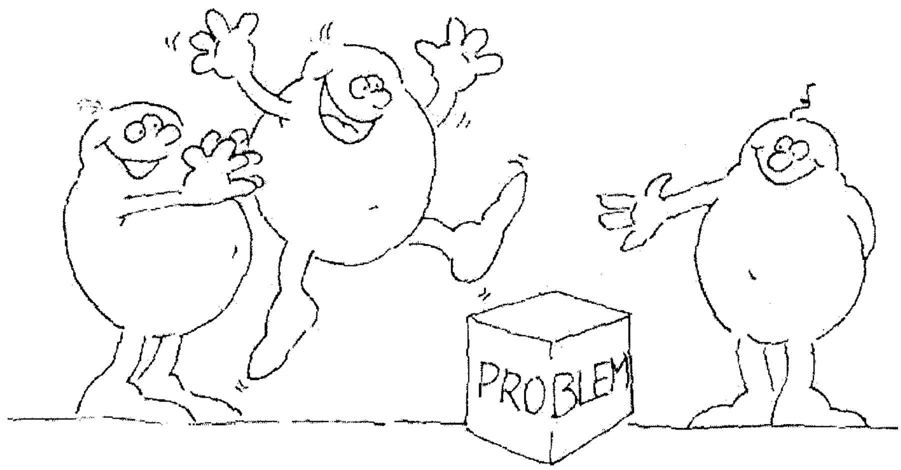
Discussion

Quelle: FBK

Your Questions?

Jan C. Aurich, Karsten Jenke
FBK – University of Kaiserslautern,
Germany

And that´s why ...



... if you have a problem – Be happy!

[Adriani, 1989]

Figure 31

-The End-

[FBK, 2002]

Thank your very much for your attention!

Jan C. Aurich, Karsten Jenke
FBK – University of Kaiserslautern,
Germany

Figure 32

Literature (I)

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Figure 33

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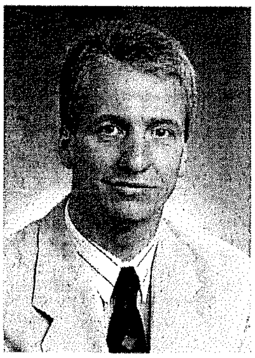
Figure 34

Profile of Lecturer



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Brief Résumé & job descriptions:

1959	Date of birth
1985	Transportation Engineer (Dipl.-Ing) at the Technical University of Berlin
1991	Ph.D. in Engineering (Dr.-Ing.) at the Technical University of Berlin
1991 - 1999	Manager of "Railway Systems Technology" in the DaimlerChrysler "Traffic and Transportation Research Group"
1995 - 2000	Private Lecturer of "Railway Systems" at the University of Applied Science Potsdam
1999 – 2001	Manager of "Systems Analyses and Systems Design" in the DaimlerChrysler "Vehicle Concept Research Group"
since 2002	Manager of "Innovation Management and System Research" in the DaimlerChrysler "Society and Technology Research Group"
Award	"Beuth-Medaille" of the German Society for Mechanical Engineering (Deutsche Maschinentechnische Gesellschaft – DMG) for outstanding scientific research

Profile of Lecturer

Title:	Dr.-Ing.
Name:	Christine Ahrend
Position:	Project Manager in the "Society and Technology Research Group"
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Brief Résumé & job descriptions:

1963	Date of birth
1992	Spatial Planning Engineer (Dipl.-Ing.) at the Technical University of Berlin
1992-1997	Scientific assistant at the traffic and transport institute, Technical University of Berlin
1997-1999	Office for mobility research and Structural Design
1999-2001	Scientist for target group researches at the DaimlerChrysler "Vehicle Concept Research Group"
2001	Ph.D. in Engineering (Dr.-Ing.) at the traffic and transport institute, Technical University of Berlin
since 2002	Scientist for future requirements at the DaimlerChrysler "Society and Technology Research Group"

Applying the TRIZ Principles of Technological Evolution to Customer Requirement Based Vehicle Concepts – Experience Report –

Dr. Eckhard Schueler-Hainsch and Dr. Christine Ahrend
DaimlerChrysler Society and Technology Research Group
Berlin, Germany

Introduction

One of the major tasks of the DaimlerChrysler „Society and Technology Research Group – STRG“ is observing the development of the company's environment, looking for future trends in society and their implications on technology and products. And the most important products of DaimlerChrysler are passenger cars (Mercedes-Benz, Maybach, smart, Chrysler, Dodge and Jeep).

Another important task is looking for better and more effective methodologies, which enable us to be more successful in future. As a connection of these two tasks we carried out a vehicle concept development project powered by two methodologies we combined the first time, GTM and TRIZ.

Future vehicle concept development means linking future customer requirements with future technology evolution options. The analysis of future customer requirements we carried out with the Grounded Theory Methodology (GTM) [Ahrend 2002], for the technology evolution options we used TRIZ. Using TRIZ for a entire vehicle concept is obviously a quite big task. We aimed at and ended with three vehicle concepts. That means also focussing on the most important issues.

The pre-TRIZ phase: Customer Requirements

But how to find these most important issues? By detailed analyses of customer requirements.

To get customers requirements, STRG uses various methodologies depending on the special task; intensive personal interviews, focus group discussions, expert interviews, customer surveys via paper and pencil or via Internet, trend analyses and scenario approaches.

The Grounded Theory Methodology, we applied here, uses the transcriptions of intensive interviews with customers (up to two hours) and leads to a methodological approach of extracting the important customer requirements out of these interview texts. That means that people tell themselves and with their own words what they really expect and require from cars as a basis to elaborate typological connections between requirements.

We concentrated on a special target group:

- age of 30 – 45 years
- family households
- middle class car (e.g. Mercedes-Benz C-Class, BMW series 3, VW Passat)
- medium to upper segment of income

The Grounded Theory Methodology also allows to describe the interdependencies between the different requirements, so we can describe not only what people want, but also why they want it. The result of these intensive research have been three typological requirement profiles, describing three main customer subgroups. That means although the target group seems to be quite homogenous, we elaborated three very different requirement profiles.

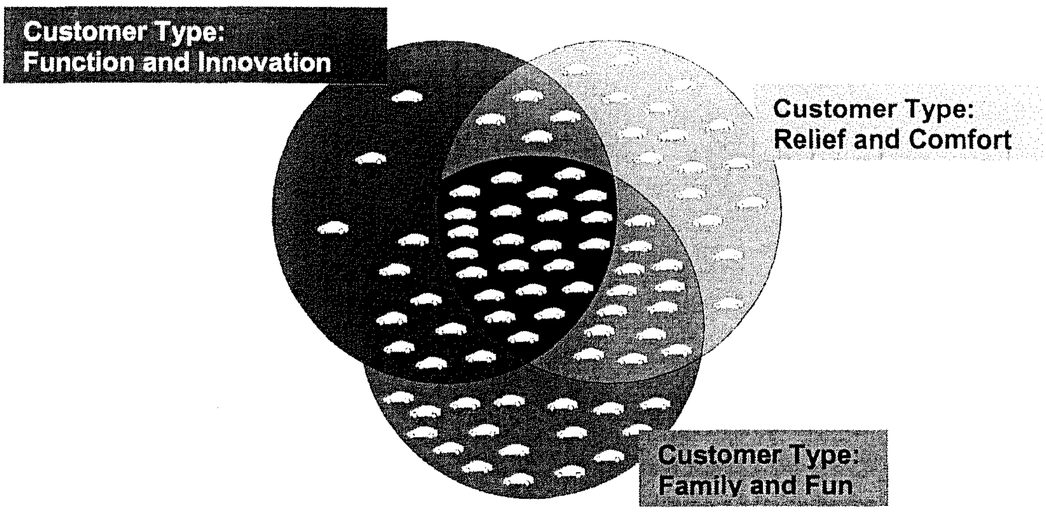

Figure 1: Requirement typology with three main customer subgroups

Every small car in the picture represents one specific requirement. In the centre are the (black) basic requirements every group has (e.g. air conditioning). The outer segments show the unique requirements of every target group segment (red, blue, yellow).

In a next step we combined the requirement profiles of today with future trends in society to assess requirement profiles related to their future perspectives.

The TRIZ phase

These requirement profiles as statements of customer's voice we translated in required vehicle functions (or in TRIZ terminology: useful functions) to start the TRIZ process.

For every important vehicle function (quite different for the three segments) we described the today's technology, assessed the today's evolutionary status and used the lines of technological evolution to generate ideas for future technology options. These ideas have been evaluated and integrated to three vehicle concepts.

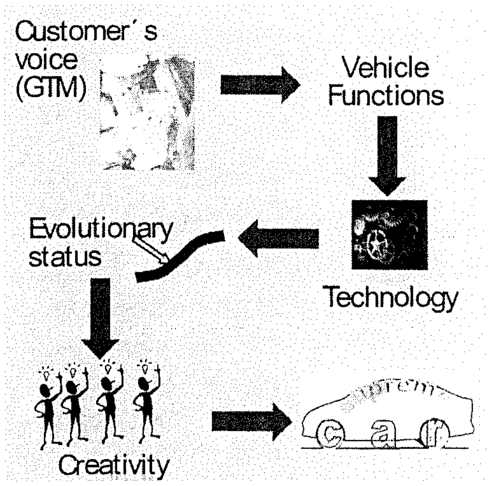

Figure 2: From customers voice to vehicle concepts

Finding the Workshop team

As a result of the customer requirement profiles and the appropriate vehicle functions we defined a list of those technologies, which seem to be of special importance for the vehicle concepts:

- conventional and alternative drives
- materials and surfaces
- active and passive vehicle safety
- human machine interaction
- vehicle dynamics
- automation
- driver assistance systems
- vehicle concept development
- information systems

For all these technologies we invited experts from DaimlerChrysler Research and Technology Group to participate in a workshop process. That means that not a team was looking for a problem solution but a problem was searching a team.

For internal reasons of using bigger technological experience we elected managers and senior managers to work with us. But working with senior managers means normally that they can't spend a lot of time to work between the workshops. Therefore we organised a project office, that supported the process by investigations, preparations and restructuring of results between the workshops.

As a good basic condition we had a lot of interested and open minded people in that process.

The workshop process

We carried out the first and the last workshop together with the entire team (about 12 to 14 researchers), for the second and the third workshop we splitted the team in two groups (A and B), to get a more efficient team size and to speed up in a parallel approach.

We went out of the normal business environment to hotels or conference centres. We recognised that as very important and with a rather big influence on workshop atmosphere.

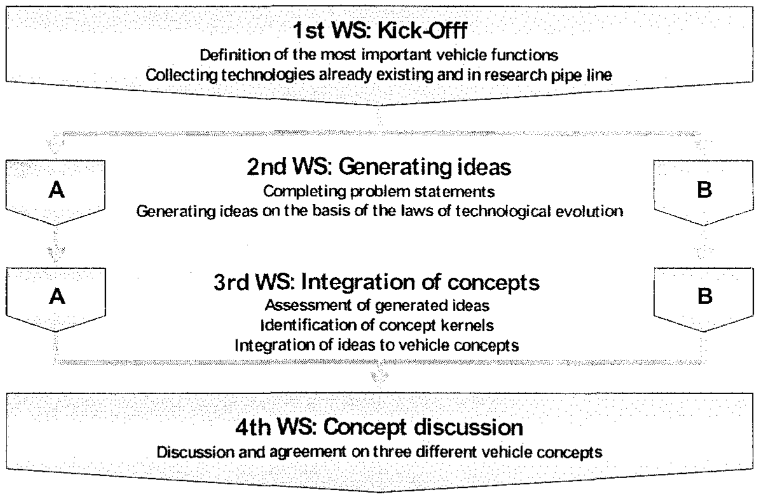

Figure 3: Sequence of workshops

1st workshop: problem analysis

At the beginning of the workshop we presented the customers' typologies to the workshop team. To intensify the understanding of the different customer types we divided the group into three subgroups, one for each requirement profile, and asked them the following questions:

- Which vehicle functions are necessary to fulfil the customers requirements for each group?
- How are the functions realised today?
- Is that realisation satisfying?
- What technologies do we have in our research pipeline?

The results of these workshop have been

- a clearer understanding of the three typologies,
- the recognition, that we have a lot of existing technologies, that we have many in our research pipeline, but that there are various existing gaps to fulfil the customer requirements.

Project office between 1st and 2nd workshop

The project office prepared the results of the first workshops and made analyses about existing solutions for the most important technological subsystems.

2nd workshop: Applying the laws of technological evolution.

Analysing one after the other vehicle function in detail related to the following issues

- technologies, which are used today,
- completing the list of technologies in the research pipeline to the function,
- working with the lines of technological evolution (here we found a valuable support in [Herb, Herb and Konhauser, 2000])

We asked questions like:

Seats are currently consisting of seat and backrest, connected by a joint and together movable forward, backward and partly upward. Customers want to have a more flexible interior. How can a higher degree of segmentation (related to seats) fulfil this requirement?

We collected all these ideas without any assessment at this stage.

Project office between 2nd and 3rd workshop

As a homework for the participants they had to evaluate the ideas concerning

- estimated increase of ideality (low – medium – high)

- estimated time horizon of series application (2003, 2006, 2010, 2010+).

The feed-back of these evaluations has been used to arrange all ideas concerning their function and their time horizon on three pin boards, one for each requirement profile (blue, yellow, red).

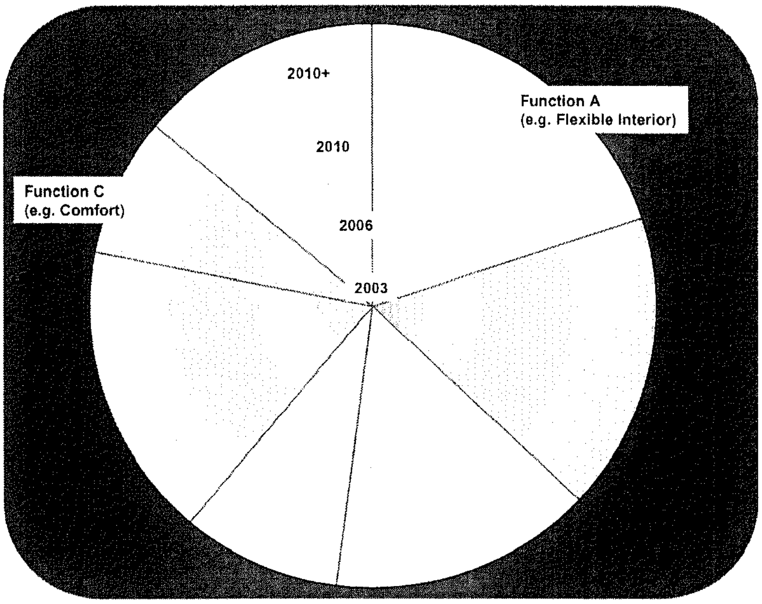

Figure 4: Structuring scheme of ideas (Profile blue, 7 functions, 4 time horizons)

3rd workshop: Concept integration

Main issues of the third workshops have been

- the discussion of the personal evaluation to find a common group evaluation,

- the integration of the high rated ideas to future vehicle concepts and

- picturing first design studies.

Project office between 3rd and 4th workshop

The different concepts have been described more in detail and for every vehicle concepts additional design studies have been prepared.

4th workshop: Concept determination

After working during the 2nd and 3rd workshop in parallel the whole group discussed together the results. This achieved

- a final discussion on the fit of the technological solutions to the requirement profiles and
- a common sense of the results for all participants.

Major experiences - or - our lessons learned

The task itself

Developing vehicle concept is a very sophisticated task for a TRIZ process. The intensive analyses of customer requirements have been extremely helpful during the whole process because it provided us with a very sophisticated basis of customer requirements. Thinking in TRIZ terminology in this case (vehicle concepts) it is not enough to define only the „major useful function". Because we are dealing with a very complex system with a lot of technical subsystems there are a lot of functions to consider. Although we had a quite intensive workshop process, we remained mostly on a conceptual level of solutions.

Of course, technology road maps are existing in every research area, but not all of the customer requirements are covered by these roadmaps. Therefore additional generating of ideas was necessary.

The locations

Going out of the normal business to hotels or conference centres was one of the success factors. If you want to think out of the box it is important that you really are out of your daily box (office).

By chance we made a very interesting experience related to the workshop ambience. One of our ideas generating workshops took place in a hotel of a small town in the south of Germany in a conference room with a mid-age knight ambience. It was very nice to be there but very difficult to think there about future technologies. Although we had a reservation there for one of the next workshops, too, we did not come back to this lovely place.

Dealing with TRIZ Methodology

During the first workshop some of the participants expressed their interest in getting taught TRIZ during that process, too.

The 2nd workshop we carried out in splitted teams, focussed on TRIZ application. But trying to explain TRIZ during that workshop proved to be very difficult, because the team members were intensively occupied with putting themselves in the complex requirement profiles. In that situation explanation of TRIZ was hindering the process. Under the basic condition of the sophisticated approach to generate vehicle concepts and of the available time frame there was too less time for teaching TRIZ. That was a experience of the 2nd workshop we carried out with group B.

As a reaction of that, we used TRIZ for the other team, giving continuously impulses during the idea generating phases. But we did not teach it there. That worked very well and the satisfaction rate of the team was quite higher.

The result

When I am talking about TRIZ methodology and possible applications to managers in my company, they every times want to have exiting and topical success stories. But these stories are that kind of stories which are normally secret. So they mostly remain a little bit frustrated.

That is exactly the point where I am now. We got very interesting results which got a very positive resonance in the DaimlerChrysler research group, the vehicle engineering group and the sales division.

But ... these results are (still) secret. That is why I am referring here about experiences, not about results.

Conclusion – Part I

The TRIZ laws of technological evolution are well appropriate to apply them to the development of future vehicle concepts. The very detailed analyses of customers requirements (GTM) have been very helpful in understanding the „useful functions“ for the different customer types and have been a big support for focussing the TRIZ process.

Because of the big number of relevant functions and the complexity of the technical subsystems the level on detail remained on the conceptual stage (this experience we already made during a pilot TRIZ application to develop a environmentally friendly vehicle concept [SCHUELER-HAINSCH, 2003]).

The next step has to be going more in technical details for interesting technical subsystems. After having made that we can prove how good our concepts really are.

Conclusion – Part II

Finishing my contribution to this congress I would like to express my major demand to the TRIZ community. To market TRIZ in big organisations like my company DaimlerChrysler, it would be extremely valuable to have some real success stories of high level inventions by applying TRIZ. That does not mean only to demonstrate that TRIZ principles are applicable to inventions (re-inventing), but that means showing real high level TRIZ success stories of the last five to ten years.

I myself mentioned some reasons why that is so difficult. But on the other hand my personal forecast is that a collection of that kind of success stories is a precondition for a breakthrough in industrial TRIZ application.

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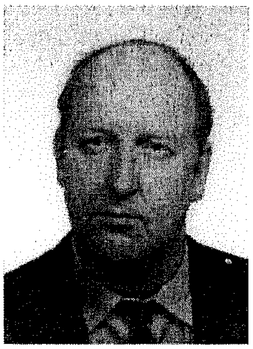
Profile of Lecturer



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Observing the Development Trends of Glass Moulds using the Laws of Technical Systems Evolution

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Introduction

Fundamental postulate of the TRIZ method is the existence of relatively independent processes of new technical systems formation according to a man's will [Altshuller].

Technical Evolution is a historical process within the framework of human evolution. Even though subjective actions of people are not always in accordance with objective Laws of the process of Technical Evolution, only those results of these human actions survive that are in accordance with existing laws. It is obvious that knowledge of the Laws of Technical Evolution makes it possible to save a lot of forces, energy, masses, time and finances. [Salamatov]

A mechanism for forming container glass was chosen as an example of using the above-mentioned laws. In the article [Hessenkemper] there was described a reason for using glass container production line and technological difficulties connected with the stabilization of production conditions.
These conditions are above all directed towards optimizing of forming and cooling of glass melts in a mould with the perspective objective of further decrease of the glass thickness while preserving the mechanical strength of the product.

What can the Laws of Technical Evolution contribute to the development of glass moulds? The answer is hidden in the following article. At first it is necessary to define a technical system.

Technical System (TS)

A Technical system (TS) is a set of in a certain way arranged and connected elements which is characterized by having greater effect than just a simple sum of qualities of single elements and which is intended for fulfilling useful functions. Main symptoms of TS are: functionality, organization, and system quality [Salamatov].

We will demonstrate using and following laws of technical evolution on a chosen technical system – Closing Mechanism and Axial Cooling of Glass Moulds in glass container production line (further only Glass Mould Mechanism) - see Fig. 1

Mechanism was simplified for the needs of this article – it includes only Closing Mechanism, one half Mould with an Axial Cooling without the top part with the nearest supporting mechanisms.

A Function is a property of TS, which shows up under certain conditions due to the influence of changes, or preservation of parameters on the relevant object (product). Every TS has its main function.

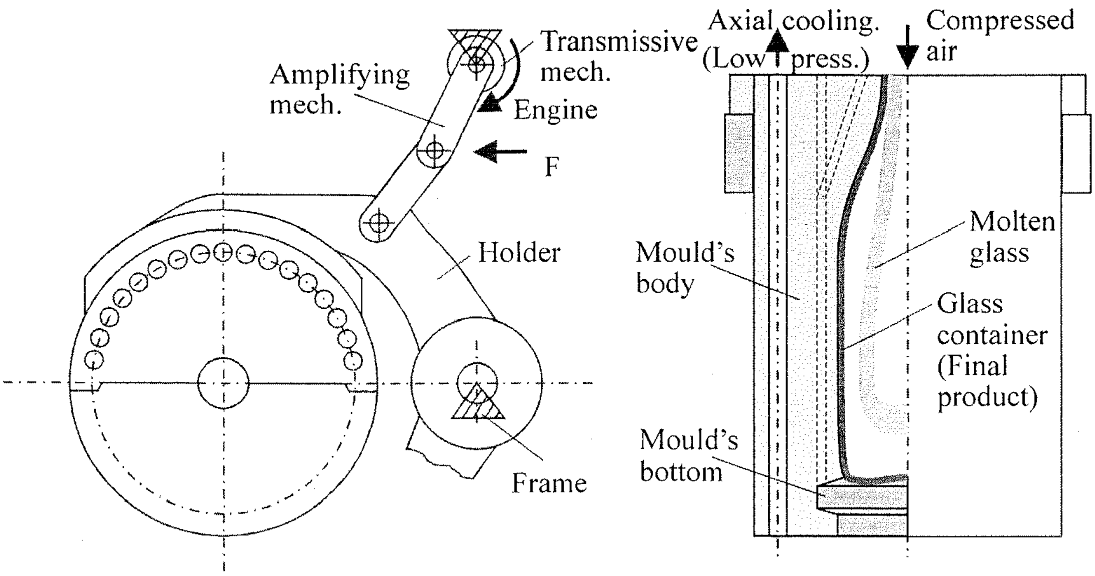

Fig. 1. Diagram of a Glass Mould Mechanism

The Main Function of the GM Mechanism is: To form a Molten Glass (in a Glass Mould).

Data about the shape, accuracy, speed and so are already the parameters of the main function. Only system as a whole can form a product, not single elements (one half of the mould, amplifying article, cooling etc).

Base element for fulfilling of the Main Function is a working unit, in our case composed from the Mould's Body with Bottom and acting Compressed Air (due to the influence of Compressed Air the Molten Glass is being pressed against the wall of the Mould Body).
These three basic parts fulfill the Main Function.
Other elements, controlling of GM Mechanism and cooling arised by further improvement of the TS in order to increase the parameters of the Main Function.

A structure is a set of elements and connection between them. At the beginning of existence an element fulfills only its Main Function to which later additional functions are added.

The set of elements and its connections within the framework of the GM Mechanism is demonstrated on the structure model – see Fig. 2.

In our case the structure of the GM Mechanism - see framed part – is determined by the fundamental elements – Mould's Body with Bottom, Compressed Air because this element fulfills the fundamental function "establishing" the Main Function of the GF Mechanism.

In the process of forming a product the first operation and function is:
- to form a Molten Glass (in a Glass Mould);
the second operation and function is:
- to cool a Molten Glass (in shape of a Glass Container).

At the beginning the Mould's Body with Bottom fulfilled both of these operations/functions. Later one part of the Mould's Body with Axial Holes enhanced the function of cooling.

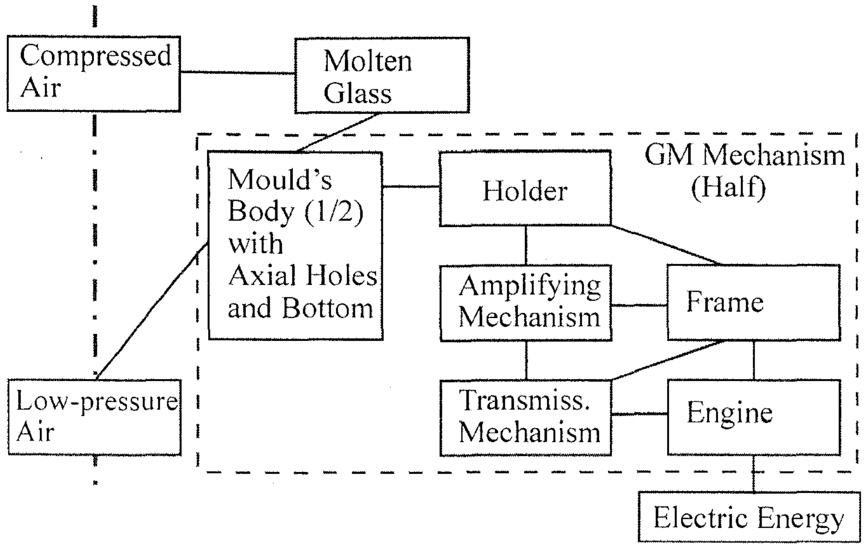

Fig. 2. Structure model of a half GM Mechanism

An organization is an algorithm of collective functioning of TS elements in space and time. Connections among the elements serve to the transfer of energy, substances and information. An organization makes it possible to control TS through connections. The principal condition of functioning of connections is the variation of energy potentials. In the case of GM Mechanism there is used the gradient of temperature (Molten Glass - Mould - Air) and the gradient of force (Engine - Transmission Mechanisms – Mould's Body - Molten Glass).

System effect and quality
The main orientation in the process of syntheses of TS is the profit of future system property (effect, quality). For one and the same TS it is possible to pick several different structures depending on chosen physical effect of executing the main function. The selection of physical effect should respect minimization of weight, sizes and necessary energy while preserving effectiveness system.

In our case of GM Mechanism the system quality – main function, to form (create a shape) a glass product and to cool (preserve a shape), is determined by mechanical and thermal principal. When these principles are realized with regard to required minimization of energy consumption it is possible to observe on confrontation of yet existing present Mechanism GM with the Laws of Technical Evolution.

Observing Mechanism GM in comparison with the Laws of Technological Evolution

The law of TS completeness

A necessary condition of TS survival is the existence of minimum workability of fundamental system parts. Every independent (relatively separately functional) TS must have four parts: Energy Source, Converter, Working Unit, Control System and Product [Petrov].

In our case: GM Mechanism became independent TS when the transition from hand-made glass production in wooden moulds onto the mechanical production occurred. The following chains express the integrity of parts:

EL. ENERGY - ENGINE – TRANSMISSIVE A AND AMPLIFYING MECHANISM. - HOLDER – MOULD'S BODY - MOLTEN GLASS

EL. ENERGY - COMPRESSOR - CONDUCTION - COMPRESSED AIR - MOLTEN GLASS

Here can be seen a chain from the power supply up to the product which is Molten Glass. Everything is without an attendance of a man.

Chain EL.ENERGY - VENTILATOR - CONDUCTION – LOW-PRESSURE AIR - AXIAL HOLES (IN MOULD'S BODY) is a system designed for cooling of Mould, which is the product in this given case.

The result from the Law of TS completeness is: To make TS controllable it is necessary to make at least one part of the TS controllable.

Is the controllability of GM Mechanism satisfactory provided? Is it possible to set the Engine controls, mechanisms settings, and control of Compressed Air in that way, so that the conditions of forming would be fluently changeable according to the needs? Is axial cooling sufficiently controllable?
These questions encourage possible improving towards better conditions of stabilization in the process of forming. By answering these questions we can think about improving the process of forming and its control.

Laws of energy conductivity in TS
A necessary condition for fundamental vitality of TS is the ability of energy conductivity through all of the system parts.

In the GM mechanism it is necessary to observe the following:

1) Conduct ability of power transmission from the engine to the mould's body. Why is so heavy power and amplifying mechanism necessary? Because it is necessary to grip perfectly heavy Moulds. Why do we need a perfect grip? The Moulds are being pressed away by Compressed Air and on the interfaces parts gaps arise due to the thermal deformation. Why are Moulds heavy? They must have ability to accumulate heat. How big power is needed for gripping the moulds? Is it controllable? By Engine? By Mechanisms?
2) Conduct ability of heat transfer into the cooling air. Does not the thickness of the mould decrease controllability?
3) How many means of energy are used? New ways of using servomechanisms fulfill the condition of using only one type of Field (Electric) for all processes. Electric Field is on the very top of all controllable fields (MATChEM) [Altshuller, Zlotin ....].
Unfortunately on the other side we use several kinds of secondary fields (compressed air, low-pressure, under pressure). Isn't there a possibility of decreasing the amount of them?

Law of rhythm coordination of TS parts
Coordination (or conscious detuning) of rhythm (frequency of oscillation) or periodicity of all the components of the system is a fundamental condition for principled vitality of TS.

In our case of GM Mechanism:

1) On a production line the process of forming and cooling of a premoulding, heating of the premoulding, and forming and cooling of the final shape happens in two-step production. This process is obviously not coordinated with the ideal cycle of forming – forming without heat transfer, cooling with a quick heat transfer
2) By pressing the air into axial holes it happens that on the exit from the holes there is an enhanced oscillation, which leads to an enormous noise. In this case it is necessary to think about a conscious detuning of the air oscillation.

The law of dynamics of TS

In order to gain higher effectiveness tough and unadjustable systems become dynamic, it means to overcome to more elastic and quickly changeable structure and to quickly changeable working regime, which can be adjusted according to the changes of external environment [Salamatov].

In our case of GM Mechanism it is necessary to consider the following possibilities:

1) To dynamics surface of the mould body to change the speed of heat transfer within the cycle of forming. By the variable surface contact (between Glass and Mould) it is possible to regulate the quantity of transferred heat. From the view of laws of technical evolution the surface of the mould should be elastic even liquid or gaseous for variable contact
2) To dynamics the whole mould body with the aim of joints, which could make it easier to open and close the mould.
3) To change the static impact of compressed air within the main function of shaping molten glass in harmony with the line of transition from the static fields towards alternating fields. Preservation of effective air pressure with a lower consumption can be reached for example by pulsation

The law of increase of the degree of S-field interactions in TS

The technical system evolution is stepping forward in the direction of increasing the degree of S-field interactions. No S-field interactions become S-field interactions and S-field interactions increase the number of elements, links and sensitivity.

In our case of GM Mechanism we can demonstrate increasing of effectiveness of cooling by adding Water Vapor according to the formula Fig. 3 to the process of blowing of Compressed Air. Insufficiently acting Compressed Air (S1) on Molten Glass (S2) is completed with Water Vapor (S3) and Thermal Field (Ft), which is available from hot Molten Glass. Thereby more effectively acting S-field originates.

$$S_1 \dashrightarrow S_2 \Longrightarrow (S_1 \overset{F_T \swarrow}{S_3}) \longrightarrow S_2$$

Fig. 3. Diagram of S-field evolution of Compressed Air with addition of Water Vapor

Change of abundant influence of the mould on Molten Glass (fast cooling) can be reduced by adding a suitable material among harmful action and by adding a field controlling this material. For instance a liquid supplied by pores of the moulds and vaporized by the heat of the Molten Glass. The effectiveness of cooling is higher (effect transition – vaporization is applied) than in cases of painting the mould various greases (increases heat transfer by conduction).

The law of irregular evolution of TS parts

Evolution of single parts of TS progresses irregularly: the more complex system is the more irregularly its parts evolve. Irregularity of TS parts evolution is the reason of creation of technical and physical contradictions [Altshuller].

In the GM Mechanism rising of output of glass products gets into contradiction with unsatisfactory cooling.

The contradiction is solved by addition of new (other) materials and fields, where a new degree of harmony among elements is accomplished. There is an effort to introduce materials and fields in terms of ideality (with minimum loss of energy, costs). Materials and fields are to be found within own resources of the TS. At the best the system would have help itself.

In the case of GM Mechanism - small amount of added water is vaporized by its own heat form hot Molten Glass, which enables a better heat transfer in TS.

The law of transition of TS structure from macro- to microlevel
The evolution of working units progressed from macro- to microlevel [Salamatov].
In our case of GM Mechanism the development of cooling of the body of the mould with its transition from radial cooling to axial and then to capillary cooling can be given as an example

The law of transition to a supersystem
Evolution of TS, which has already reached its peak of development, can continue on the level of so called supersystem. During the transition of TS to a supersystem there some delay might occur. The reasons for that might be economical interests of various groups, prolonging of the lifetime of the previous TS even at the expense of living environment.

In our case of GM Mechanism there is a suggestive question arising: why axial cooling, which achieved its physical limits of the principal (maximum wholes, maximum noise), has not been yet changed to effective liquid cooling. Yes, there exist some interests, because axial cooling has not returned all invested money and thereby not enough money has been invested into the development of liquid cooling to remove danger problems at the beginning concerning the contact of liquids with Molten Glass, narrow boundary of regulation, changing mechanical arrangement etc.

The law of increasing the degree of ideality
A general direction of technical evolution is defined by the law or increasing the degree of ideality of TS. [Petrov]. The extreme is: Ideal system is that which does not exist but its function is filled. Since a function can be operated by material objects only it means that other objects, materials and fields located in the near surroundings must provide the function for the disappeared object. In the final faze it leads to a transition to so-called „smart" materials.

In our case of GM Mechanism a thermal chamber or thermal tube could be characterized as a „smart" material, but its use is at the very beginning.

Approaching TS towards the ideal state can be done by means of simplifying (trimming) as well. A simplified GM Mechanism, after removing of amplifying and converting mechanism, is demonstrated on the Fig. 4.

It is possible to remove an element from TS if his function is undertaken by other element of the system.

In our case the Amplifying Mechanism can be removed if the function of holding the mould is undertaken by other element. The second half of the Mould can be such element that exists in the TS. Two halves of the Mould can hold each other. The words "itself" are very important because they express the ideal solution without other resources. It is possible to prepare various engineering designs to provide a simplified structure. The Transmissive Mechanism can be removed by the same process.

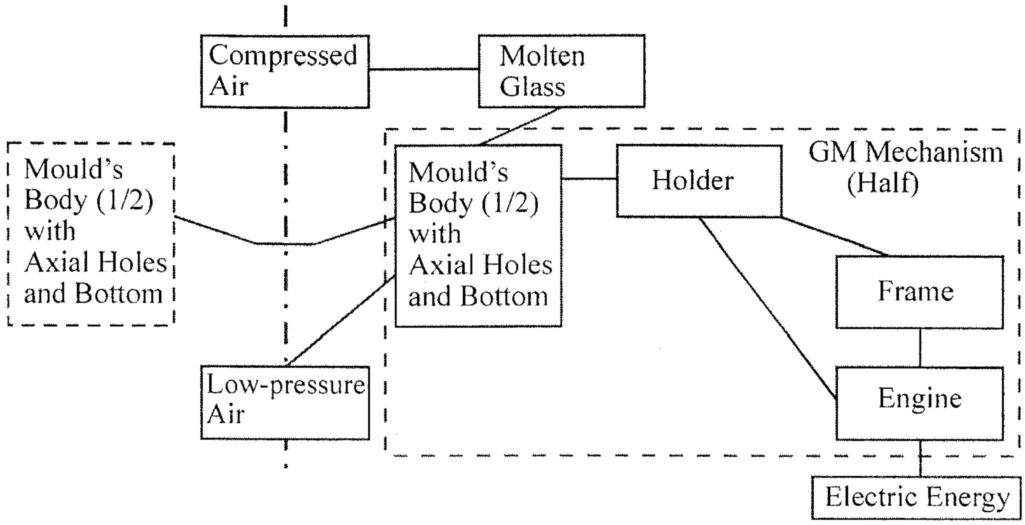

Fig. 4. Structure model of the simplified GM Mechanism

Summary of knowledge gained from observing of Mechanism Glass Mould in confrontation with the Law of Technical Evolution

From the view the Law of Technical Evolution, development of GM Mechanism is at the very beginning. Confrontation of the existing state of the Mould with the knowledge of Laws offers number of directions on how to improve the arrangement of the Mould, cooling, simplifying Control Mechanisms to reach lower sizes, weight, energy, material and time.
It is possible to present a vision of an ideal GM Mechanism. Ideal mould should provide itself with closing a shape for the function forming a product and its own cooling as well. This ideal Mould might be in the form of ideal substance (e.g.. capillary porous), whose control for different degrees of fulfilling of several functions would be controlled by using relevant fields.
The mould would dynamically adapt at contact with Molten Glass to the needs of either hold on the heat or quickly remove the heat. The goal is the transition from static stability of the process of forming to dynamic stability during each mentioned cycle.
Thereby the contradiction of harmless cooling during the process of forming and insufficient speed of cooling would be overcome. After that there is only a small step towards the future vision of perspective objective: to increase the strength of the glass wall to a such value which enables to produce thin-wall products but preserving the same mechanical strength as before. Overcoming this contradiction would enable transition to a more simple forming process.

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Summary:

Observing the Development Trends of Glass Moulds using the Laws of Technical Systems Evolution

The heterogeneousness of development trends of glass moulds is influenced by many requirements. That influences various design of Glass Moulds including use of materials. There were written a lot of publications about the development of Glass Moulds and a lot of effort on simulation of processes in Glass Moulds have been recently put.
This article offers a new view on the development trends of Glass Moulds using the Laws of Technical Systems Evolution.
In this article detailed examples of evolution trends of selected parts of Glass Moulds in the moments of its creation, development and innovation from the view of the ideal solution will be stated.

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TRIZ Future 2003
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TRIZ experience at HUTCHINSON

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Hutchinson is world market leader in the industrial rubber sector, and is part of ATOFINA, the chemical branch of the TOTAL group. Hutchinson's business is organized into eight activities in 3 principal sectors. These are automotive, aerospace-industry and consumer products. Hutchinson operates principally in Europe, the Americas and Asia. At the end of 2002, Hutchinson employed 24820 people in 145 manufacturing and sales establishments in 31 countries. Research and Development was at a high level for the sector. This strategy enables Hutchinson to devise increasingly innovative products in line with its sustainable development objectives, while developing more competitive. Environment friendly manufacturing processes and anticipating the future expectations of its many customers. So when someone talks about a new theory and method to systematic innovation, naturally Hutchinson try to know what it means...

Like everybody in France, Hutchinson discovered TRIZ in 1998 by 2 main ways. Firstly by a lot of articles that talked about a new method and a new way of thinking for resolving problem an improve innovation efficiency. Secondly by a new software that could help engineer to solve all problems and improve conception efficiency.

TRIZ and innovation are associated, so Hutchinson couldn't be unaware of TRIZ. Remember Innovation is the principal way of life of Hutchinson. On our website you could read "Hutchinson the strength of innovation".

So in 1999, began an experimentation. Several Hutchinson's Departments were interested by TRIZ and TechOptimizer. These Two tools were presented like the universal solution that needs minimum (only a computer) and could give the maximum (solve all problem without difficulties).

Two Students of INSA Strasbourg, start to develop and experiment TRIZ in 4 Departments. Tests were on different levels (solving problem, prospecting, and pure innovation). Results of their works were excellent and it appeared, it was necessary to implement TRIZ.

However student's works showed several things:

- TRIZ need to be learn. It's like a car, if you don't learn to drive, you directly go to the crash!
- TechOptimizer (TO) don't work alone...TO need knowledge about TRIZ and about its using...

So for the deployment we were needed to define different points. Firstly we had to define the applicant profile and what they need ? And secondly define how answer to their needs ?

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Every Departments need TRIZ but Hutchinson have a star Organization where each business unit is free with its organization. Concretely it's impossible for each Department have an internal TRIZ user. Not enough time, training cost too high and so on..

But learning is not enough, if you don't practice usually, you don't improve your efficiency of use it and to solve problem. If each time you use TRIZ you have to re-learn it. The improvement is lost in the waste of time...
Conclusion : TRIZ user have to know and have a regular practice.

Te best place for the TRIZ user is to centralize him at the R&D unit (Hutchinson Worldwide Research Center, Montargis, France).
TRIZ in Hutchinson is ONE USER (your servitor). Thus each Department could decide to integrate TRIZ punctually.

Concretely what is necessary to do for implement TRIZ in our Company ? The most important thing is to communicate about TRIZ because a lot of person know this acronym but a little bit knows exactly what it means...And often the few person have a false idea about TRIZ... and with near 25000 employees it's difficult to inform all of them.

The first job in Hutchinson has been to communicate by all internal communication systems : Little articles in internal press, Creation of an internal intranet website (describe theory and tools, typical planning of study, vocabulary glossary), go to each Department to communicate about TRIZ.

the second job was to learn TRIZ sufficiently to be autonomous and practice it. Two aspects was approached: theory and practice.

Theory : based course by INSA Strasbourg
Perfection course by ADEPA in association with INSA Strasbourg

Practice: the 2 levels course of Invention Machine

For TRIZ expert is probably seems too light but I think it's enough to begin any studies and progressively improve his level and feeling where difficulties are and have good questions.

But the most important to improve knowledge and exchange opinion and so on was the adhesion of TRIZ France association. I think the most interesting things I have learned for the implementation and using TRIZ, was by discussion with the associations members...

What is the result with such deployment, it's difficult to talk about operating result because each TRIZ work concerned advance study and often it have to wait until the system is designed. So I'm going to give you some general view

Since 2000 TRIZ represents around 3 or 4 studies per year
5% of the result idea could represent a patent
Each sector of Hutchinson worldwide have ever used TRIZ one time.

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HUTCHINSON WORLDWIDE

It's difficult to find a criteria that show the performance of TRIZ.

As a conclusion, today TRIZ is usually used in Hutchinson, but not really integrated like a reflex. As I ever said each business unit is free in its own organization. So TRIZ couldn't be impose in any processus. TRIZ have to take its place progressively. It's probably the best way to change.

Another important thing, the deployment become more easily because new engineers arrive with a TRIZ sensitizing. They learned TRIZ in school and they ever show when where and how TRIZ could be used. The Communication work could be lighter and TRIZ work could progress speeder...

TRIZ experience at HUTCHINSON

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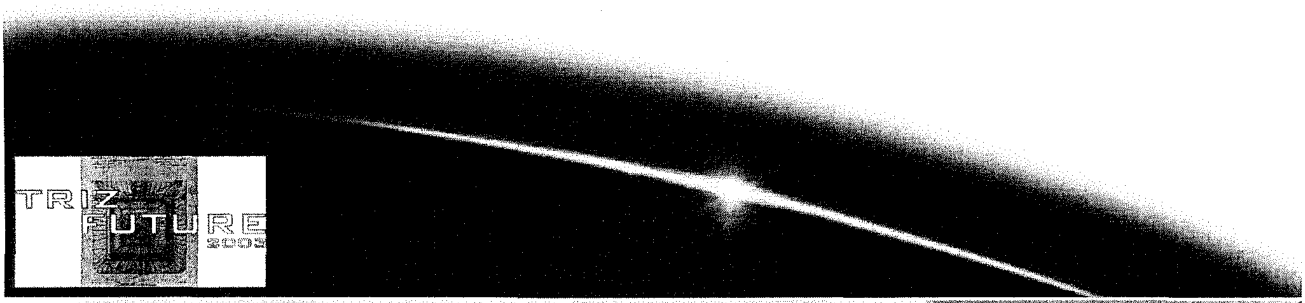
ETRIA World Conference
TRIZ FUTURE 2003
Aachen (Germany) 12th- 14th November 2003



TRIZ experience at HUTCHINSON
HUTCHINSON® WORLDWIDE

Summary

- Part 1: **HUTCHINSON Corporate Group**
- Part 2: **TRIZ discover**
- Part 3: **TRIZ experimentation**
- Part 4: **TRIZ deployment**
- Part 5: **TRIZ result**
- Part 6: **TRIZ Future**

TRIZ experience at HUTCHINSON

HUTCHINSON® WORLDWIDE

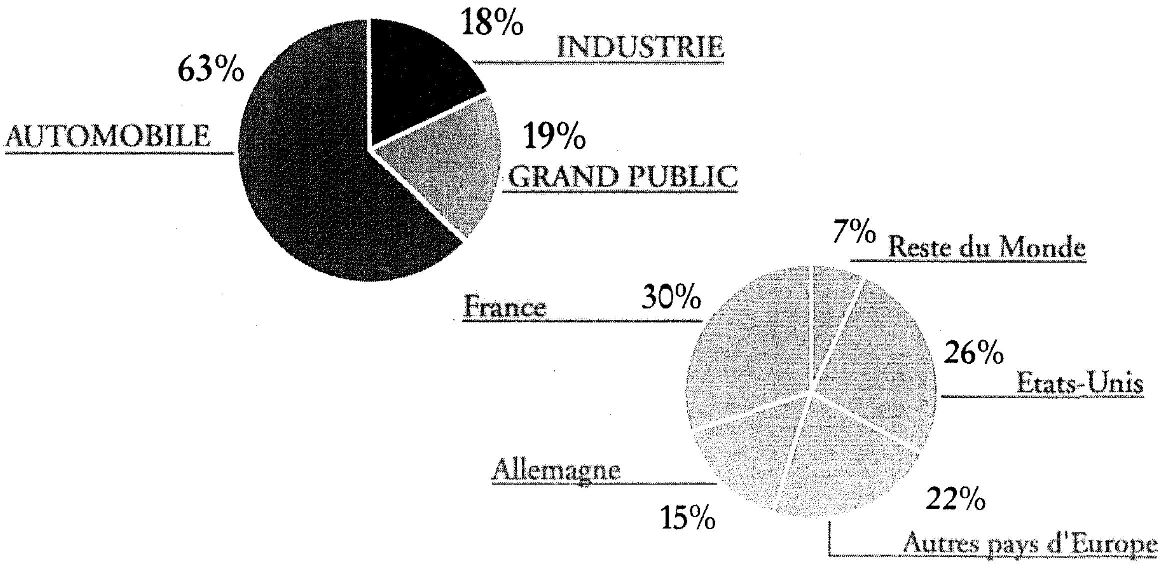
- 1853 : Hiram Hutchinson sets up production of rubber in Montargis, France, in a former royal paper mill.
- 1900 : **Hutchinson** manufactures its first products for the automobile industry. *Hutchinson have more 100 years of experience in this sector.*
- 1910 : **Hutchinson** manufactures its first products for the aircraft industry. *Hutchinson have more 90 years of experience in this sector.*
- 1974 : **TOTAL** acquires a controlling interest in **Hutchinson**.
- 2000 : Hutchinson go to **ATOFINA**, chemical parts of **TOTAL** .

TRIZ experience at HUTCHINSON

HUTCHINSON® WORLDWIDE

Turn Over

2,709 billion Euros

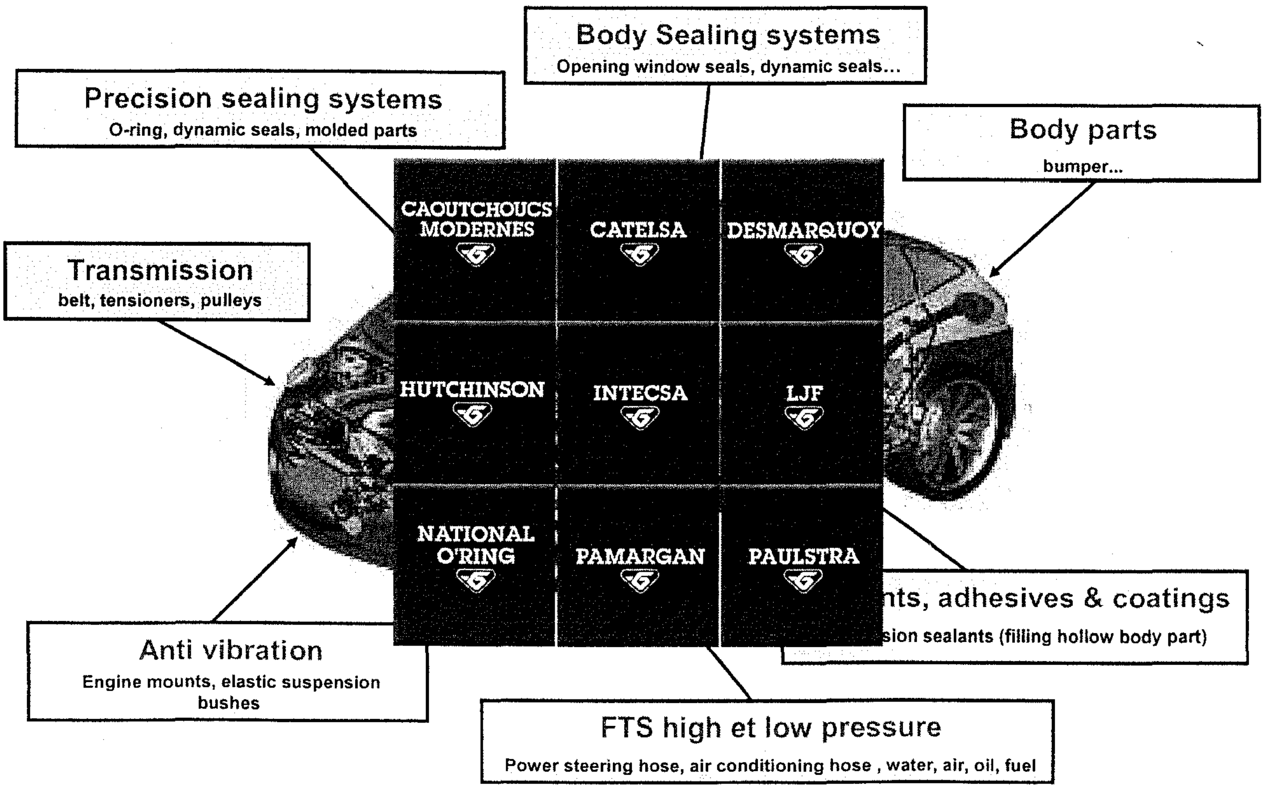


HUTCHINSON WORLDWIDE

- 24 820 employees in

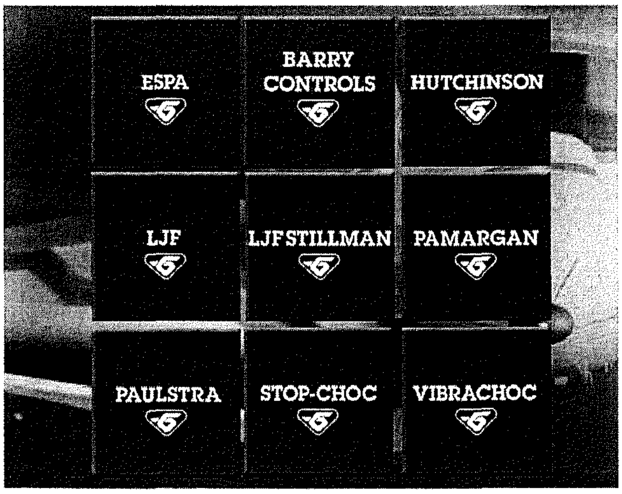
94 industrial sites
50 commercial sites
in 31 countries
on the 5 continents

HUTCHINSON WORLDWIDE



Sealants, adhesives & coatings
Sealing mastics for aircraft & for windows assemblies

Panels
Visualization panels for TGV & other



Precision sealing systems
O-ring & molded parts for aircraft industry, army, nuclear & train industry

Fluid Transfer System
Hose assemblies

Run flats and security systems
Run flats systems for blinded vehicles, equipments for navy & aircraft

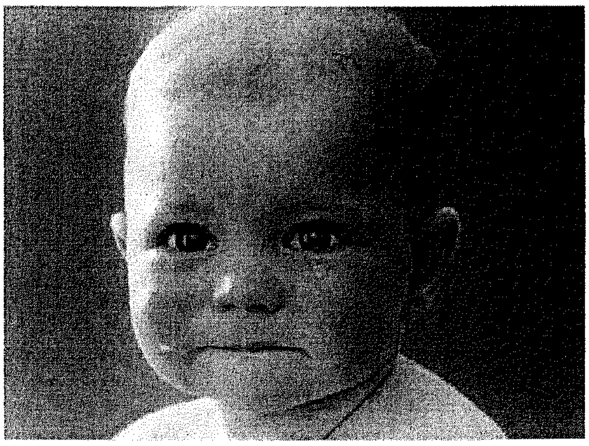
Anti vibration
Metallic & rubber shock absorbers

Health
condoms, medical articles

Hand Protection
Cleaning & industrial gloves

Hygiene
sponges, cleaning accessories

HUTCHINSON
MAPA®
Tigex



NUK®
Spontex®
söke

Hobbies
Gloves for garden

Babies
tetines, feeding-bottle, toy

Sport
Tire & air chamber for 2 wheels vehicle

Summary

- Part 1: HUTCHINSON Corporate Group
- **Part 2: TRIZ discover**
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- Part 6: TRIZ Future


VIENNE

Une méthode qui donne à penser

LYCÉE DU PORTEAU

Penser autrement

INNOVATION

La méthode TRIZ ou la créativité en fait que science exacte

Several articles talk about a new way of thinking and new thinking and theory : TRIZ


CONCEPTION

Un logiciel qui débride l'innovation

L'INNOVATION ASSISTÉE PAR ORDINATEUR

SCIENCES ET AVENIR

Machine à inventer

E&R ÉTUDES ET RAPPORTS INFORMATIQUES

Several articles talk about a software that's invent…

Summary

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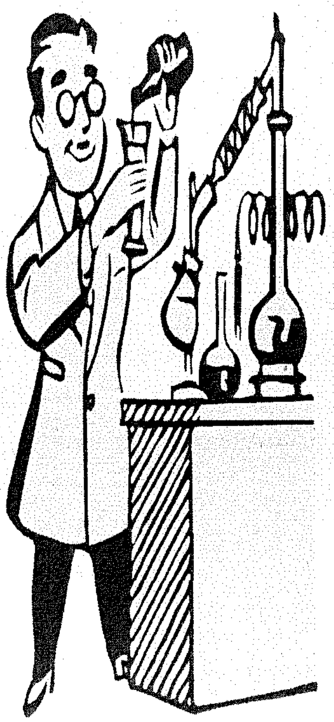
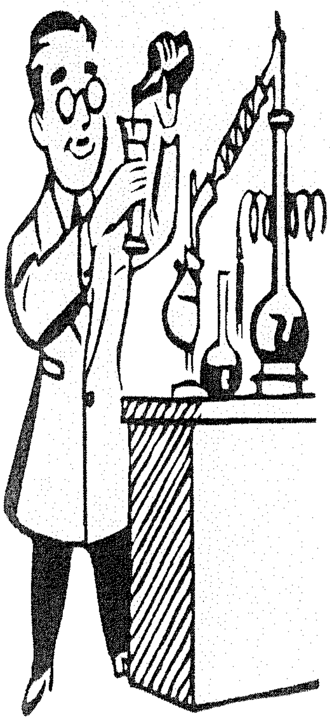
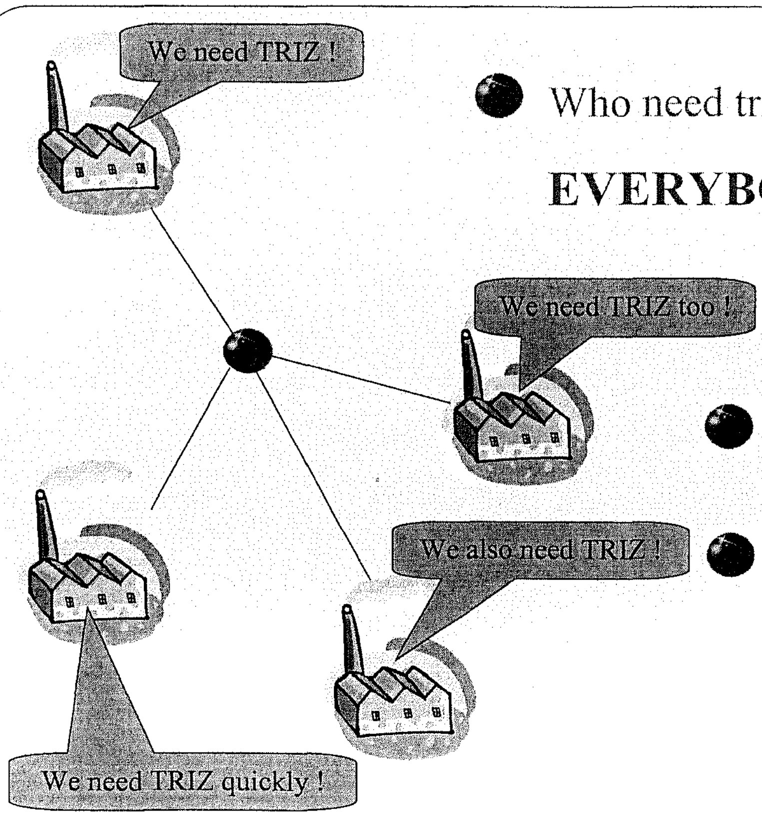


- 2 Students of INSA Strasbourg
- 4 TRIZ jobs experimentations
- Several levels : solving problem,
  prospecting,
  pure innovation



- Results : very interesting
  Applause by everybody
- TRIZ needs to be learn
- TechOptimizer don't work alone
- Necessary to define what's applicant profile? And what they need?
- How to answer to theirs needs?
- Conclusion : Hutchinson have to implement TRIZ

TRIZ experience at HUTCHINSON
HUTCHINSON WORLDWIDE



- Who need triz in HUTCHINSON?

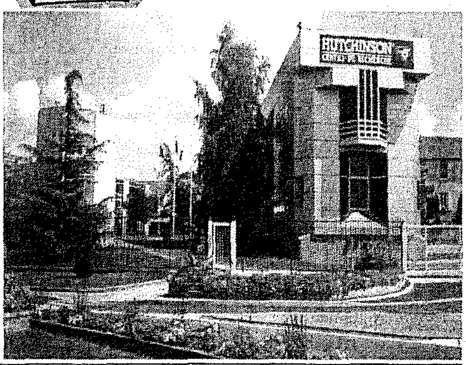
EVERYBODY

But

- not enough time to learn TRIZ
- Training cost too high

Don't need every time

Summary

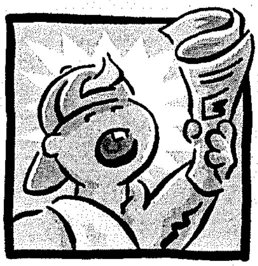


TRIZ user profile

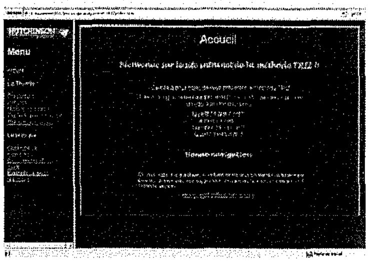
- Practice usually TRIZ
- Available
- Could centralize every knowledge about TRIZ

So TRIZ user

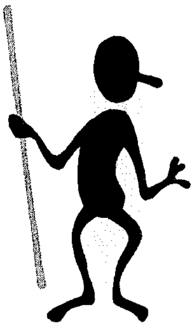
- Is one person
- Based in the Hutchinson Research Center
- Available for all Departments



Internal press



Website on the intranet server



Direct communication in each business unit

Theory course (INSA Strasbourg, ADEPA)

Practical course (Invention Machine)

Adherent of TRIZ France

member of communication workshop

Association Francophone des Utilisateurs de TRIZ

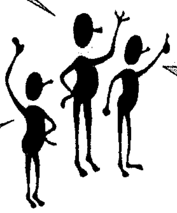
Everyone have his own attempt about TRIZ assistance.

I would like use TRIZ but, I don't have any time, I only have a problem !

Rapid Triz

with invention machine software

I have a problem that's probably need a TRIZ deployment. We have 6 month to find a solution



Paper Triz

more time, resolution team, deployment of TRIZ approach

I have a very hard problem, I ever try lot's of solutions and experts Do you know TRIZ could do anything?

Expert Triz

very hard problem that's need ARIZ, and an external expert

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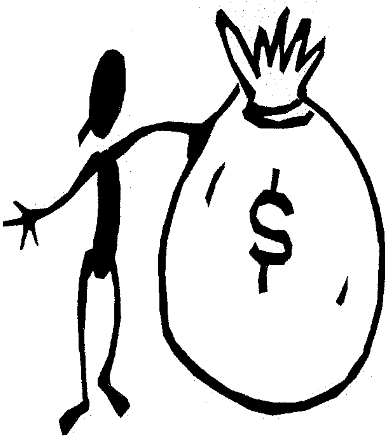
Triz Results



- 3 or 4 studies per year
- 5% of result idea = patent
- Each sector ever used TRIZ one time

Triz Future ! ?

What is the situation ?

What is the future ?

TRIZ experience at HUTCHINSON

—

ETRIA World Conference

TRIZ FUTURE 2003

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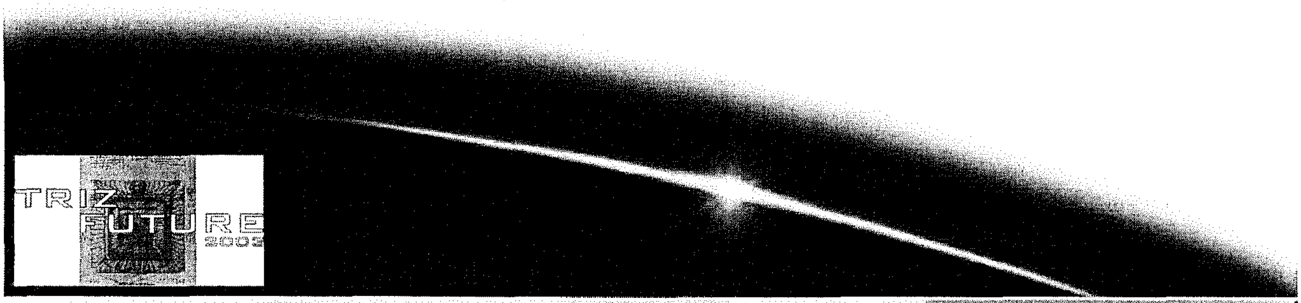
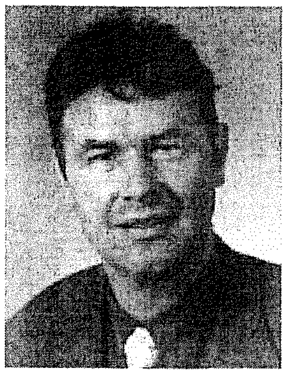


Profile of Lecturer



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Telefax:	+43 / 66477 / 1340180
E-mail:	s.luger@lugerresearch.com
URL:	http://www.lugerresearch.com

Brief Résumé & job descriptions:

1962	Date of Birth
1981	Educational attainment for Electronic Engineer at the HTL in Rankweil
1981-1996	Electronic Design Engineer in Lighting Business
1996	Project Leader for Global Research Lighting Projects
1999-2001	Product Manager Europe for Lighting Controls
2001	Educational attainment for business administration at PHW St. Gallen
2001	Foundation of LUGER RESEARCH – Innovation Consultancy
2001	Cooperation with Invention Machine Corp. for Austria
2002	Cooperation with STN-International for Austria
2002	Foundation of SPIN Network (Strategic Product Innovation Network)
2003	Publisher of the Internet TRIZ Portal www.triz-austria.com

Amendments:
- Originator of the worldwide Lighting standard DALI
- Inventor of a new helmet concept for formula 1 (lighting helmet)
- Inventor of a new watch concept for children (kidxtimer)
- holds over 20 patents

TRIZ based patent analysis for lighting electronics

oec.eng.(fh) Siegfried Luger
LUGER RESEARCH
Dornbirn, Austria

Abstract
According to the statistics by the World Intellectual Property Organisation (WIPO), the patents cover 90-95% of the worldwide research results. Efficiently used patent information would reduce 60% of research time and 40% of research costs /Lit1/. So the early recognition of patent values can be seen as an important management factor today. This study shows a TRIZ based methodology to create a patent index which was tested in the field of lighting electronics.

1. Introduction

The extraction of inventive principles out of patent analysis was started in the beginning of Altshuller's work. The result consists of invention levels, contradictions, standards, effects and trends /Lit2/. Nowadays an inverse approach could be used to answer the question of patent valuation. Patents are one of the most important sources where companies document there inventions and therefore it should be known which potential exists in one single patent or in a whole patent database of a company. Classifying these inventions with a TRIZ based methodology and establishing a patent index were the main tasks of this study.
Primary the work was focused on a structure to build up the methodology. Finally a practical application in the field of lighting electronics was used to verify the model and point out the pro and cons of this patent index tool.

2. Tools

Subsequent is a list of possible TRIZ tools which generally could be used for classifying patents /L3/:
Ideality: Is derived from the parameters useful functions, harmful functions and costs. Each technical system tries to increase the degree of ideality within its life cycle.
S-curve: The s-curve describes the performance change of a technical system over time. There are typical stages within a product life cycle.
Trends of evolution: Several different trends of technical evolution are determined for new product developments.
Contradictions and Principles: Technical and physical contradictions are main triggers for innovation. The solutions are based on 40 principles.
Substance field relationships: Optimization of substance field structures with inventive principles (standard solutions) improves systems locally.

Resources: Resources, seen as not used or not effectively used system parts, parameters or fields are highly relevant for innovation. New systems should act as resource sparing.
Space-time operator: The system operator space-time is used to structure the system over time and hierarchically and shows the product changes.

3. Tool system model

We compared the TRIZ tools with the needs of patent analyser. The following list shows the most important items to satisfy the requirements: 1. comparison to a reference patent; 2. Easy to use and business adaptable methodology; 3. Valid predictions.
Interactions between the different TRIZ tools show us patent innovation drivers and receivers. As an overall result we can observe, that the s-curve position, the innovation level, the trends of evolution and the principles are the dominant drivers (high active points), where functions are the most dominant receivers (high passive points). The evolution trend of increasing ideality is the basic law technical systems follows. The tool system model (see figure 1) combines the results into a tool dependency for generating the patent index. The analyse direction is vice versa to the innovation flow because of the fact, that we start with the global view (market and function) and condense the results until a single s-curve and its new invention.

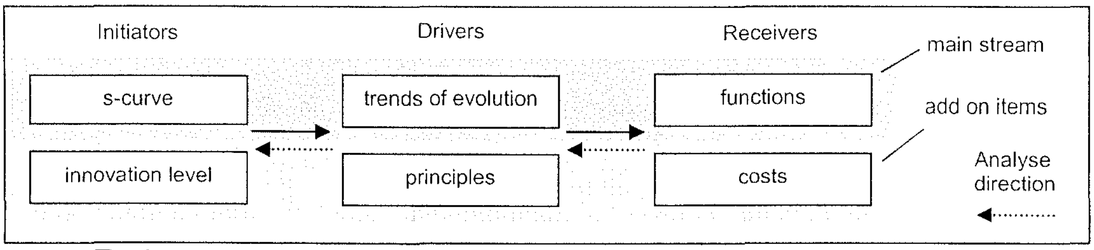


Fig. 1: Tool system model

The integrated invention quality spectrum of patent valuation /Lit4/ shows additional patent indicators as: claims (length and breadth), resources, family size, technical description, maintenance level and citations. These indicators are necessary to resume overall patent analysis but can be eliminated if we are interested in the technological value of patents. Herein an exception is the resource indicator, which is subsidiary within the trends of evolution.

The different hierarchical system levels of products require a categorization for evaluation. TRIZ offers us the system operator (9-screen view), which divides the product into three system levels: supersystem – system – subsystem.
Supersystem: the application level (interface to outside the product)
System: product level (system parts)
Subsystem: component level
To perform a patent index its necessary to define the system level first and retain this analyse view for each step within the procedure.

4. Patent Index

5.1 Methodology

Based on a patent description the keywords were extracted. Especially the differences between the reference patent and the new patent are important and should be listed. This generated list is transformed into a function list that characterizes the invention. The valuation of the function list leads to a first classification number. In a second stage the function list is measured against the trends of evolution and aggregated into the trend classification number. In a third stage the cost relation is calculated also as a relative parameter. Finally the position within the s-curve is defined and delivers the last factor to create the patent index, which is a weighted summation out of the calculated different classification numbers.

In figure 3 the theoretical model behind the patent index shows the hierarchical approach of generating the index. The overall function increase is reached from the improved system components which themselves used new trends for specific parameters. If we benchmark the parameters in depth (innovation steps), in breadth (innovation s-curve count) and in height (innovation level) we are able to recognize the influence on system components as well as on functions /Lit5/.

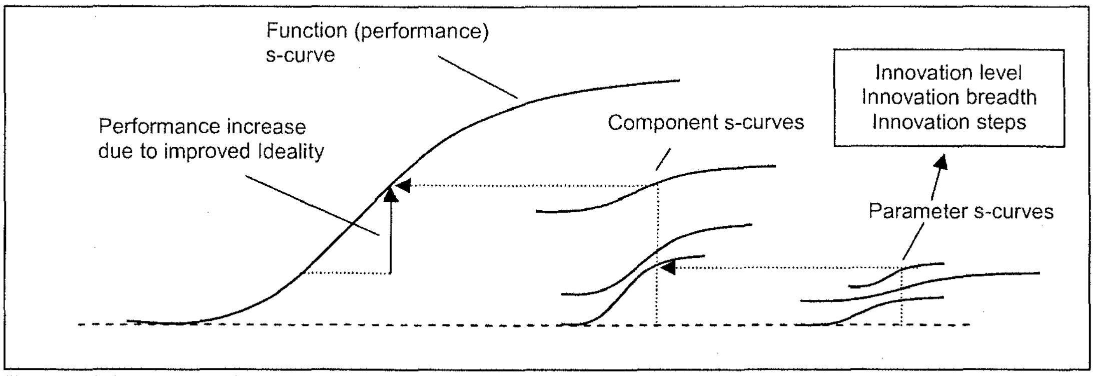


Fig. 3: Theoretical model supporting the patent index

5.2 Functions

Patent analysis showed that the description part is suitable to understand the new technology because it is a comparison to reference technologies and include application and functional statements. The list should document all changes happened against the reference, to obtain the improvements which are necessary for the function and trend valuation. Figure 4 shows a backward citation to which the new patent is referred to. The delimitations to these patents unfold the improvements of the new inventions.

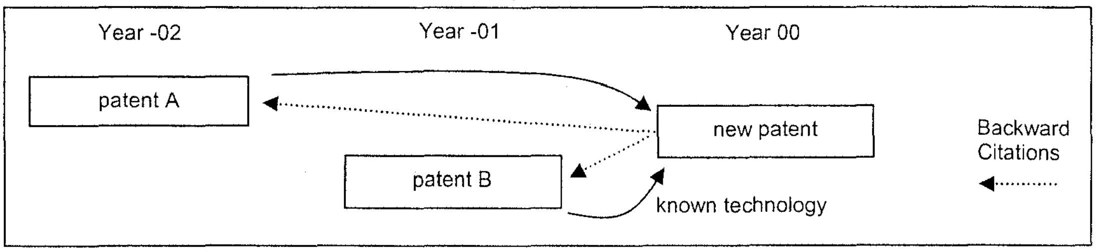


Fig. 4: Patent citations

To perform the function valuation all specific functions and parameters are listed and weighted in matters of the importance for the considered technical system. The system level defines the view to these features and limits the count of necessary items. Functions are classified as useful or harmful ones and the primary useful function is listed at the top of the keyword list. In comparison to a function model the weighted function list can be created easily and interpret the system relevance as it is from customer point of view. The valuation is made out of the knowledge about the existing system as the base line and the new patent technology where the improvements are shown within the keyword list. Looking for long term valuation the weight can be adapted out of scenario management results.

5.3 Trends and S-Curves

The evolution trend matrix is used to compare the trends of evolutions against the functions and system parts. The horizontal ranking defines the function importance where the vertical ranking indicates the trend importance of the new patent technology. Each trend is valuated for system parts in terms of innovation steps, innovation step counts and innovation levels. The innovation steps are defined as the discrete stages of each technical trend with a maximum number of possible steps. To calculate the evolution improvement we summarize the transfers to higher steps and build a relation to its maximum possible number. The evolution factor can be seen as the new relative technological patent potential and indicates the inherent chances for improvements. As shown in a research study for smart packaging the evolutionary potential plot was a suitable method to recognize the technological chances for new generation products /Lit6/. Furthermore as described in /Lit7/ the hierarchical structure of a technical system allows summarizing the evolutionary steps of system parts into an overall trend factor. The trends of evolution could be split into three areas as time, space, interfaces and are available in discrete well defined evolutionary steps /Lit8/.

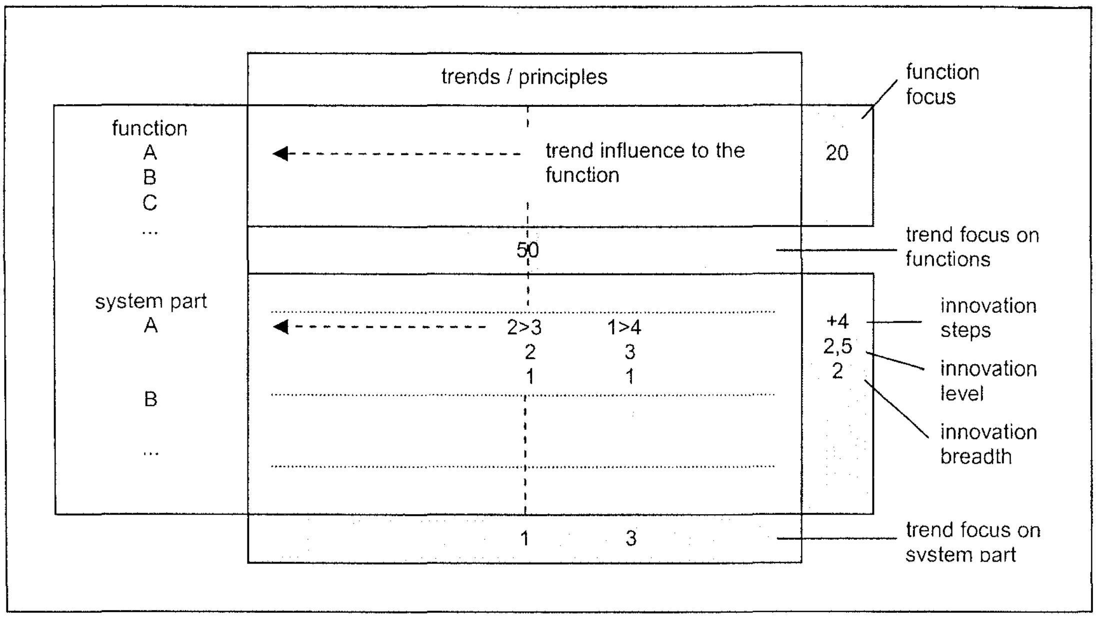


Fig. 6: Evolution trend matrix

The performance of technical systems evolve along an s-curve with distinguish stages; childhood, growth, mature state and saturation. The trend matrix shows which evolution laws where changed for the new patent technology, whereas the s-curve potential is the relation between this number and the maximum possible trends valid for a technical system.

5.6 Validation

Following the TRIZ studies made for lighting systems /Lit9/ the patent index were evaluated in field of lighting electronics. The used reference patent was highly interested because of its worldwide business success, even though a rough check would not unhide the value behind it. As documented in /Lit9/ the evolution of lighting components shows a saturation of existing systems. The need for new basic technologies and therefore new inventions should lead to new concepts following new s-curves. Especially the law of transition to the supersystem and the miniaturization are dominant founded trends which will play a relevant role within this business in the future.

The patent analysis based on the described methodology showed the following results:
1. The specific factors and rankings lead to a better understanding of the invention
2. Function, trend and s-curve consideration are necessary for an overall view
3. The breakdown structure can also clarify the main content of complex patents
4. The straight forward methodology is highly reproducible
5. The method can be implemented in standard software tools easily

5. Conclusion

TRIZ based patent analysis lead to a deeper understanding of the overall context for technology patent analysis and TRIZ tools. The calculation of different patent innovation indexes has to be verified with more specific applications to get statistical data /Lit10/. However it could be seen, that the relevance of a patent index and the possible derived cognitions are worth for further investigations.

Literature

/Lit1/ Tseng, C. H.; Tasi, C. C.: Using TRIZ for an Engineering Design Course at NCTU in Taiwan; TRIZ Journal; 2000

/Lit2/ Mann, D.; Dewulf, F.; Zlotin, B.; Zusmann, A.: Matrix 2003; Creax Press 2003

/Lit3/ Herb, R.: TRIZ, Der systematische Weg zur Innovation; MI-Verlag; 2000

/Lit4/ Winkless, B.; Cooney, J; Conner, B: Invention Quality Measurement (IQM); TRIZ Journal; 2003

/Lit5/ Mann, D.: Hands on systematic innovation; CREAX Press; 2002

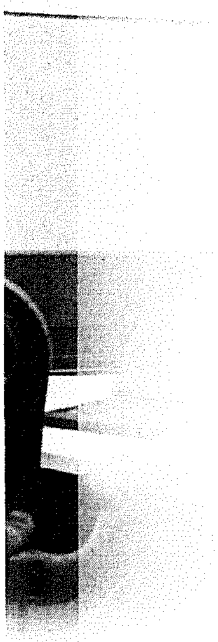
/Lit6/ Cooney, J.; Winkless, B.: Utilising TRIZ methodologies to evolve and develop next generation food packaging products; TRIZ Journal; 2003

/Lit7/ Cascini, G.; Nanni, R.; Russo, D.: TRIZ patterns of evolution as a means for supporting history of technology: analysing the Brunelleschi's dome cranes; TRIZ Journal; 2003

/Lit8/ Mann, D.: Evolutionary-Potential in technical and business systems; TRIZ Journal; 2002

/Lit9/ Luger, S.: Die Evolution von Beleuchtungssystemen; Tagungsband Licht Konferenz Maastricht; 2002

/Lit10/ Mann, D.: Updating TRIZ, 1985/2002 patent research findings; TRIZCON 2003 in Philadelphia; 2003



TRIZ based patent analysis for lighting electronics

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Aachen, 14th November, 2003

TRIZ FUTURE 2003 LUGER RESEARCH

Figure 1

Introduction

Lighting Electronics

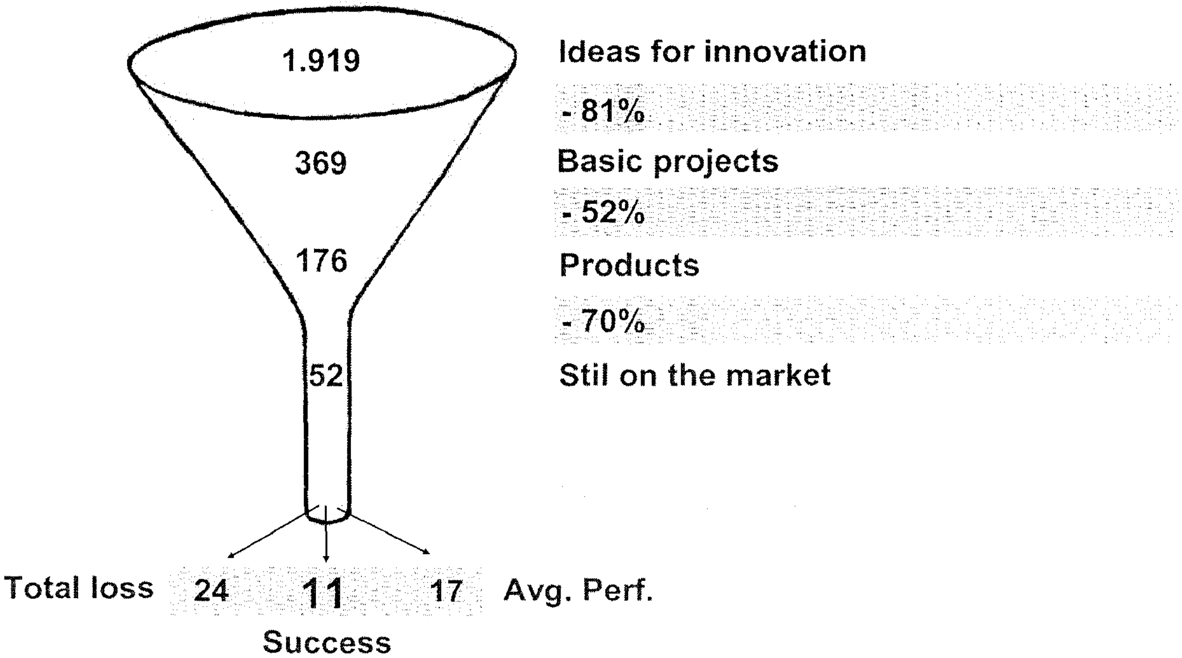
TRIZ based Methodology

Summary

TRIZ FUTURE 2003 LUGER RESEARCH

Figure 2

Just 0.6% of all ideas turn out to be successful on market



Source: Kienbaum Survey 1993

Comparative Competitive Advantage (CCA)

- **A missing CCA explains 4 out of 5 failed innovations**
- **Factors that lead to failure**

Electronic mouse trap	28%	80% without CCA
Mee too product	24%	
Technical weaknesses	15%	
Competitive weaknesses	13%	
Price deterioration on market	13%	
Problems in the environment	07%	

Source: Kienbaum Survey 1993

Patent analysis

- Recognition of promising technologies
- General technology view since patents covers 90-95% of worldwide research results
- Efficiently used patent information would reduce
  - 60% of research time
  - 40% of research cost

Source: WIPO, Tseng, C.H.

TRIZ FUTURE 2003 LUGER RESEARCH

Figure 5

Only few companies valuate their patent stock

	large companies	investors & analysts	total [%]
quantitative valuation	not normally	hardly realistic	8
qualitative valuation	not normally	important	15
need for valuation	for special tasks	great	

Source: Ernst & Young 2000

TRIZ FUTURE 2003 LUGER RESEARCH

Figure 6

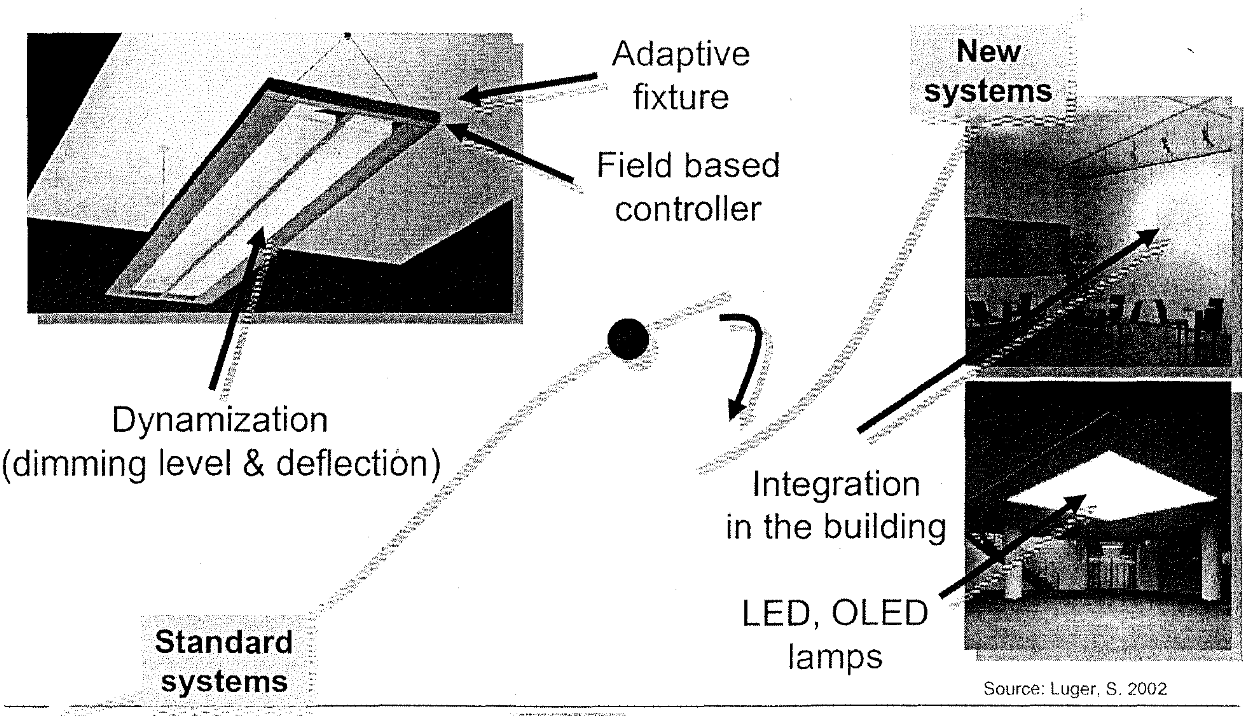
Introduction

Lighting Electronics

TRIZ based Methodology

Summary

A lot of new systems arise in the lighting industry



Source: Luger, S. 2002

Introduction

Lighting Electronics

TRIZ based Methodology

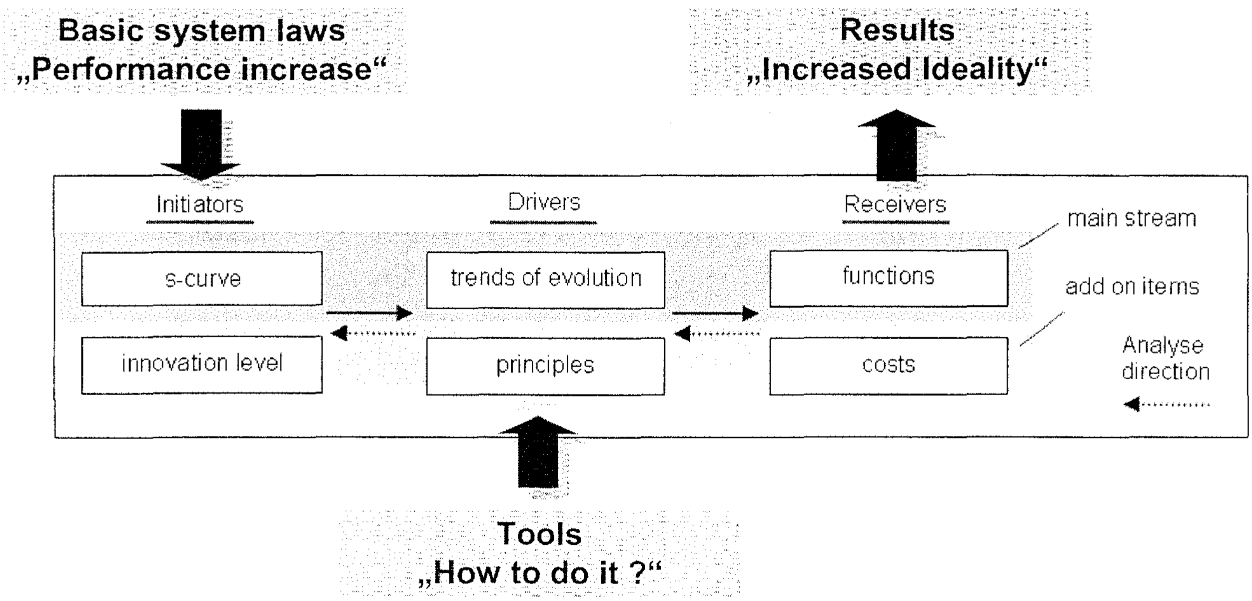
Summary

General conditions for the patent analysis tool

- **Should show a relative technology innovation index; comparison to a base line**
- **Should indicate technology & market attractiveness**
- **Should act on different hierarchical system levels**
- **Should be used as a management control tool**

Source: Luger, S.

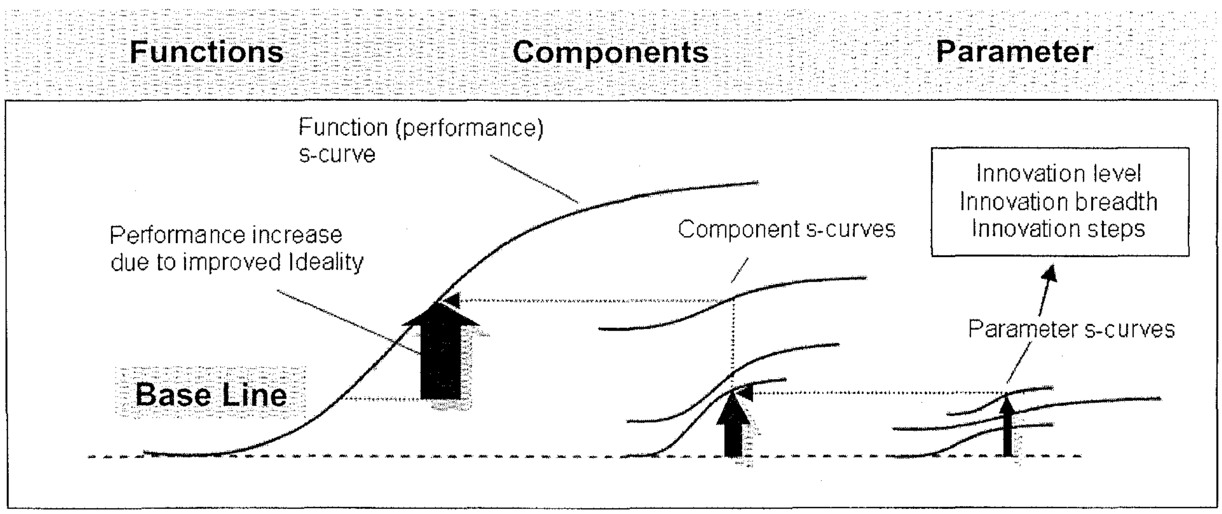
Basic model for patent assessment: tools and process



Source: Luger, S.

Figure 11

Basic model for patent assessment: s-curve dependency



Source: Luger, S.

Figure 12

Definitions and generated key values

- **Performance increase =**
  functional change (u.f. and h.f.) compared to base line
- **Innovation breadth =**
  changed trend lines / max. number of valid trend lines
- **Innovation height =**
  innovation steps / max. number innovation steps
- **Innovation level =**
  average value of all improved and valid trend lines

Source: Luger, S.

Function analysis

Strategic weight (marketing view)

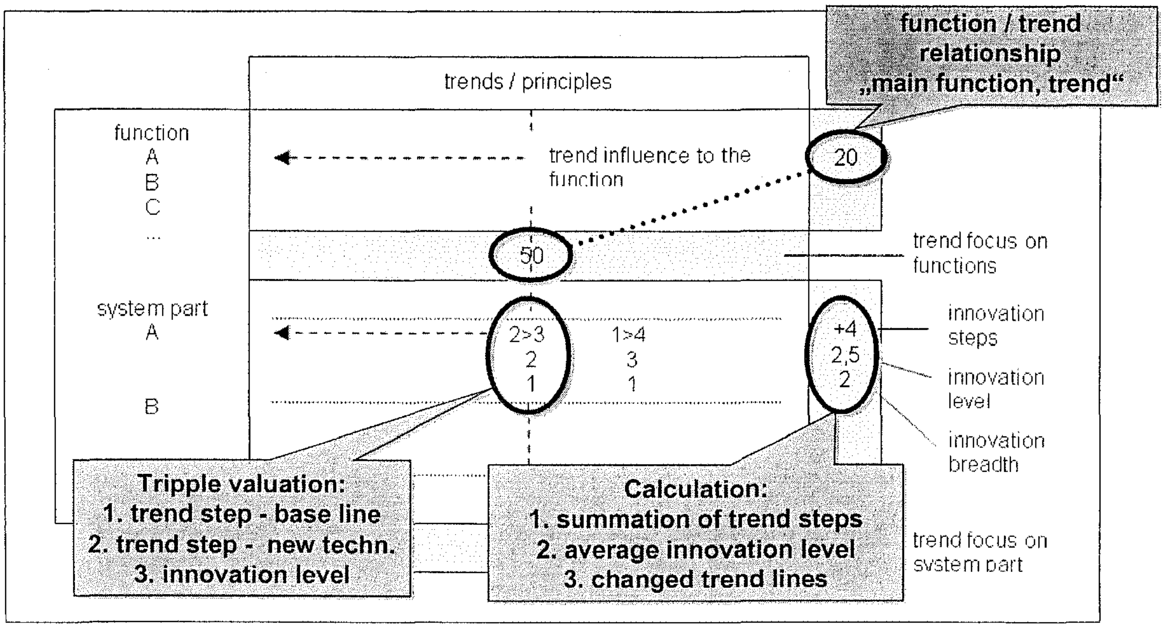
valuation / function (parameter) list	u/h	Weight	Improvement	points (w)	base line	new technology	Points
0 illuminate the room	PUF	9	-1	9	80	70	-90
1 change colour	U	9	+1	9	80	90	90
2 use in different applications	U	3	+3	9	30	70	120
3 link to central systems	U	3	+5	15	[illegible]	90	210
4 set colour independently	U	9	[illegible]	[illegible]	[illegible]	[illegible]	540
5 increase efficiency	H	1	[illegible]	[illegible]	[illegible]	[illegible]	10
6 increase information exchange with central systems	U	3	[illegible]	[illegible]	[illegible]	[illegible]	180
7 programme the setup time	U	1			50	60	10
8 address the system	U	3	+5	15	20	90	210
9 increase the information content	U	9	+3	27	20	80	540
10 combine different system modules	U	3	+5	15	10	50	120
							1940 (5200)
relative function Index (rfi) rfi = 37% uf = 5100/1930/+37,8% hf= 100/10/+10%							37 %

Performace change (in percentage)

Weighted performance increase for useful and harmful functions

Source: Luger, S.; IMC

Trend analysis based on function/trend (f/t) matrix



Source: Luger, S.

Patent assessment process

Name of file: TRIZ based patent analysis for lighting electronics - LUGER RESEARCH Copyright by LUGER RESEARCH 2003

- **Extract key word list**
- **Valuate function matrix**
- **Valuate function / trend matrix**
- **Calculate costs**
- **Calculate patent index**

Source: Luger, S.

Introduction

Lighting Electronics

TRIZ based Methodology

Summary

Summary

- The shown methodology was able to point out also "hidden" patents
- The patent – index was important to understand the worth of patents
- For an overall patent assessment the TRIZ based index can be combined with other parameters (e.g. citation counts,...)

Source: Luger, S.

"Most IP valuations lack the technical significance factor in their bottom line numbers"

Source: TAEUS 2003

Profile of Lecturer

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1975	Date of Birth
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since 2001	Scientific assistant of Fraunhofer-Institute for Production Technology

TRIZ-based Technology Intelligence

Dipl.-Ing. Markus Grawatsch
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Article 1 – Executive Summary

"The intensified technological Darwinism demands for new thinking!"

Technologies are the central and success-determining factors of every technology-oriented company. To insure a solid and sustainable technological base, that also endures fast changing market requirements, an early focus on high-potential and forward-looking technologies is advised.
TRIZ-based Technology Intelligence is a method that assists technology managers in identifying competing technologies, in order to forecast their development and to determine their potential. The development of the primarily technological but also customer-related surrounding is also taken into account to guarantee a holistic and simultaneously focused view.
To reach this objective, the Technology Intelligence method includes different tools of the TRIZ-methodology, such as the Trends of Technological Evolution, and TRIZ-related methods. These related methods include, for instance, systems theory and morphology. The different methods are combined into a four stage process. First the relevant surroundings (super- and subsystems) with the competing technologies (alternative systems) are defined. Then the main parameters and functions, that are relevant for the success of the systems, are identified. On this basis, the future of the different systems can be anticipated and their potential can be estimated. Finally, the results will be documented in a technology roadmap. The outcomes of the TRIZ-based Technology Intelligence can be used to derive the risks and probabilities of competing technologies. On this basis, the critical technologies can be further monitored or used for an individual company's strategy. Hence, existing business areas can be expanded by technological optimisations and new business areas can be build up by generating new knowledge.

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TRIZ-based Technology Intelligence

Dipl.-Ing. Markus Grawatsch
Fraunhofer Institute for Production Technology, Aachen

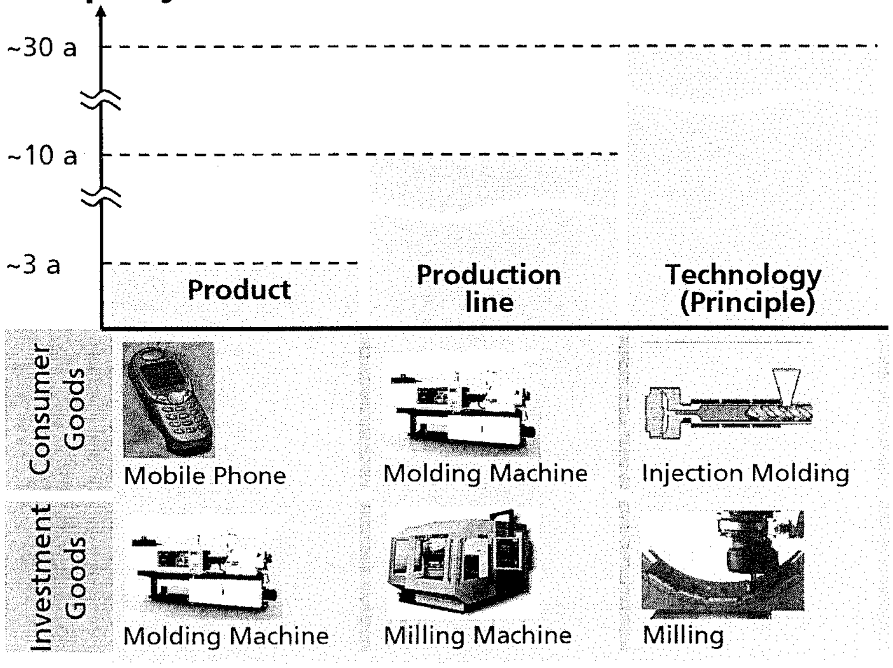
Aachen, November 14, 2003

Content of lecture

- Introduction
  - Focusing on the right technological basis in time
  - Identifying the appropriate technological basis with Technology Intelligence
- TRIZ-based Technology Intelligence
  - Basis of TRIZ-based Technology Intelligence
  - Approach to TRIZ-based Technology Intelligence
- Summary and conclusion

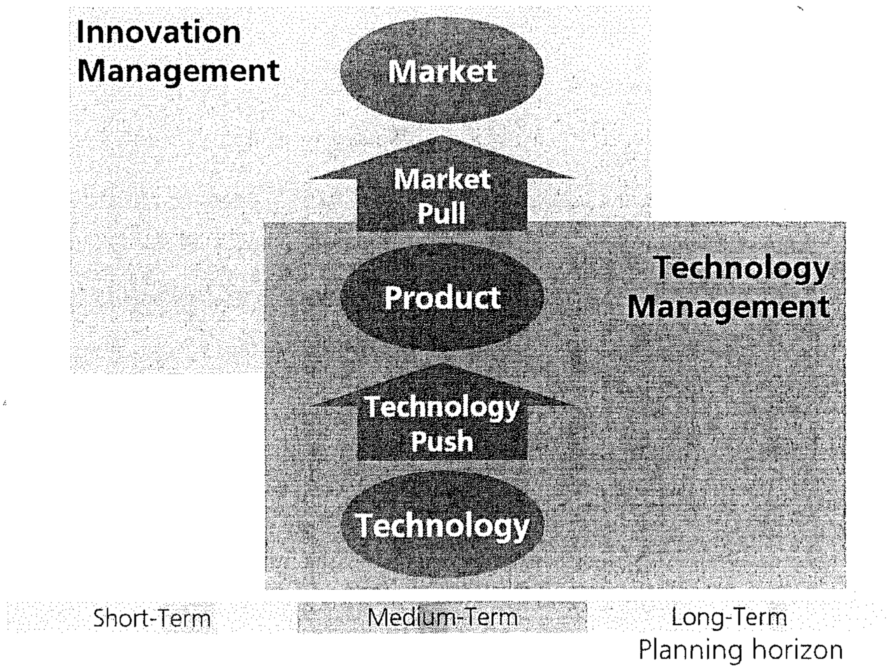
Technologies are the vital and critical resource of every Technology-oriented company

- New products come into the market at an increasing velocity.
- New products are often produced on already existing production lines.
- Production technologies have a comperative long live cycle.
- Product technologies have a comperative long live cycle.



Planning long-term corporate success with Technology Management

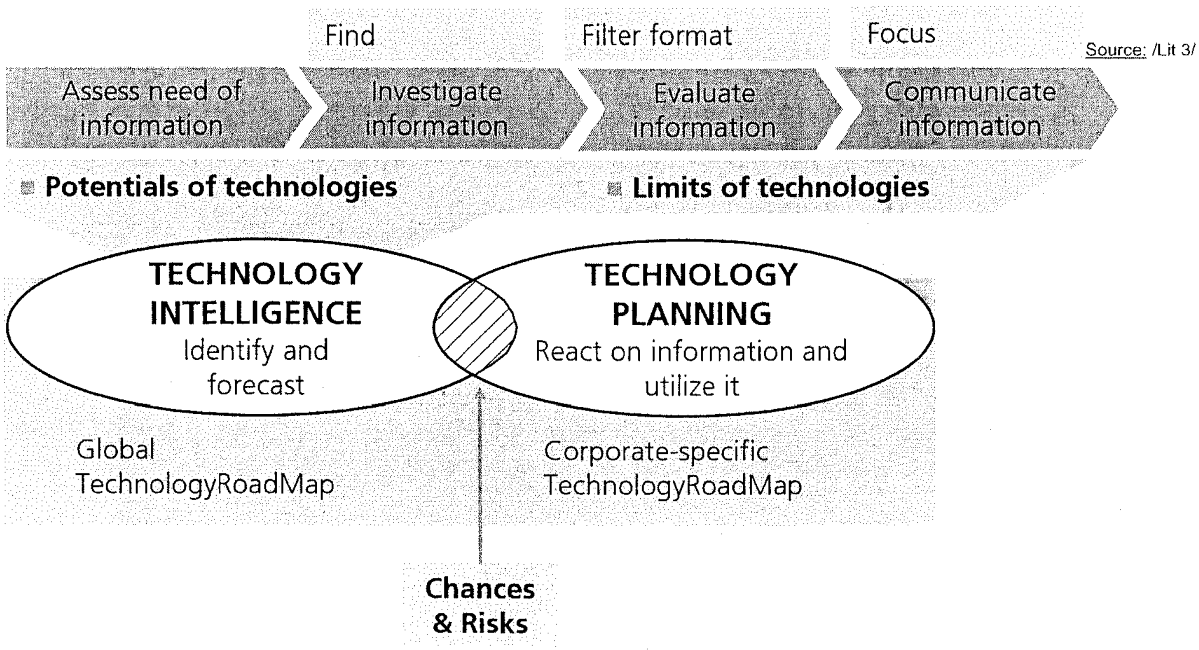
- Short-Term:
  React on precise customer requirements and short-term shifts of the markets.
- Medium-Term:
  Align product development with shifts of the markets and future market requirements.
- Long-Term:
  Establish the technological basis for lasting corporate success.



Content of lecture

- Introduction
  - Identifying the appropriate technological basis with Technology Intelligence

Technology Intelligence:
Basis for an active Technology Planning



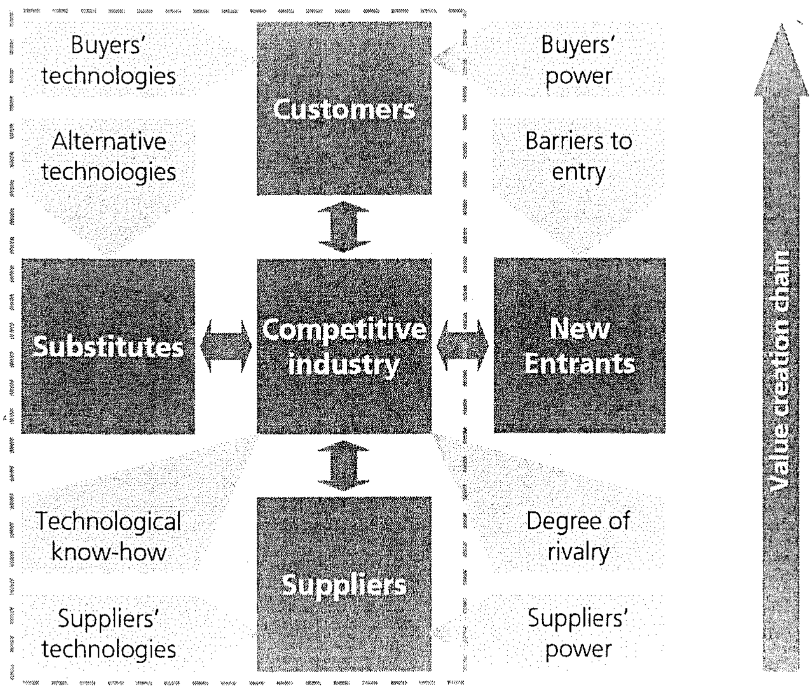
Content of lecture

- TRIZ-based Technology Intelligence
  - Basis of TRIZ-based Technology Intelligence

Framework of the TRIZ-based Technology Intelligence

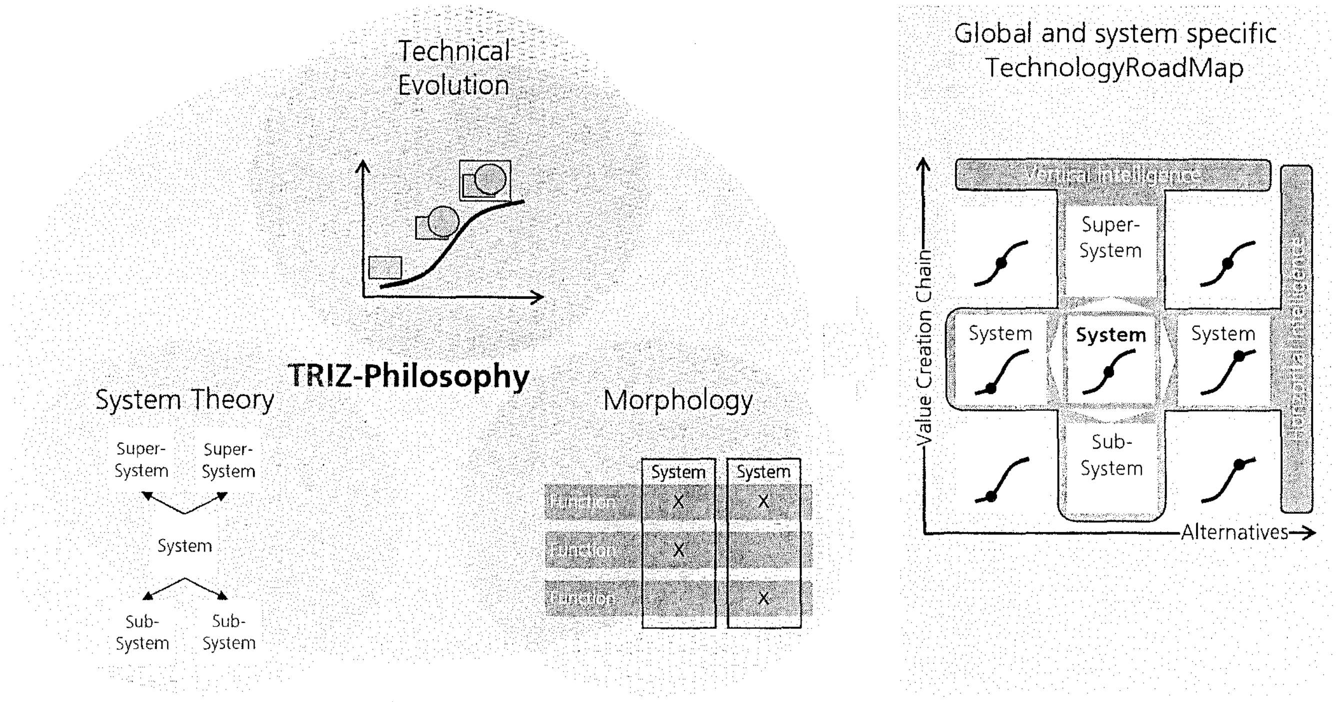
- Focus on technological aspects
  - Product technologies
  - Production technologies
  - Material technologies
  - Information technologies
- Focus on product technologies

How can the potential of product technologies, which accomplish the same primary function, be evaluated from the perspective of a technology owner?



Source: Porter: Wettbewerbsstrategie -- Porter's Five Forces

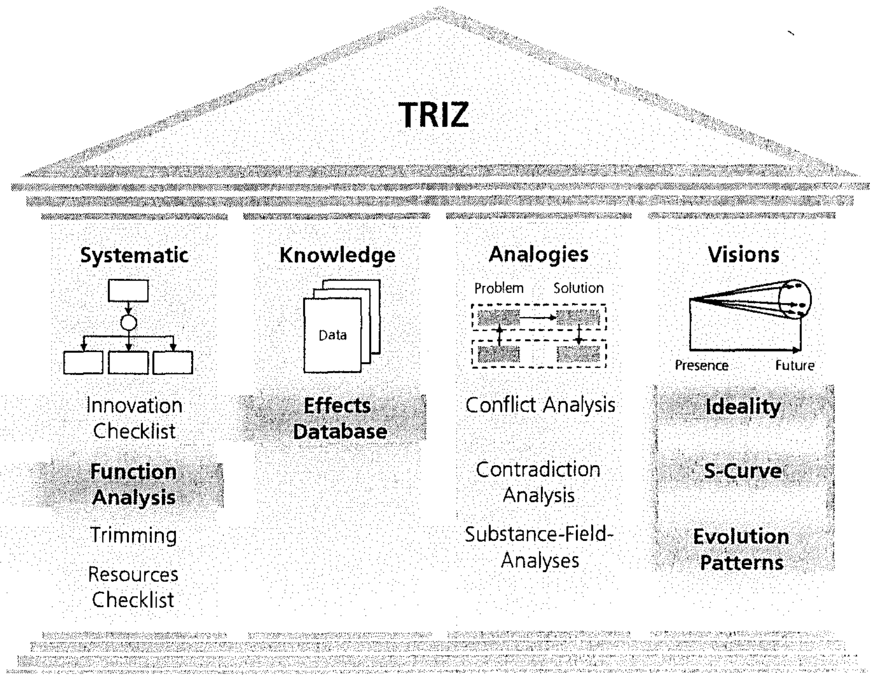
Basis of TRIZ-based Technology Intelligence



Source: /Lit 5 / Lit 6 / Lit 7 / Lit 8/

TRIZ-Tools for Technology Intelligence

- Morphology
- System Theory
- Technical Evolution



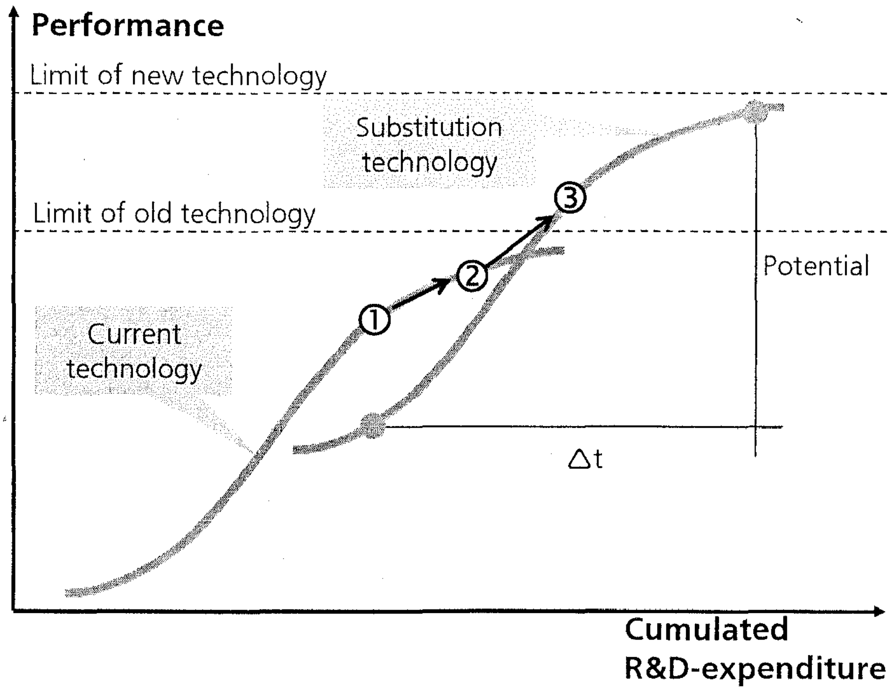
Source: /Lit 9/

Content of lecture

- TRIZ-based Technology Intelligence
  - Approach to TRIZ-based Technology Intelligence

How to assess the potential of technical systems by S-Curve Analysis

- Define current technologies
- Identify alternative technologies
- Identify origin and limits of technologies
- Draw S-curve charts
- Evaluate position
- Derive potential
- → Make decision



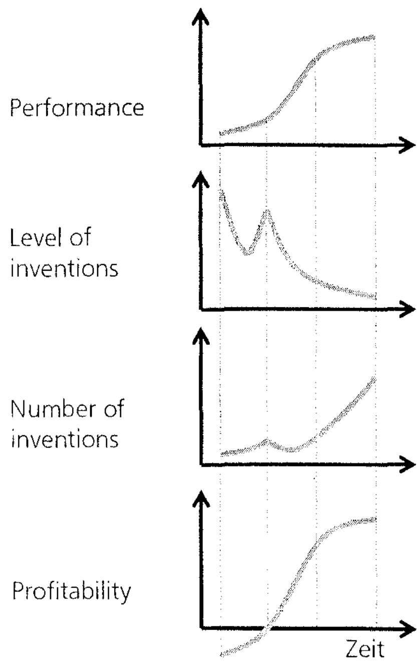
Legend:

① → ② Short-term: Technology optimization

② → ③ Long-Term: Change of technology

Source: /Lit 10/

How to define to position on the S-curve by patent analysis



The highest level of inventions always lies at the beginning of each lifecycle. Before stepping into the long run the level of invention increases.

During the transition of the system into the period of growth the number of inventions (patents) reaches a first culmination. The step-up in the phase of aging keeps the system competitive.

The success resp. the profitability of a system follows the course of the S-curve. The graph is displaced into the negative area at the beginning due to investments.

Source: /Lit 11/

Problems finding the position on the S-curve by patent analysis

Gathering of data

- Patent descriptions are encoded.
- Terms are not used precisely.
- Precise allocation of patents to technologies is complex.
- Obtaining sales data is not feasible for every technology.

Analysis of data

- Standardized definition of the amount of inventions is difficult.
- Determination of the amount of inventions for every patent is a very complex task.
- Determination of the current position on the S-curve and of the technological limits can only be done qualitative.

Methods of resolution when positioning on the S-curve

Positioning utilizing additional information
Source: /Lit 12 / Lit 13 / Lit 14 / Lit 15

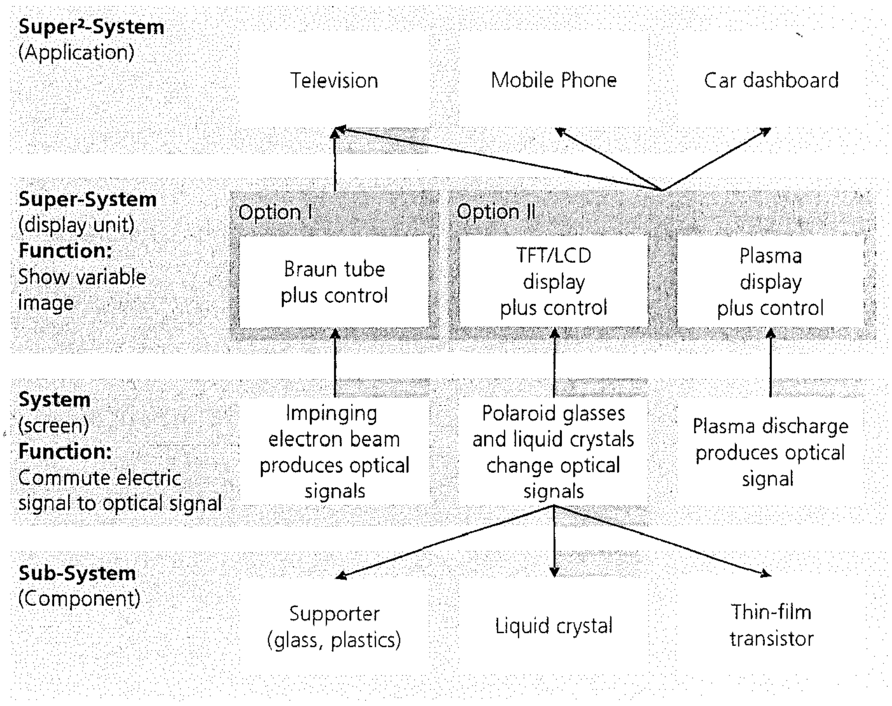
- Identify the date of first patent application.
- Identify the date of market entry.
- Determine date of significant patent applications and technological breakthroughs.
- Draw S-curves incl. technological limits for individual parameters.
- Determine sales volume indirectly.
- Deduce focus of patent application over course of time,
  e.g. - Increase of performance,
  - Increase of efficiency,
  - Cost reduction.

Alternative/ supplementary proceedings

- Analyse system environment and alternative technologies.
- Derive long-term development targets.
- Anticipate future of systems through evolutionary patterns.
- Anticipate potentials of systems.

Analysing system environment and alternative technologies

- Align super- and subsystems along value added chain (supplier and customer)
- Identify alternative systems via main function (competitive product)
- Develop relationships between systems (components)



Deriving long-term development targets

Modelling the ideal system from the perspective of a super-system

- What does the ideal system look like from a super-system's perspective?
- What are useful functions?
- What are harmful functions?
- Which characteristics of which parameters are ideal for the super-system?

Defining important parameters and auxiliary functions

- Which important and therefore success determing parameters and auxiliary functions can be derived?

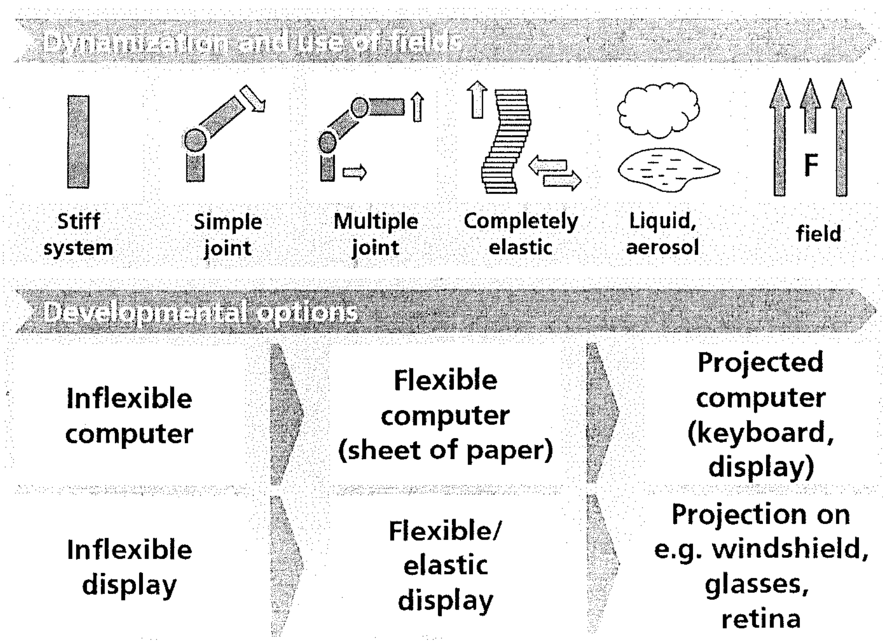
Deriving the potential

- Which technology has the greatest potential in fulfilling these parameters or auxiliary functions?
- In what time can the full potential be utilized?

Anticipating the future of systems via evolutionary patterns

- Deduction of development directions of super- and sub-systems
- Analysis of the development potential of systems
- Finding of ideas in order to derive future development projects

Example:



Source: TechOptimizer Software

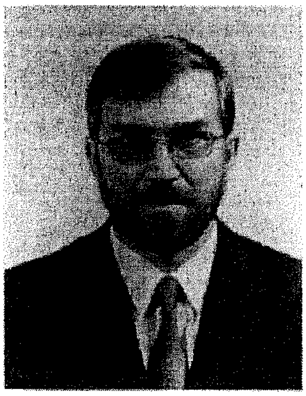
Content of lecture

- Summary and conclusion

Summary and conclusion

- Provide the technological basis in time in order to secure lasting corporate success.
- React on fast changing market requirements from this basis.
- Identify promising technologies via Technology Intelligence.
- Utilize TRIZ as a tool for technology intelligence:
  - Define framework for examination (Function Analysis; 9-Windows)
  - Identify alternative technologies (Effects database; construction catalog)
  - Define long-term development targets (Ideality)
  - Anticipate development directions (Evolutionary patterns)
- Derive potentials, document results, communicate findings

Profile of Lecturer



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Brief Résumé & job descriptions:

1954	Date of Birth
1977	Mechanical Engineer diploma from Melitopol Agricultural Institute (Ukraine)
1986	PhD. in Engineering at the SPA "Belselkhozmekhanizatsia" (Belarus)
1980-1992	Junior researcher, researcher, senior researcher at the SPA "Belselkhozmekhanizatsia"
1992-1994	Deputy Director of the small enterprise "Kantekst".
1995-1999	Professional TRIZ developer in the capacity of a senior researcher for the Invention Machine Laboratory (IMLab).
since 2000	TRIZ Expert in LG Electronics, (LG PRC)

Peculiarities of structural and functional analysis of forecasted engineering systems

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Introduction

Traditional prognosis is usually aimed at determining quantitative changes in TS evolution and technical parameters (productivity, power, weight, etc.), which are expected in 5, 10 or 15 years. Long-range prognosis in TRIZ, as distinct from traditional methods, is aimed at determining the principle of action, functions and composition of a new generation of forecasted machines. A prognostic project includes a preparatory, informational, analytical, solving, conceptual, verification, introduction and after-prognosis stages. The article is devoted to the peculiar features and structural analysis of a forecasted TS carried out at the analytical stage. The examples given in the articles are taken from the prognostic project concerning grain production, grain-harvesting combines and striping devices.

Selection of objects of analysis in prognostic projects

The first difficulty related to the analytical forecast stage is selection of objects of analysis. Selection of a modern prototype does not cause any problems - a customer wants to carry out an analysis of a certain project. But forecasting also includes analysis of the previous generations of technical predecessors of a modern TS. There may be tens and hundreds of such predecessors so it is not clear which one is suitable for this kind of analysis.

Several different variants are possible in this case.

1. Somebody has already made a retrospective analysis and the information stage resulted in obtaining information about the device generations that preceded the appearance of the forecasted devices. Then it only remains to select a characteristic prototype from each generation – TS1, TS2, TS3, etc.
2. Literature provides information about one or two generations and the researcher has to study the rest and to choose a prototype by himself.
3 The researcher has not managed to find a systematic analysis of generations or the found information does not reflect the specific interests of the researcher. In this case, the researcher should identify by himself both the generation and the prototype of analysis.

TRIZ definition of a new generation of TS is as follows: a new generation of TS solves the key contradictions that occur and are aggravated in the course of TS perfection and hamper further evolution of TS.

The generations of a forecasted TS are identified by carrying out a historical analysis of preceding machines and tools, their functional differences and functional novelty being analyzed in the first instance. The historical analysis is a labor-consuming part of a prognostic project, but it results in the identification of TS generations and selection of a prototype for the analysis. The most characteristic prototypes - TS1, TS2, etc. are selected for analysis, but in this case selection mostly depends on the availability of information on a prototype.

Table. The generations of grain-harvesting tools and machines revealed in the course of the historical analysis of the grain-harvesting combine evolution.

№	Machine, tool	Place and time of development	New function	Developed prototype
1	Sickle for mowing; Animals for thrashing; Fork for separation; Bowls (+wind) for cleaning	Ancient Egypt 2-3 thousand years before Christ	Hand-labor	Sickle, fork, bowls
2	Reaper for stripping; Thrashel for thrashing; Fork for separation; Spade for cleaning	Roman Empire, Gaul 1-2nd century of our era	Using force of animals for stripping	Gallic reaper
3	Scythe for mowing; Thrashel for thrashing; Fork for separation; Spade for winnowing away	Mediaeval Europe 12-16th centuries	Separation of mowing and binding	Scythe, thrashel, fork, spade
4	Horse-drawn reaper; Horse-powered thrasher; Winnowing machine with a ventilator	Europe 18th century	Using animals for mowing and thrashing	«McCormick» reaper, thrasher, winnowing machine
5	Stripping harvester	Australia 1885	Stripping is combined with grain thrashing and cleaning	"Sunshine" stripper H. V. MC Kay
6	Horse-drawn combine	America 1836	Mowing, thrashing and cleaning in the field	«Californian» combine
7	Tractor-drawn combine, 1st generation	America 1930	Using a mechanical engine	S-1, USSR

8	Self-propelled combine 2nd generation	Canada, Massey Ferguson, 1953	Combined controlled by a single man	SK-3, USSR
9	Self-propelled combine 3rd generation	USSR 1969	Cabin for driver protection	SKD-5, «Sibiryak»
10	Self-propelled combine 4th generation	USA 1985	Hydraulic drive of mover	Don-1500, USSR
11	Self-propelled combine, 5th generation	Forecast	Forecast	Forecast

For instance, in the prognostic project concerning the grain production technology and grain-harvesting combines, the historic analysis revealed the following generations of machines, tools and prototypes for analysis.

Peculiarities of structural and functional analysis of prototypes

The methods of the structural and functional analysis of a prototype in the historical analysis were described in detail in the article «Historical analysis of engineering systems in prognostic project" **/Lit1/**. Therefore let us only dwell on the three main peculiarities of such analysis.

The first one consists in that the analysis includes the analysis of effect of a supersystem that caused TS change. The supersystem analysis (we also call it the analysis of casual chains) at the moment of creation of a new generation of TS includes:

- Analysis of historical conditions;
- Analysis of socioeconomic conditions;
- Analysis of available resources (knowledge, technologies, materials);
- Comparative analysis of TS with TS of a preceding generation.

The second peculiarity of the prognostic analysis is that it is aimed at revealing not only new functions, but also the functions lost in the process of evolution. It often happens that not only harmful, but also useful functions are lost during evolution. At a given historical stage, a supersystem is just unable to perform of a needed function because of the lack of knowledge, technology and materials. Information about the functions lost during evolution will be necessary at a subsequent, conceptual stage for the formation of a functionally ideal scheme and an operational functional scheme of a forecasted TS of a new generation.

The third peculiarity is that the main object of analysis is not so much the main structural elements and basic functions as additional and auxiliary ones. During evolution, TS «overgrows» with additional and auxiliary subsystems. In the structural and functional analysis, it is necessary to identify these new subsystems and to trace changes occurring in existing systems. This information serves to analyze and build the evolution trends of a forecasted TS and its subsystems.

Presentation of analysis results

By carrying out the structural and functional analysis of selected prototypes we obtain a large volume of information. This concerns first of all the description of changes occurring in the subsystems of a forecasted TS. Not to be drowned in these seas of information and to efficiently use it, we present this information in the form of prognostic maps and transformation trees. To construct a tree, we employ the known TRIZ method based on the laws and trends of technical systems evolution. The methods of constructing such maps and trees is described in a series of articles **/Lit2/Lit3/**, so we are going to dwell here only on the peculiarities connected with prognostic research, structural and functional analysis.

While analyzing TS, we proceed from the particular to the general, from specific elements of function carriers to a function and principle of action. Then, while solving a prognostic problem of synthesis of a future TS of a new generation, we create its optimal composition based on the principal of action and functions to be performed by a future machine. That is why functional approach is so important for prognosis. When analyzing TS prototypes, we consider them as a rationally organized structure that performs a predetermined function. For instance, when considering harvesting tools and machines, we build a functional model – a tree of functions performed by these tools and machines. Each new generation of machines adds changes to the tree of functions. New functions appear, some old functions are lost, part of them transforms, changes, leaving only basic functions unchanged. For instance, when transferring from a horse-drawn combine to a tractor-drawn combine, the horse control function transforms into the tractor control function.

When transferring from a pull-type combine to a self-propelled one, the function of the combine propulsion by a tractor disappears and the function of combine propulsion control occurs. The basic functions, such as, for instance, to mow a plant, to thrash a plant remain unchanged. The constructed functional trees for each prototype of TS are analyzed for new and lost functions and a list of new and useful functions is compiled. At the same time we make a list of TS evolution contradictions. Unsolved contradictions tend to aggravate with each new generation of machines. For instance, contradictions between the combine capacity, its mass and pressure on soil, hopper volume and the time needed for discharge has become critical in modern combines and require fast solving. At a subsequent stage, we employ this information for the synthesis of a new machine, a new combine.

Conclusions

The purpose of TRIZ-prognosis is determining the principal of action, function and composition of a new generation of a forecasted machine. The experience proves that the functional approach is the most efficient in the context of development of optimal prognostic solutions for complex technical systems. In the functional and structural analysis of evolution, it is necessary to trace the changes in the subsystem requirements and changes in TS functions when transferring from one generation of a machine to another. For a more efficient use of information, the analysis results are presented in the form functional trees and transformational trees of subsystems.

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Peculiarities of structural and functional analysis of forecasted engineering systems.

Peter Chuksin,
TRIZ Expert

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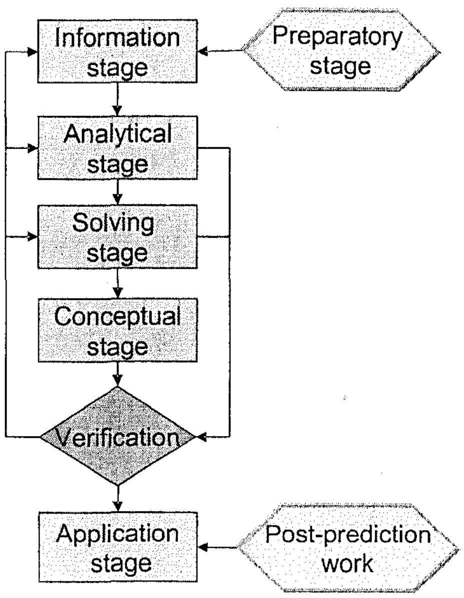
Aachen, November 14, 2003

Structural and functional analysis of forecasted system

Flowchart for TRIZ-forecast



Analytical stage in forecast project.

multi-screen analysis of forecasted system (FS)
analysis of FS resources;
analysis of FS models:

- structural model of FS;
- functional model of FS;
- parametrical model of FS;
- historical model of FS;
- contradiction models of FS;

trends of FS evolution.

Results of stage:

- super-system analysis;
- resources analysis;
- set of FS models;
- functional tree;
- trends of evolution tree;

Source:

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1972 - 1977	Researcher at 'Systems Development Laboratory, Hitachi, Ltd. '
	: Software engineering for making compilers
1977 - 1981	Researcher at 'the Tokyo Metropolitan Institute of Medical Science'
	: Artificial intelligence systems for medical decision making
1981 - 1986	IT Consultant at 'Ishida Information Processing Consulting Office'
1986 - 1991	Systems Engineer at 'Kure Computing Center'
1991 - 1999	IT Consultant at 'Business Solution Systems Division, Hitachi, Ltd.'
	: Software engineering and Systems engineering
since 1999	Department Manager of Planning Department at 'Business Solution Systems Division, Hitachi, Ltd.'
	: New business solutions development

Using TRIZ to Create Innovative Business Models and Products

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Abstract:

Most companies have many subjects around their business, and wish fast and effective solutions with new information technology. In other words, companies and their clients want innovative and impressive business solutions, to overcome severe business environment. We tried to use 40 Inventive Principles and a Contradiction matrix of 'invention methodology TRIZ', to create innovative business models and products. In this paper, we presented the methodology in 2 phases.
In the first phase, we defined essential subjects and contradictions on business, and made a „Business idea database" using TRIZ. In the situation, we defined a „business / products strategy classification" and an „information technology classification" which represented current and future business and technology. We changed mechanical concepts into business concepts and vice versa in this phase.
In the second phase, we proposed a process of conceiving innovative business models and products, using the „Business idea database" made in the first phase. Besides, we presented an example of application. At last, we evaluated this methodology, using real business models and innovative products.
As a result, it was found that TRIZ could be effective for systematic business solutions development.

Introduction

We thought that advanced business models and products could resolve contradictions in business. Recently, we found that similar solutions such as ‚distribution systems' were used in robotics and business systems. We thought that it might be possible to change business strategy or to create innovative business models and products with mechanical problem solving way. So, we decided to conceive business models / products using the 40 invention principle and the contradiction matrix with 39 parameters.
We argued about our methodology in following two steps(figure 2).
(1) We customized the contradiction matrix of TRIZ considering present business environment and information technology, and made a „Business idea database".
(2) We introduced a process of conceiving business models and products using the „Business idea database", and applied it to a concrete example.
The methodology was evaluated by applying to advanced business models and products.

Making a „Business idea database"

To change business models or strategies in a company is not small improvement but reengineering from the bottom. Competent technologies are also important to realize business ideas. So, we defined a „business / products strategy classification", and an „information technology classification" with catching notion of actual business(figure 3).

Definition of a „business / products strategy classification":
From our experiences of business systems construction, we defined common strategy classification, including following three elements.
(1) Expand business / products' functions: In the case of business, it includes amalgamation, cooperation with the other company, advance to new business, etc. In the case of products, it includes addition of new functions.
(2) Concentrate business / products' functions: Narrowing down of business field or product's function according to selection and concentration, withdrawal from unprofitable operations, deletion of an unnecessary function, etc. is included.
(3) Change business process / products' structure: In the case of business, it includes business process reengineering by improvement of internal business process and cooperation with other companies such as global business deployment. In the case of products, it includes change of mechanisms to realize functions.
They are not exclusive. For example, when we want to advance to a new field, concentrate power there and reform a business process, our strategy may be a combination of (1)(2)(3).

Definition of an „information technology classification":
Information technologies have had big influences on the latest business. The following three elements were selected in consideration of what kind of subject has so far been solved by information technology.
(1) Reduce time or space: Technologies of network, throughput of hardware, and technologies of broadcast are included.
(2) Change media of information: Technologies of multimedia are included.
(3) Distribute or integrate information systems: Technologies to integrate information systems.

Making a „Business idea database":
In order to conceive business models or products, we made a „Business idea database" according to a next process(figure 4).
(1) For each business / products strategy, contradictions generated by essential subjects were taken out. At that time, the contradiction matrix was applied to them, the principles of invention were taken out.
(2) On the other hand, the principles of invention were translated to the words of business. We called them ‚patterns of business idea'.
(3) We applied patterns of business idea to taken out principles of invention and made a „Business idea database".

For each business / products strategy, we extracted expected improving points and degrading points(figure 5). For ‚Expand business / products' functions', we took out two improving points ‚Correspond strongly to a pressure from outside' and ‚Promote business strongly towards

outside'. At the same time, we took out two degrading points ‚An organization becomes big' and ‚Useless tasks increase'. Similarly, for ‚Concentrate business / products' functions', we took out three improving points and two degrading points, and for ‚Change business process / products' structure' we took out six improving points and two degrading points.
Next, we chose parameters of TRIZ corresponding to these points. For example, for ‚Correspond strongly to a pressure from outside' we chose ‚Tension, Pressure', and for ‚An organization becomes big' we chose ‚Volume of moving object'.

Figure 6 shows part of principles of invention taken out for every combination of improvement parameters and degradation parameters. We wanted to connect them with the idea of business. Mechanical words used in TRIZ were translated to the business words by the following methods.

In order to apply principles of invention taken out from the contradiction matrix to business models or products, we translated them into words of business. We called the result ‚patterns of business idea'. Each pattern was correspond to each principle of invention. Moreover, we added information technology classification elements that could be used to realize each pattern. For example, a principle of invention ‚Universality' was translated to ‚Abstract, standardize and reuse functions' and as realization technology ‚Distribution and integration of information systems' was selected.
Part of obtained patterns of business idea is shown in figure 7. Although these are primitive interpretation of principles of invention, they can be changed with social environment and technical trend.

We applied patterns of business idea to principles of invention, reconstructed and made „Business idea database" (figure 8). We can conceive new business models or products using this database. At that time, it is necessary to consider strategies and environmental conditions of each company.

Process of conceiving business models or products

In this phase, we will show a process that makes advanced business models or products by potential needs of clients using a „Business idea database" (figure 9).

Overview of the process:
The first step of the process is gathering information about business strategies of a company and customers' environment. Information about a company's core technology and allied products is also needed.
In the second step, business ideas are taken out from the „Business idea database", and several candidates of business models or products are created from them.
In the third step, these candidates are evaluated, and the best one is selected. Finally, appeal points of the selected business model or product is clarified, going back to original subjects, solutions, and improving points.

How to evaluate business models or products:
When business models or products are conceived, environment that surrounds a company, actual condition of business and more detailed request of market and customers are investigated. We need to evaluate whether the company can capture value from conceived business models or products. We introduced evaluation criteria that combine five forces (Rivalry, New entrants, Substitute products, Customer power, Supplier power) that influence on value capturing, and requirements for sustainable advantages (Scarce, Hard to transfer, Hard to imitate, Hard to identify, Durable, Hard to substitute) /LIT 1/(Figure 10).

Example of application

We tried to apply the process to a new business model creation in a virtual company that holds following subjects (figure 11).
[‚Company X' is developing and selling products for consumers and companies. It wants to make a new business model like Internet-commerce, for the increase in sales, and improvement in profit. In this case, what kind of business model for what kind of products should be made?]

At first, we considered a rough strategy, then, chose business / products strategy elements and expected improving points. These were selected strategy elements.
(1) By expanding business, it promotes business strongly towards outside.
(2) By changing a business process, it accelerates business.
(3) By changing a business process, it simplifies structure of works and reduces useless works and costs.
On the other hand, we selected core technologies could be used and corresponding technology classification elements.
(1) Internet: Reduction of time and space
(2) Accumulation and distribution of digital data such as image and sound: Medium change of information

We took out business ideas from the „Business idea database" using strategy classification elements, expected improving points and technology classification elements. Figure 12 shows business ideas for a strategy ‚By expanding business, it promotes business strongly toward outside'.
By arranging taken out business ideas, we selected next 6 ideas.
(1) Change a form of products, an accumulation method and a dispatching method by a new medium.
(2) Add new products and services to conventional products / services and provide them in a new viewpoint.
(3) Change a form of a product or a service into a form that has an influence on customers' consciousness.
(4) Simplify a structure of circulation and sell products directly.
(5) Although channels of information are many, windows to receive from customers are unified.

(6) Set up quality levels of products and services from a customer's viewpoint, promise them to a customer.
They were taken out almost automatically from the „Business idea database".
Finally, environmental conditions and information technologies were investigated, and several business models were conceived using them.

We introduced one of them as an example (figure 13).
[Internet sales of digital pictures with sound: ‚Company X' ties up with prominent ‚Y art museum' and sell digitized pictures on the Internet. Each picture has music suitable for its image, and customers can listen to them when they look at sample pictures. Furthermore, X develops new audiovisual equipment for seeing digital pictures with sound with another maker, and puts on the market at the same time. X installs a customers' window and promises customers' quality levels beforehand.]

According to the evaluation criteria, we evaluated the degree of the value capturing by this business model for ‚Company X' (figure 14). Considering the present environment of ‚Company X', by adopting this business model, it would acquire big value certainly. Some elements such as know-how of digital contents dealings including pictures' copyright and relations between ‚Company X', ‚Y art museum', and an audiovisual equipment maker, influence the success or failure of this business model.

Evaluation of the methodology

We would like to estimate whether this methodology might be able to conceive advanced business models or products. We evaluated the methodology with a following process(figure 15).
(1) We picked up certain business models and products, and took out essential subjects, expected improving points and technologies that can be used.
(2) Using taken out subjects, expected improving points and technologies, we extracted business idea group from the „Business idea database".
(3) We compared the extracted business idea group with the currently used idea group of target business models or products. We evaluated whether this methodology can conceive more various ideas than current ideas.

For evaluation, we selected two business models from patent journals and two latest idea products. Outlines of them are shown in figure 16,17,18.
Figure 19,20 show a part of business ideas taken out by this methodology, comparing with ideas of present business models and products. Round marks show ideas closely related with target business models / products. Double round marks show new ideas that are not included in current ones.
For example, in ETC (electronic toll collection system), ‚Change a service or a product into a form that has an influence on users' consciousness', ‚Add new information to conventional information and analyze it in a new viewpoint', ‚Improve works in a customer's place and set up a quality level', may be used to conceive higher value added business models or products.

Although evaluation with four business models or products is not sufficient, we can grasp that the methodology is quite useful for conceiving new ideas.

Conclusion

We made a „Business idea database“ using the 40 inventive principles and the contradiction matrix and a method of conceiving new business models or products using it. We evaluated the methodology and recognized following points (figure 21).
(1) Using this methodology, we may make more various ideas compared with conventional ways of thinking.
(2) This methodology has a possibility that extend a business opportunity, by using together with the existing requirements analysis techniques, marketing techniques, and business planners' sense.

There is a subject that should be solved from now on. The „Business idea database“ made in this paper is an example based on experiences of authors, and may be changed according to social environment and technical trends. We need to evaluate a „Business idea database“ and patterns of business ideas that are origin of it, and make an improvement mechanism.

Business models / products that ‚betray' customers' expectation in a good meaning, may impress them, and raise purchase volition. They should be connected with the solution of subjects that customers and companies might give up or might not notice.

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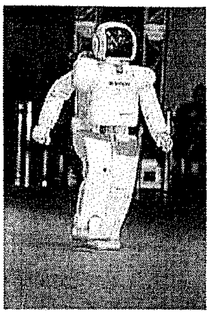
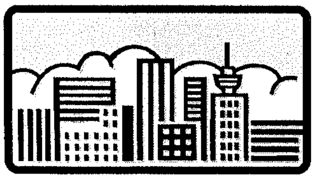


by HONDA

robotics

↕

business



Using TRIZ to Create Innovative Business Models and Products

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Hitachi,Ltd., Japan

Aachen, November 12, 2003

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Figure 1

Innovative business models/products creation methodology

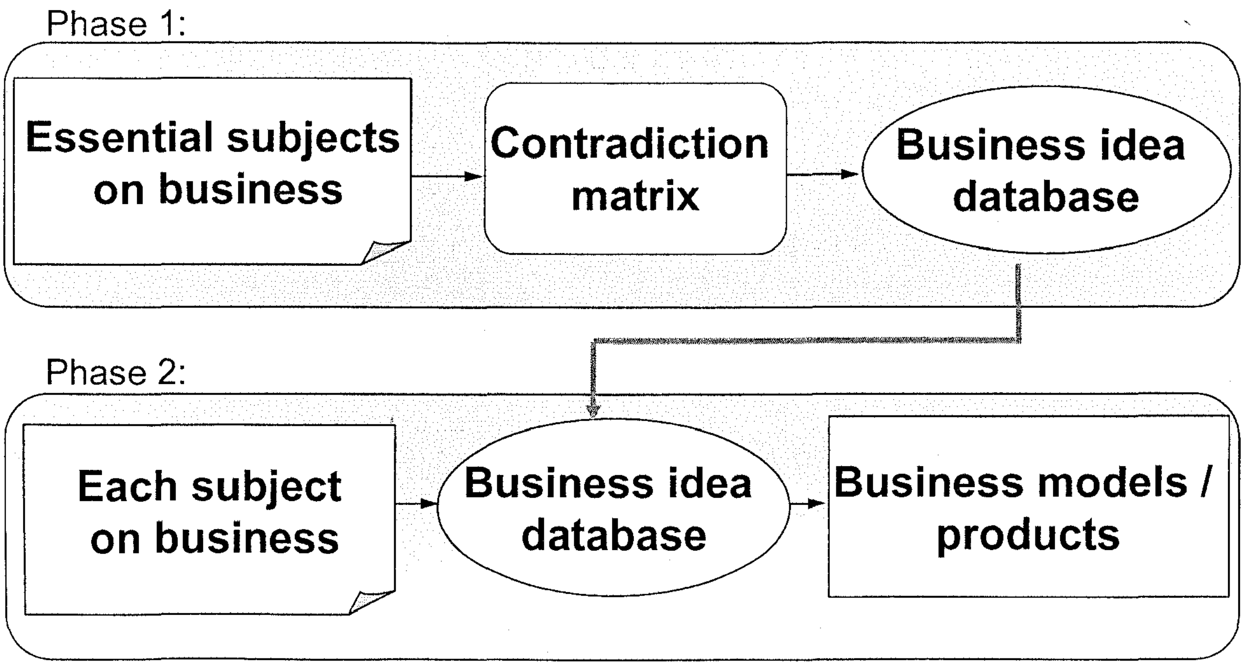

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Figure 2

2 classifications used in a "Business idea database" Phase 1

Classification of business strategy

Expand business / products' function	Concentrate business / products' function	Change business process / products' structure

Classification of information technology

Reduce time or space	Change media of information	Distribute or integrate information systems

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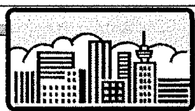
Figure 3

Process of making a "Business idea database" Phase 1



Each element of business strategy

Extract expected improving points and degrading points

↓

Take out principles of invention from contradiction matrix

Make "patterns of business idea" correspond to principles of invention

apply

Arrangement

↓

Make a "Business idea database"

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Figure 4

Extracted improving/degrading parameters(partial) Phase 1

strategy	Improve or degrade	improving / degrading points on business	improving / degrading parameters
Expand business / products' functions	improve	Correspond strongly to a pressure from outside.	Tension, pressure
		Promote business strongly towards outside.	Power
	degrade	An organization becomes big.	Volume of moving object
		Useless tasks increase.	Energy spent by moving object

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Figure 5

Taken out principles of invention(partial) Phase 1

strategy	improving points	degrading points	principles of invention
Expand business / products' functions	Tension, pressure	Volume of moving object	Universality, Parameter changes, Preliminary action
		Energy spent by moving object	Spheroidality – Curvature, Intermediary, Preliminary action, Thermal expansion
	Power	Volume of moving object	Parameter changes, Universality, Strong oxidants
		Energy spent by moving object	Partial of excessive action, Universality, Periodic action, Thermal expansion

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Figure 6

Patterns of business idea(partial)

Phase 1

principles of invention	patterns of business idea	information technology
Segmentation	Divide a system and summarize common functions.	distribution/ integration
Taking out	Divide a system and eliminate useless functions.	distribution/ integration
Asymmetry	Cooperate old systems and new systems and live together.	distribution/ integration
Universality	Abstract, standardize and reuse functions.	distribution/ integration
Asymmetry anti-weight	Divide a system and add or change functions to optimize as a whole.	distribution/ integration
Preliminary action	Prepare standard parts beforehand and make systems with them.	distribution/ integration
Beforehand cushioning	Give redundancy to a function and avoid risks.	distribution/ integration

Figure 7

Business idea database(partial)

Phase 1

strategy	improve	patterns of business idea	information technology
Change business process / products' structure	Accelerate business	Prepare standard parts beforehand and make systems with them.	distribution/ integration
		Change a service or a product into a form that has an influence on user's consciousness.	change media
		Cooperate old systems and new systems and live together.	distribution/ integration
		Divide a system and enable to substitute each element easily.	distribution/ integration
		Divide a system and add or change functions to optimize as a whole.	distribution/ integration
		Change a business process by flexible change of business rules.	distribution/ integration
		Change form of information, accumulation method, and dispatching method.	change media
		Add new information to conventional information and analyze it in a new viewpoint.	change media

Figure 8

Process of conceiving business models/products

Phase 2

Step1: Gather information about a company and customers, and extract core technologies of the company

↓

Step2: Extract business ideas from a "Business idea database", and conceive business models or products

↓

Step3: Evaluate conceived business models or products, and select the best one

↓

Step4: Clarify appeal points of the selected business model or product

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Figure 9

How to evaluate business models or products

Phase 2

Five forces		Evaluation criteria
Rivalry	Requirement for sustainable advantage	Scarce
New entrants		Hard to transfer
Substitute products		Hard to imitate
Customer power		Hard to identify
Supplier power		Durable
		Hard to substitute
		Customer power
		Supplier power

Source: Most Practical MBA Strategy & Strategic Thinking

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Figure 10

Example of application: subjects definition

Phase 2

Company 'X' is developing and selling products for consumers and companies. It wants to make a new business model like internet-commerce, for increase in sales, and improvement in profit. In this case, what kind of business model for what kind of products should be made?

Essential subjects

- By **expanding business**, it **promotes business strongly** towards outside.
- By **changing a business process**, it **accelerates business**.
- By **changing a business process**, it **simplifies structure of works** and reduces useless works and costs.

Core technologies | Internet | Data accumulation / distribution

Taken out Business ideas (partial)

Phase 2

"By expanding business, it promotes business strongly toward outside"

Patterns of business idea	Technology
Change form of information, accumulation method, and dispatching method.	**change media**
Add new information to conventional information and analyze it in new viewpoints.	**change media**
Dispatch information periodically and change interval.	**reduce time/space**
Make structure of broader-based propagation of information.	**reduce time/space** **change media**

Conceived business model (an example)

Phase 2

Business ideas

- Change a form of products, an accumulation method and a dispatching method by a new medium.
- Add new products and services to conventional products/services and provide them in a new viewpoint.
- Change a form of a product or a service into a form that has an influence on customers' consciousness.
- Simplify a structure of circulation and sell products directly.
- Although channels of information are many, windows to receive from customers are unified.
- Set up quality levels of products and services from a customer's viewpoint, promise them to a customer.

Internet sales of digital pictures with sound:
Tie up with prominent 'Y art museum' and sell digitized pictures on the Internet.

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Figure 13

Evaluation of conceived business model

Phase 2

Evaluation criteria		Internet sales of digital pictures
Scarce	◎	Pictures in prominent 'Y art museum'
Hard to transfer	◎	'Company X' brand and 'Y art museum' brand
Hard to imitate	◎	Digital pictures with sound, new audiovisual equipment
Hard to identify	○	'Company X' has a reputation of high quality products provider
Durable	◎	Rich assortment of pictures in prominent 'Y art museum'
Hard to substitute	○	Huge list of customers, customer centers, many channels of sales
Customer power	◎	Novel products, brand, quality level agreement
Supplier power	△	Relations with 'Y art museum' and an audiovisual equipment maker

◎ :very high ○:high △ :neutral

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Figure 14

Process to evaluate the methodology

Pick up certain business models and products.
Take out essential subjects, expected improving points and technologies.

Extract business idea group from the 'Business idea database', using taken out subjects, expected improving points and technologies.

Compare the extracted business idea group with the currently used idea group in the target business models and products.
Evaluate whether this methodology can conceive new business ideas other than current business models or products.

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Figure 15

Selected business models(patent) for comparison

classification	Business model / product	function
Patent (official paper)	Image-processing equipment.	Equipment that takes photograph of a predetermined subject with a digital camera and computes the insurance amount of it automatically.
	Method of firm banking service.	A service that takes out and offers new-arrival information about a field corresponding to User ID after a firm banking service. New-arrival information is memorized to separate storage according to each field.

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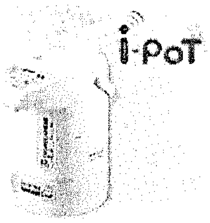
Figure 16

Selected advanced business model for comparison

i-POT

A service especially for taking care of old people.
Those who live in the distance can regard
use situation of an electric pot in a place of
an old person living alone, using PC or
a cellular phone.



遠くからそっと見守る安心感

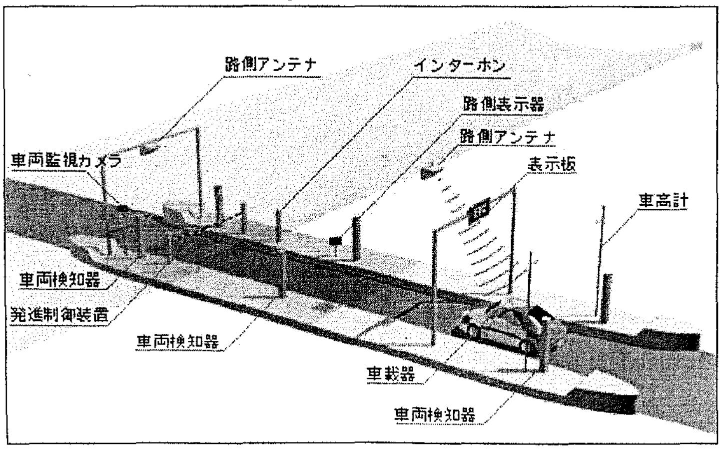
i-POT

象印マホービン株式会社

Selected advanced business model for comparison

ETC (electronic toll collection system)

A system which passes a car through a tollgate nonstop by using communication machines on a road and a car, and ETC card on a car by wireless communications.



A machine on a car contains data of the car, and ETC card contains individual data.

Business ideas from essential subjects: i-POT

Essential subjects: By changing business process / products' structure -Cope a sudden situation flexibly. -Automate business process as much as possible. -Secure continuity of work. **Technology:** Reduce time/space Change media	Make a structure of broader-based propagation of information.	○
	Change a service or a product into a form that has an influence on user's consciousness.	○
	Dispatch information periodically and change interval.	○
	Change a form of information, an accumulation method, and a dispatching method.	○
	Improve works in a customer's place and set up a quality level.	◎
	Unify windows for information acceptance from outside and information dispatch to interior quickly.	◎
	Dispatch information continuously and frequently.	○

◎ :New idea ○ :Current idea

Figure 19

Business ideas from essential subjects: ETC

Essential subjects: By changing business process / products' structure -Accelerate business. -Automate business process as much as possible. **Technology:** Reduce time/space Change media	Change a service or a product into a form that has an influence on user's consciousness.	◎
	Change a form of information, an accumulation method, and a dispatching method.	○
	Add new information to conventional information and analyze it in a new viewpoint.	◎
	Unify windows for information acceptance from outside and information dispatch to interior quickly.	○
	Improve works in a customer's place and set up a quality level.	◎

◎ :New idea ○ :Current idea

Figure 20

Conclusion and remaining subject

Conclusion

(1)We may make more various ideas with this methodology, compared with conventional ways of thinking.
(2)By using together with existing requirement analysis,marketing, etc. this methodology might extend business opportunities.

Remaining subject

We need to evaluate a „Business idea database“ and „patterns of business ideas“ which are origin of it, and make an improvement mechanism.

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Figure 21

Thank you very much.

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Figure 22

Profile of Lecturer

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Brief Résumé & job descriptions:

1961	Date of Birth
1979-1981	studied TRIZ at the Technical creation Public University
1981	CID-trainer at engineers courses in Kiev (Ukraine). (CID = Creative Imagination Development
1984	Master of Computer science at the State University, Petrozavodsk
1981-1984	CID – trainer at the Technical creation Public University, programmer of the Computer Centre of Petrozavodsk State University
1989 – 1990	CID-teacher at school
1991-2002	realised the experiment "An introduction of TRIZ elements in the school educational programmes with the purpose of development students"
1990 – 2003.	Lecturer of more then 30 TRIZ and CID-courses for teachers (from 20 to 144 hours), including: 1993-1994: Minsk (Belarusia) 1991-1994: S-Petersburg (Russia) 2000: Kharbine (China) 2003: Seoul and Tegou (South Korea)
2002	Key-speaker at the 2nd ETRIA-conference in Strasbourg

since 2002	Editor of the pedagogy column of the site of OTSM-TRIZ technologies Centre
since 2003	Postgraduate of the Academy of educator's retraining and upgrading
Awards:	2001 – Finalist of the Ford Foundation International Fellowship Program

On the question of the generating typical solutions

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Abstract

The specialists dealing with problem-solving in new areas often undertake to find "40 principles" for a particular field of knowledge. Apparently, a direct analogy with technical systems is neither unique nor the best way of coping with the problem.

The given paper is an attempt to describe some ways of generating new knowledge, i.e. algorithms of object synthesis and transformation, in the framework of the Element-Name of Feature-Value of Feature (ENV) model. The paper also discusses the mechanisms of composing an "informative model" of an object, i.e. determining the features which may appear useful for problem-solving in this particular field.

The given paper can be seen as the first step towards the methodology of teaching problem-solving technologies in the framework of the OTSM-TRIZ approach. The proposed methods can be also employed in specialist training.

1. Introduction

TRIZ contains a lot of principles and methods for solving typical problems. The principles for contradictions resolution, standard solutions of inventive problems, banks of physical, chemical, geometrical and other effects, laws of technical systems evolution help us to solve problems on different levels, from very specific ones to those dealing with forecasting.

However when we face a new area of knowledge, we often come to the problem of creating a new class of principles, standards, effects, laws. In the framework of the OTSM-TRIZ approach they are usually named typical solutions.

The given paper is aimed to consider how the employment of the OTSM-TRIZ models can increase the efficiency of generating typical solutions in a new area .

2. A general research process

Traditionally, a research process in a new area looks as follows:

- ✓ Information about some class of objects is collected;
- ✓ Models are created;
- ✓ A search of properties, effects and laws is actualized with the help of these models;
- ✓ The results are checked and / or proved;
- ✓ The properties and effects originate a typical solutions set;
- ✓ The typical solutions can be used to solve problems in this area.

The material of advanced school programs is used as informative base for some parts of this paper. But the way which is described above reflects a general approach to a research process.

3. A research process as a work with a model

During a research process we really analyze models of objects, but not objects themselves (Axiom of Description of the OTSM-TRIZ approach).

The moment when we observed an object and decided which features were important for us was crucial. We selected the features for comparing this particular object with others, for observing its transformations and for stating cause-effect relations. From that moment we've been working with the model of the object, but not with the object itself. We selected from the -unlimited set of features only those which we need for solving our problem.

3.1. The model "Element –Name of feature –Value of feature" (ENV-model) as a basis of modeling objects

The ENV-model was introduced by N.Khomenko in the framework of the OTSM-TRIZ approach. Its prototypes were the models "Object – Attribute – Value" and "Frame of object", which were provided and merged in one "Element – Name of Feature – Value of a Feature" model, which is partly described below.

In this form the ENV-model corresponds to the models of classical TRIZ and gives new possibilities for modeling problem solving process. The main function of this model is to describe contradictions. But here we'll consider some features of this model

We can call **elements of the world** (or simply "elements") all we can observe, analyze, research and use during the problem solving process (it can be an object, a process, a model, a device, a principle, a characteristic). The element of the world can be both substantial and non-substantial one. What is important however is that this element is described by means of the ENV-model, i.e. it is characterized by a set of features.

"Name of Feature" is a name of characteristic, a description parameter. Every feature has many (not less than 2) values.

Element	Name of Feature	Value of Feature
pen	color of ink	Blue, red, black,...
	way of work	Boll-point, quill, ...
equation	An order	Linear, quadratic, ...
	A left part	(5X-3); (X^2-6)
attraction	An action	To climb mountain, to dive, ...
	Users	Children, adults, retired ,...

In the framework of the OTSM-TRIZ approach all elements of the world have the same unlimited range of features. The features have particular values for all the particular elements.

When we start to solve a problem we decide which features we need for this particular process.

Here is a simple example. In different frames of reference there are many different ways to determine coordinates of the solid in the space.

In the OTSM-TRIZ approach the ENV-model becomes a language for analysis of problems and synthesis of solutions. This language makes it possible to use the same method for processing a problem situation irrespective of the field of knowledge in which the problem appeared.

3.2.Kinds of features in the ENV-model

We can distinguish general and specific features inside the ENV-model. The general features are actually the lines of multi-screen scheme. The specific features are caused by a concrete problem.

The specific features in a model can be divided into three groups.

The first group reflects **essential** features of the element. The values of these features are the same for all the elements in the class. If we change the value, the element goes to another set (another class).

The following are essential features of a parallelogram: it is situated on a flat surface; it consists of 4 legs; the beginning of every leg is the end of the other leg; its opposite sides are equal and parallel.

The following are essential features of a technical system: it includes basic parts (according to the law of system completeness) and energy conductivity between all the parts.

The values of features can be connected with each other, and the presence of a constant connection can be an essential feature too.

The second group reflects **distinctive** features. Their values can change within a group of elements. During the element research process and /or a problem- solving process the range of possible values of these features becomes the most important.

For example, when we calculate the area of a parallelogram we can use the lengths of sides, the height, the size of angles as distinctive features

If we need to invent a new bicycle, we can choose variants of its main parts as the distinctive features. If we want to solve the problem of breaking on the road, e we may be interested in particular features of the road, wheels and brakes.

If an abstract model is enough for as, it's described by means of these two groups of features.

The third group of features can be called **special** features. We need them if we want to deal with the model as with an object. These features have new values to make the problems-solving process easier.

A model of a parallelogram, which consists of a piece of plotting paper, allows us to prove a formula for calculating its square. A little copy of a bicycle gives a chance of testing some its properties without great charges.

During a research process a model is developed, some new features are added, values of some essential features are corrected; links between values of features s are established.

3.3. Properties, effects and laws in the terms of the ENV-model

It's convenient to define a property, an effect and a law using the ENV-model.

3.3.1. A property

A property is an essential condition of existing objects.

For example: *"**If** the object is parallelogram, **then** its opposite angles are equal". "If the object is a capacity Technical System, then it transports energy from an engine) through all main parts to the tool executing the function of the system.*

A property in a general form is: "**If** an element belongs to a particular set (it means it has a particular range of essential features) **then** the value of the feature called **X** belongs to the set of values called **Y**.

3.3.2. An event or a fact

An event (or a fact) is a change of one of element's features.

For example: *"The flower is exploding". "The water is cooling down". "The bicycle is falling". "The angle in a triangle is increasing".*

An event (a fact) in a general form (further we'll use the term "event" only) is: "the value **Y1** of the feature **X** transforms to the value **Y2** of the feature **X**"

3.3.3. An effect

An effect is a set of events connected with each other by cause-effect relations.

For example: "If we cool water cower than 0oC, then it will transform into ice" (The value of the "aggregate state" feature depends on the value of the "temperature").

"If we observe the development of the TS during a certain period of time, we can notice that it "strives for the ideal system" (its functionality is rising and expenditures are falling)". (The values of the features "functionality" and "expenditures l" depend on the value of the feature "time").

An effect in a general form is: "**If** we change (increase, reduce, state equal to some quality) values **Y11,... Y1n** of the features **X11,... X1n** of a class of elements in a particular way, then values **Y21... Y2m** of the **features X21... X2m** will change in a particular way too ".

The examples above show that a structure of the law is similar to the structure of either an effect or a property.

3.4. A typical solution according to the ENV-model

A **typical solution** is a certain system transformation, based on the objective laws of the concrete field of knowledge, which is usually applied to a particular class of objects during the problem-solving process.

For example, *when we solve a BI-quadratic equation in math, we use a change of the value ($x^2 \rightarrow t$), and it's a typical solution. Generating all the roots of the initial equation is assured by properties of a quadrate. It's an objective law.*

To understand what a typical solution looks like we can draw a parallel between typical tools for problem solving in TRIZ and the notions we've described above.

3.4.1. A Principle

A principle corresponds to an event or family of events. It proposes to transform a value of feature of an element (to divide, to make orbicular, flexible, to warm, to cool and so on.) At the same time a principle doesn't show conditions, in which this transformation is profitable. It doesn't determine problems which can be solved by means of this transformation. So principles themselves aren't typical solutions yet.

In the case of "40 principles" by G.Altshuller, the matrix of technical contradictions transforms the principles into effects and shapes them into an effective tool for a directed change of technical systems.

3.4.2. A rule (a standard, a typical solution)

A rule, or a standard, or a typical solution can be presented as an effect.

But one part of this statement must be a description of a goal (a desirable result or erasing undesirable result) and cause-effect relations which provide this particular result for this element. A comparison of a rule and an effect is given below.

It's an effect. *If a ferromagnetic thing is heated up to the Curie point (it's a transformation of the e value of feature, so it's the event), then it will lose its magnetic properties.*

It's a rule (a typical solution, a standard). If you need to demagnet e a ferromagnetic thing (it's a goal) then you should heat it up the Curie point.

A typical solution in general form is: "**If** you need to find the values of the sets **Y11...Y1n for** the features **X11...X1n** of the element A, you must give the features **X21... X2m** values of the sets **Y21... Y2m.**

So the model of an element allows to find effects in a given area (= to establish relations of features) which leads to generating new typical solutions.

4. Using the ENV-model for typical solution research

Now we try to answer the questions.

1) How can we construct a model? This question can be formulated in a different way: how can we determine 3 groups of features which compile the ENV-model (3.2) according the problem which we are solving?

2) How can we find effects and transform them into typical solutions? In other words, how can we know which relations of the values of features appear relevant for solving a particular class of problems? How do we find this relations with less expenditures?

4. A typical solution search using the ENV-model

We try to answer the questions:

1). How can we construct a model? Now we can reformulate this question on another way: how should we determine 3 groups of features, which compile a model (3.2) to solve our problem easily?

2) Where can we look for effects? On another war, how can we know, which relates of features values can appear relevant for this particular class of problems? How can we find these relations with fewer charges?

4.1. Two approaches to typical solution generation

4.1.1. Traditional approach

As a rule, we use the following approach:

If we want to learn to create some kind of elements, we must collect a bank of them, then compare them with each other to determine the features which are essential. So we come to a model. Using it we can create elements. In the same way we search principles: we collect a bank of resolved problems, select more effective (strong) solutions and formulate typical transformations of the system, i.e principles. .

Such an approach helps us to present the experience in a convenient form. But it can't give new solutions, as we research the earlier resolved problems from the same field of knowledge.

4.1.2. Proposed approach

Here is another way of generating typical solutions. We'll go from aims and contradictions, which are seen as an obstacle on our way to the given goal in a particular situation limited by a certain set of resources.

In this case, in order to construct a model of an element we must determine the features, which can lead us to the required result taking account of the available resources Some of these features contradict each other. It means there is a constant connection between them, and it can be described as an effect.

We can suppose that methods of eliciting and avoiding these effects in a particular field are typical solutions for it.

4.2. The technology of using our approach

Watch this method on the example of the system "attraction". Assume that we want to solve the problem of generating ideas for new attractions.

Step 1. Determine of the aim

Determine the aim (function, result) of the system "attraction".

The aim is to entertain people in public places by executing some actions and arousing sharp feelings.

Step 2. Determining essential features

If we answer the question "What kind of features must the system have to reach the aim we formulated?" we'll get the essential features of attraction. Additional landmarks on this way are general features, the multi-screen scheme and the principle of ideality.

Essential features

- The ability to arouse sharp feelings.

1) joy caused by overcoming a difficulty or

2) agitation caused by feeling danger or

3) surprise (it appears when the result we anticipate is quite different from the result we really get. For example, a chute is directing down, but it jumps us up).

- Presence of special technical devices (further – simply "devices") providing necessary actions and results;
- Presence of impacts from users to devices and vice verse.
- safety
- Applicability to different people;
- Suitability to public places.

Comment:

The feature "arousing sharp feelings" disintegrates in 3 groups. So it allows us to divide the class of attractions into 3 subsets. Because of restrict volume of the paper, we'll further describe only the attractions which produce the effect of surprise.

Step 3. Determining distinctive features

- Basing on the essential features, we will get distinctive features (the features of the 2nd group) the values of which will vary in concrete systems.
- Determine the information sources, which will fluctuate in particular cases.
- Find the range of possible values of the features.

1. The essential feature of attraction is *the ability to create the feeling of surprise.*

Actually, such an effect can be created in different ways. Some of them are acceptable for attractions.

Methods of generating ideas of attractions presented in the model "What we anticipated – What we got" will give us a range of values of the distinctive feature (*We expected the object to fall down – but it poised. We expected the stream to gulf us, but it jumped us up, and so forth*). This range can be written on the basis of a domestic experience. Another way is to analyze some elements, containing this feature (for example, plots of cartoons).

2. The essential feature "presence of action" determines the distinctive feature "kind of n action"*(wobble, looking for a thing; rise, fall, s and so on).*

The list of values can be found from the list of verbs, which denote human's actions and reactions on people.

3. The essential feature "safety" brings us to the distinctive feature "methods of providing safety", which looks like a connected couple: 1) dangerous effects which we want to dispose off *(such us impacts, high speed-up, changes of push, temperature and so on) and 2) effects which help to counteract them.*

Comment:

As the 2nd feature depends on the first, it appears useless to collect its values. Finding it is a separate task, and we'll consider it below.

Information sources are reference literature on the medicine and the physics.

Another part of distinctive features probably appears from general features of the element. But this question is beyond the scope of this work. Further we'll use following distinctive features.

- ✓ Users (adults, children, retired, all categories of people);
- ✓ The place of the attraction (open space on the land, open space in water, closed room, air space,...)
- ✓ Devices which provide movement (chutes, flip-flops, cable ways,...)

Comments:

1. Here we also deal with information bank However such an approach gives more possibilities, because it allows to take information from different fields.
2. Actually the third step gives us a base for a morphological box. The simplest way to continue is to build a morphological table and then to gain from it appropriate variants of solutions. But evidently this method doesn't guarantee finding a strong solution. Below we will try to reduce the solution search space.

Step 4. Determining special features

Now we come to special features and include symbols for constructing the model of attraction.

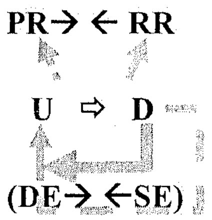
We denote the distinctive features in this model one or two first letters; a direct action will be denoted by an arrow (⇑), relations of features values will be marked "→/←".

Specific signs:

Feature	Sign
Creating effects methods	**ER** – an expected result, **RR** – a real result.
Providing safe methods	**DE**- a dangerous effect, **SE** – a safe effect
Users	**U**
Actions of users	⇨
Movement devices	**D**

Step 5. Constructing model

Now we construct the attraction model based on a surprise effect.



A user (**U**) is acting **(**⇨**)** to a devise (**D**) expecting a result (ER), but he sees an opposite result (RR). It might be accompanied by a dangerous effect (**DE**), which needs to be undone by a safe effect (**SE)** (brackets shows that the dangerous effect doesn't nessesarily appeare). It 's desirable that resources necessary to provide the safe effect belong to the inner resources of the divice itself.

Example:

D - a chute,

⇨ - a climb up;

ER – making an effort we are climbing;

RR – the less we try, the easier we climb, or we step up, but we come down.

We can construct the system starting from different features, but it's important we understand how they connect.

We could start from a device and find appropriate values of other features for it.

We can go from a couple of opposite predictions: he wants to go straight, but he goes round, he pushes a thing towards, but it's jumping back to him and so on, and in this way we can determine the device and the user.

So if our goal was to make up new attractions, we've already solved this task. Now we know where we can find the range of values of features and how to reduce the solution search space.

However we've come to quite an abstract solution. A wish to make it more specific will cause new tasks.

Step 6. Determin ing an effect search space

Now we clarify a search space of effects, in which we need to make up particular attractions.

Pay attention to the oppositely directing arrows in the model. They point out to the contradicting values of features. How does this contradiction appear?

Observe the couple "an expected result – a real result" **(ER →← RR).**

A user does some action and predicts the result based on knowledge about certain regularity, (an effect) ("If I push the lorry ahead, it will go onward, if I push down, the lever will drop, if I want to go straight ahead, my steps will line up. But our system should break these expectations, should set the effect at naught.

One of the OTSM-TRIZ rules is: "an objective law can be avoided only with the help of this objective law. It means we need to understand the law deeper for coming to our aim.

If expectations of a user connect with bodily movement, we need effects which interrupt habitual movement laws with the help of the laws. If their predictions connect with certain visual impressions, we must find effects that break right perceptions of reality.

So to change an expected movement direction we need to define what forces depend on and how they are disposed and what effects cause their transformations. If the body blows, its trajectory depends on the center of gravity. If during the movement it's in a broken poise, its trajectory can depend on a friction and so on.

In the same way it's possible to observe a contradiction, connected with – provision of safety **(DE→←SE).** For providing the function of the attraction the user must be under the influence of a dangerous factor (acceleration, great height, losing balance and so on). But for safety reasons this factor has to be eliminated or not appear at all. And here we must find a way to avoid the dangerous effect with the help of itself too.

If we want a small height to seem big, we need to realize mechanisms that f create the feeling of height without transporting a person up. One of such mechanisms (from the big height everything seems quite small) can be turned on using optical effects.

Resume

So we can propose that if in every model of an element, constructed according to the present algorithm (steps 1-5) there are a couple of contradictory features, then we can expect that eliciting objective laws which cause this contradiction ,we'll get the principles to resolve it.

It is necessary to note that the model constructed on the 5th step allows us to observe the contradiction between the expected results and real results without specifying all features of the system.

Aside from the given contradictory features, a model can include others. Their values can change, which allows us to build a lot of different systems based on a particular model. During creating them the same contradiction will appear, and we'll solve it with the help of the same transformations of the system. We can predict that such principles as "a flexible center of gravity", "an optical trick", dynamic friction' and so on will be the typical ones for coping with problems when inventing new attractions.

5. Conclusion

The given approach brings us to the following results. A classification of specific features in the ENV-model is offered.

With the help of this classification a model construction technology based on the ENV-model is made. It is based on determining a goal of a system and elicitation of contradictory features.

As demonstrated, this approach allows us to do the following:

- To collect information bank more effectively picking the most appropriate information source for finding values of every feature.
- To build a model of an element considering relations between its features.
- Specifying the values of contradictory features and resolving the contradictions faced, we can find typical solutions for the given area, which can became more utility typical solutions.

Thus, the technology of generating typical solutions is proposed.

In conclusion, it is necessary to mention the following. The more difficult is the system, the more manifold are resources and more difficult are functions, the more typical transformations there are in it and the more difficult it is to look for a a suitable principle for solving a particular problem.

It's more profitable to go straight to rules (standards). It allows to connect a principle with a particular typical problem. But to generate rules we have to find effects and laws characteristic of this area at first. They'll give us information about resources of the system, which will be necessary for solving both typical and non-standard problems. So to examine a new area we need not principles, but effects.

The technology for generating typical solutions proposed in the given paper demands an ability to build convenient models for work, research and learn effects in a new area, elicit and resolve contradictions. Taking into account the booming expansion of new knowledge, we can suppose that these are the skills specialists must be taught. It's much more effective than giving specialists new and new arrays of typical solutions, provoking them to search for a necessary principle by the trial and error method.

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	Seminars by own games in Mogilev, Minsk, Moscow
	4 USSR- patents on the games (№ 1819394 "Toys", № 2037324 "Designers", № 2111785 "Board games", № 10102 " the Game in cards ")
Publications	2 books, 6 articles, 8 reports on conferences, 6 patents on inventions are published

TRIZ for people: psychological aspects

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Executive Summary

TRIZ and NLP - two the most powerful methodologies for increasing people's creative level and efficiency of their activity. They appeared and develop independently one from another in the second part of 20 century1, however much many instruments of these methods can be are successfully used for expansion and increasing the efficiency of each other. Report is intended for experts of TRIZ and NLP-psychologists.

Introduction

TRIZ allows to formalize, describe and solve the technical problems from different branches using one system notion **/lit1/.**

Neuro-Lingvistic Programming (NLP) - humanitarian technology, which problem are decision the problems of the personality, formalization successful creative experience for learning people to it **/ lit2/.** The Language of NLP in united system of terms describes the different processes, occurring in such area, as marketing, management, psychology, pedagogics, etc. This allows to carry and use the achievements from one discipline and processes to others. The Descriptions on NLP language change in a system of algorithms and acceptances i.e. in NLP-technology.

But can we compare these two formalized languages to use the achievements of NLP in the field of decisions personal, interpersonal problems and organization - for TRIZ specialist, and achievements TRIZ - for NLP?

The report contains the analysis and some possibilities of the join the TRIZ- tools and NLP-tools for increasing the personal success of TRIZ-specialist and firms, in which they work.

[1] TRIZ (Altshuller, first publication in 1956), NLP (Bandler&Grinder - in 1975).

1. The Analogies between tools: TRIZ and NLP

Theory... this metaphore, costing between model and data. Understanding in science is a sensation resemblance between intricate data and familiar model...

Julian Jaynes, by R.Dilts "Skills for the Futute"

1.1. The model of the world

By NLP: Creativity is an unceasing process of the constant increase of flexibility and expansions the "maps of the world", by which we live. It has significant importance for successful adapting of a person, therefore that we live - work, interact with the other people - in ambience, teeming of uncertainty and change. For the successful adaptation is exceedingly significant to know how to occupy the different positions of the perception to realities. In NLP becomes firmly established that if you are capable to enrich or increase your "map of the world" then in the same reality you see more alternatives. That people, which them to see the most great ensemble of the prospects and possibilities of the choice.

The Processes, promoting development and creative increasing is a representation anything by means of metaphores, symbol, drawing. The Different types of representations differently place the accents in problem space, attach significance different factors and their interrelationships.

By TRIZ: The analogue of the notion "map of the world" in TRIZ is 9-Windows (analyze Super-systems, CO-systems, ANTI-systems). Different forms of representations are used broadly. The drawings is use at "an Operation Zone ", at the "little man" method; Symbols is use at "Substance-Field Analysis", X-element, Ideal Final Result; diagrams is use at a laws of the System evolution; metaphores is use at a defining the contradiction, are broadly used in TRIZ-method of the creative imagination development.

The Conclusion: TRIZ-specialist possesses the sufficient an creative ability to raise its success in vague, variant ambience. How to use their own "technically directed" creative TRIZ-skills for improvement of the own life? The Methodses for this is designed in NLP **/lit2 - lit5/.**

1.2. "Re-framing"

NLP-method "re-framing" (R. Dilts,1990) is called to help the people to change the look at tight situations and consider their not as problems, but as the possibility given by life, and to focus attention on desired result / lit3/. "Re-framing" allows the person to recognize limiting his beliefs to be more shifty in their own reaction, in transformation of the negative beliefs. With psychological standpoint to produce re-framing means to convert the sense of anything, having placed "THIS" in new frame or context, different from source, having increased thereby our perception to this situations.

Analysing linguistical structure of the beliefs, R.Dilts has installed that limiting beliefs place our experience in a frame "problems", "mistakes" or "impossibility". If a person builds the map of the world on the base of such beliefs then beside it can appear the feeling of hopelessness, helplessnesses or uselessnesses to life as a whole or to some os his actions. So, people, for which became accustomed constantly to neglect the positive side of its experience, often use the limiting word "but", creating in their internal map frame "problems" and "impossibility".

"Re-framing" allows to interpret otherwise that or other problems and find the new decisions. This occurs by of the changing frames, in which these problems are perceived, by dint of the premises the limiting beliefs in more positive frame. The Main function of the "re-framing"-methods is to teach people to realized switch attention

1. from the frame of the problem to the frame "result"
2. from the frame of the mistake to the frame "feedback"
3. from the frame of impossibility to the frame "as if".

We have found the analogies TRIZ-tools in 12 (!) events from 14 principals of re-framing by R.Dilts **(see figure 1).** Specified on figure 1 TRIZ-tools develop skills of the thinking, necessary for effective application "re-framing".

figure 1

NLP Name and description re-framing's principal	Necessary skills of the thinking	TRIZ-tools
1. The Model of the world Reassessment beliefs with positions of the other models of the world. It is used technology "three positions of the perception": the other person (concerned in problem-solving situation); the independent watcher; significant for you person (mentor)	Skill is realized build different models of the world, see on-systems, CO-systems, intercoupling	9-Windows (analyze Super-systems, CO-systems); Altshuller's Inventive Principal № 17
2. Division Crushing element of the utterance on more small details, due to that changes or enlarges the perception of the sense of the message.	Separation of the subsystems, searching for their analogue	9-Windows (analyze Sub-systems); Altshuller's Inventive Principal № 1
3. Association Generalization one of the element of the utterance before higher-level categorizations, than is reached enrichment of the perception of this utterance	Skill to classify	Training "Yes-No"
4. Opposite example Searching for exceptions to the rule, which put	Skill to reveal contradictions and	Work with contradiction;

under doubt generalization, definied data by belief	their allow	Altshuller's Inventive Principal № 13, 22; TRIZ-methodses of the creative imagination development
5. The Analogy To Increase the look at concrete judgement by means of discovery of the other statement, having similar intercoupling. This allows to find the new prospects and new facility.	Skill to reveal similar functions in miscellaneous system (Co-systems), facility of the different systems, forecast future of the system with new resource	9-Windows (Functional analyze); Resources; TRIZ-method of the creative imagination development: Fantogramma
6. **Change the size of the frame** Reassessment importances of the concrete action, generalizations or judgements in new context: a long - a short time cell; with standpoint of the greater number of the people (or the other groups of the people); in more broad context of the lifes	Skill forecast the consequences of the event in miscellaneous gap time; Reveal different Super-system and value the functions of the system with their standpoint; Revealing the Co-systems, Laws of the system evolution	9-Windows: (movement on axis of time, on miscellaneous Super-systems), Laws of System Evolution (analyze of development system and CO-systems); Altshuller's Inventive Principal № 2, 3, 19, 20, 21
7. **Other result** Switching on other purpose (differing from declared in statement) to call in question pertinence only one possible result, purposes	Skill to define for system function miscellaneous, formulate different variants of the Ideal Final Result	Function's analyze; **Ideal Final Result** Altshuller's Inventive Principal № 16
8. **The Intention** Switching attention on problem or positive intention, hidden for belief. Allows to learn to respond to positive intention, rather then on utterance	Skill to define to functions, results	Function's analyze; Ideal Final Result Altshuller's Inventive Principal № 11
9. **The Redefining** Change one of the words in wording of the belief by new word, which marks something cognate, is however made by other underlying theme. Allows to reduce the negativism an estimation and label	Skill to find similar objects on function	Function's analyze

10. Consequences To direct attention on positive (or negative) result in which can result a certain statement	Skill to analyse future (systems, Super-systems)	9-Windows, TRIZ-methods of the creative imagination development: Fantogramma and Snow lump
11. Hierarchy of the criterion Reassessment beliefs according to criterion, exceeding on value any one of that, on which leans givenned belief (hierarchy of the criterion is one of the main reason of disagreements between people, groups and cultures)	Skill to select criteria, value value, search for opposite examples	ABC- Function's analyze; Contradictions; TRIZ-methods of the creative imagination development
12. Meta-Frame Estimation beliefs from frame unceasing larval-oriented context	Skill to value consequences	9-Windows (Super-systems, motion on axis of time)

As we see, 12 principals of re-framing are similar to different TRIZ-tools, including Altshuller's Inventive Principals. But in TRIZ there is 40 principals, and many of them we can add to NLP-principals of re-framing.

However, morder to TRIZ-specialist could effectively use Altshuller's Inventive Principals for re-framing own beliefs, realized education, "the transfer" is necessary /lit6/. At present the method consists from the consequent exhibit all the Altshuller's Inventive Principals and 9-Windows to "changeable belief" as an "object". However further for the re-framing of belief can be and should be designed special Conflict Matrix (matrix linking Typical Social System Conflicts with the Altshuller's Inventive Principles). Certainly, many of Altshuller's Inventive Principals it is necessary specially to adapt to "human" system, using features to personalities, groups of the people. For instance, Altshuller's Inventive Principal №26 "Coping" can sound as "vizualization", Principal № 28 "Substitution for mechanical means" can sound as "use the other channels to representations". Work on adapting the terminology Principals № 4, 5, 8, 9, 10, 12, 15, 18, 24 - 28, 32 - 40 for use in re-framing is conducted now.

The Conclusion: any TRIZ-specialist can use known Altshuller's Inventive Principals and 9-Windows-analyze for the independent re-framing that their own beliefs, which he wants to change.

1.3. Problem solving

1.3.1. The Description of problem space

NLP defines the problem as a difference between the current and desired condition. It is Important to realize that as soon as you define the desired result, you create a problem to yourself. The having Formulated purpose or desired condition, you create a problem literally from nothing - only because you did not yet reach the desired condition. If between the person whom you are, and that whom you want to become, there is no difference - you do not have also problem. The Small difference means presence of the small problem. The essential difference - the essential problem.

For the maximum incidence of the different areas of problem-solving space the NLP-specialists offer to use the model SCORE, which contains such elements, as S - symptom, C - couse, O - outcome, R - resouces, E - effect. The Specialist on TRIZ will easy see in these element well known notions: S (symptom) = Undesirable effect; C (couse) = Operative zone, Formulation of the contradiction; O (Outcome) = Ideal Final Result; R (resouces) = Resouces, X-element; E (effect) = Primary function.

When the problem-solving space is determined, in NLP offer to research the space of the decision by the accompaniment new element to existing map of problem-solving space or by changing of this map by some image. For instance, change the value of temporary frame, position of the perception (the technology 4-position), or concentration on the other logical level (the mission, beliefs, value, identification, actions, strategies, context) capable to change the importance of the concrete problem-solving situation.

From a position of TRIZ, these methods of the decision of the problem are the use of 9-Windows scheme of the thinking (as well as Co-systems), as well as Altshuller's Inventive Principals and Standarts (see "re-fraiming"). However the procedure of the work on decision of the problems is described in TRIZ more in details (ARIZ), than in NLP.

The Conclusion: TRIZ-specialist handles the same notion at description problem-solving space, as NLP-specialist, and owns the more concrete methods of the decision of the problems.

1.3.2 Problems in group and organization

NLP describe two main types of the problems in organization - repeating and unusual. The Different types of the problems use different in its base types of problem-solving space, and identical decision of them requires the different approach.

The Efficient decision of "reiterative problems" requires from the person cognitive skill "to narrow" problem space for the of to reason install the reason of the problem, its sources, and interactive skill: to delegate the subordinate specific actions. There is ARIZ and training "Yes-No" In TRIZ for efficient development cognitive skills.

Unusual problems have no precedent in the organization and are connected with high degree uncertainty in respect of both methods of the decision, and result (for instance, making the new product or expansion market). Unusual problem usually precede the changes to encirclement or organizing system (the market, political situation). Exactly, the change Super-system's aspect creates in problem space uncertainty or inconstancy. For decision unusual problems necessary creation of a team, synthesis of the information concerning elements of the problem, plural descriptions of problem space, generating of new prospects is necessary. The purposes and substantiations rotate around of achievement of understanding and the consent of members of a team concerning the formulation of problems, definition of results, an exchange of opinions and knowledge. There is TRIZ –tools for the development of the system thinking, forecastings consequence on different system level, in CO-system (Laws of the systems evolution, 9-Windows, TRIZ-methods of the creative imagination development: Fantogramma and Snow lump).

As we see, in the first and in the second types of the problems not only cognitive skills are necessary, but also interactive skills of the relations with people. In NLP consider that joint creative activity, founded on interaction between teammate, quite often turns out to be more significant for Innovative thinkings, than tools themselves, by means of which is realized. In NLP the training "modeling of the abilities" are used for this.

The Conclusion: TRIZ-specialist owns the cognitive skills, which are used in NLP for decision of a personal and organizing problems. He have to increase their own interactive skills of the relations with people. And than more powerfully tools, which owns the Team (TRIZ-specialists), more high, cynergetic result for a firm, can give an education of members of a team efficient skill to communications.

1.4. Modeling of the abilities

The Purposes of modeling in NLP: do something by new way; do something better; do something new; change its perception; increase the possibility of the choice. As we see, at a rate of integer between NLP and TRIZ also exist the analogies (do something by new way; do something better; do something new). However NLP opens before a TRIZ-specialist new purposes: change its perception; increase the possibility of the choice that will allow better itself to feel in changing world.

Modeling in NLP is built on the base of oriented on purpose of the loop to feedback - TOTE (Miller, Gallanter and Pribram, 1960). The Abbreviation TOTE is decipherred as Test-Operate- Test -Exit. The model points that in mentation we (realized or not realized) define to purposes and develop the procedure of the check that, is reached purpose or no. TOTE implies that all the psychic and behavioural programs revolve around constant purpose and varied facilities of its achievement. That or other ability, outside of dependencies from degree of the difficulties, forms from several "embedded" cycles TOTE on miscellaneous level skill (the cognitive, behavioural, linguistical: simple and complex) that allows to prototype any ability as "a Designer" - from "blocks" **/lit 4/.**

In particular, for the achievement of the success of any sort is necessary to have a skill to install purposes and to define the motivations for success. This expects presence of the abilities for conceptualization, analysis, observation, performing the certain procedures, interactions with the other people, and control relations with people. A part of these abilities develops at NLP (the interaction with the other people, control relations with people), but TRIZ allows to develop other necessary skills of the thinking: conceptualization, analysis, observation, performing the certain procedures. We shall compare the questions, which will assign NLP- specialists for development these skill, and TRIZ-tools, which also develop these skills (**see figure 2**).

figure 2

Skills of the thinking	**NLP**	**TRIZ**
Conceptualization: The ability to understand the integer and or insert it in more broad system, or correlate with the other system.	As problem of this skill? When you are going to use it? As he matches with other your ability	The Skill to see the hierarchy of the Systems, CO- and ANTI- systems to define Primary Function, Coordination resource
Analysis: The ability to split something on component and classify them	What discriminating abilities of this skill? On that they indicate? As their functions?	Separation of the subsystems, determination their function and features
Observation: The ability to collect significant information in mode "real-time"	What signs (or groups sign) are the most significant? That is the most significant for observation in purpose of the successful realization of this skill?	Separation significant sign and their features
Performing the procedures: The ability to cause in memories and realize the sequence an action, leading to purposes.	As the most most important sequences action required for successful realization the skill? To what level they belong to? As "sequence step"? When and where it is important exactly to execute this sequence? When and where it is important to show flexibility?	ARIZ

If we shall consider NLP - an algorithm "Incremental procedure of modeling", that sees that he much looks like steps ARIZ **(see figure 3)**.

figure 3

	NLP	**TRIZ**
	Incremental procedure of modeling	ARIZ-85B
1	Determine the expert which abilities should be to	The Problem "as it is given", Super-

.	model, and also contexts in which he applies the abilities	systems Step 1.1.
2.	Execute procedure of the collection to information different position of the perception	System, CO-systems
3.	Otfilitruyte results of the collection to information, selecting significant, cognitive and behavioural Patterns	Select elements of the problem, write in not special term Step 1.1, 1.2
4.	Reduce these patterns in logically coherent structure or "model"	Write model of the problem Step 1.3.
5.	Check efficiency and usefulness built to models, having tested it in a different context, and make sure that you capable to reach desired result	Determination of the Ideal Final Result and resource Steps 3.1, 3.2
6.	Shorten model, having left only the most simple elements, allowing reach desired result	Operative zone, formulation contradiction Steps 3.3 –3.5
7.	Identify best way to send skills, determined in process of modeling	Reflection way of the decision of the problem Steps 9.1 – 9.2
8.	Define the most appropriate facilities of the measurement of productivity the model, as well as limits or borders its reliability	To transfer the way of the decision on other area Steps 8.1 – 8.3

Practically on each stage ARIZ is used the same model of feedback TOTE, as in NLP.

However the key condition of the efficient modeling in NLP is necessity to define, on what exactly level of the skill follows to concentrate attention. The Notions and acceptance, successful in modeling of the sibling of the skill, can turn out to be absolutely to be inefficient at modeling the other level. NLP offers to use model ROLE (R - representational systems, O - orientation, L - links, E - effect) for the efficient to transfer the modeling skills to the other context /lit 4/. Not stopping on the procedure of the transfer, shall note that this model also uses the known TRIZ- specialist of the notion and procedures - a discovery resource, system vision (9-Windows), orientation to result - it will allow to increase easy the application of these "technical" skill. However as the concepts "attribute" and "value of an attribute" of alive system essentially differ from the same concepts of technical system, TRIZ-specialist has to pass first education to procedure of modeling under the direction of experienced NLP-specialist to learn to define "attribute ", "level" in the personal and organizing systems. This will allow hereinafter flexible to use new "technician-social" skill of modeling for the independent use.

The Conclusion: Thus, the person, able to solve technical problems by ARIZ, already owns cognitive skills of thinking in order to transfer the "technical" skill to the other "object", in the other context – to the development own communication abilities for effective interaction with other people.

2.Particularities of the using tools: TRIZ and NLP

2.1. i9-Windows

NLP system consider the person and organizations, so 9-Windows looks thereby (see fig. 4, 5).

figure 4

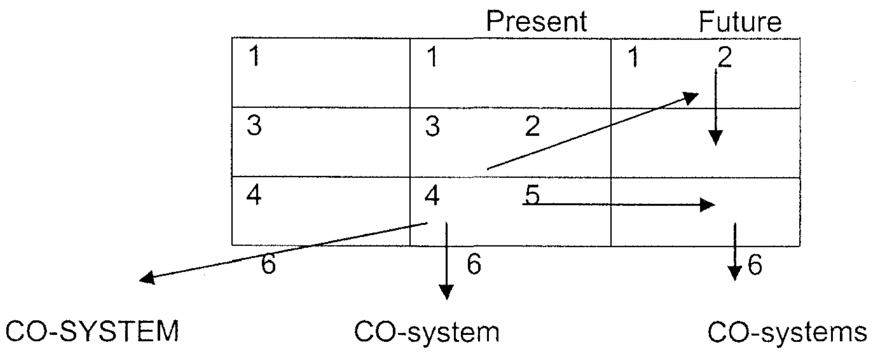

figure 5

Logical levels	**Questions**	**9-Windows**
1. Spiritual, Mission	The particle what, much greater system I show? What my mission? What my spiritual destination?	Present Super-system Future System Purpose
2. Motivation	Why? My motives, value, beliefs	Problem deliver Super-system for System
3. Identification	Who I am?	System, Primary Function
4. Strategies and abilities	As? My strategies, abilities, characteristics	Sub-systems
5. Actions	That to do? My behaviour, actions	Transition from the Present to the Future
6. Encirclement	Where, when, with whom, how much? Reactions on roving	CO-Systems

It is possible to say that a motivation is that engine, which directs moving the system (the person) to expected by him future moreover this future as it were "itself" attracts the person by the Super-system's energy, for which "it is necessary" the execution from a person some problem. The more high logical level directs the choice of the person to lower levels /lit 4/.

At 9-Windows-analyze of a person or a firms it is necessary for taking into account, that the purposes and the main functions can be directed to different logic levels.

For example, the purpose of the firm possible to formulate in terms:

- "action", for instance, "to finish the test of new helmsmen management to friday";
- "abilities, strategy", for instance "to improve the creative abilities employee";
- " Identification " – "to reach the status of the leadinging enterprise in our branches";
- "motivations, valuables" purpose can be worded as "to do the accent on the suitable product for people with physical defect";
- " Spiritual,visions" - "to change way of the contact of the people with each other".

The various levels of purposes demand substantiations and actions at various levels. Problems which will arise on a way to their realization will be different also. NLP expects the expansion of the card of the possible decisions for count of the account of different logical level.

The Primary task of the using of TRIZ to the decision of the technical problems is: a narrowing the field of searching for the possible decisions. The Ideal Final Result is formulated to one system level only, and this creates the difficulties even the at decision of the engineering problems.

The Conclusion: At the decision of the problems connected to people and the organizations, by TRIZ-tools it is necessary to consider the contradictions at different logic levels, increasing the field of the possible decisions

2.2. The internal interpreting of the experience

For the analysis of the problems of personalities by 9-Windows necessary "to increase" on one measurement - the channels of the representations (visual, audial, kinestetic). Then it will be possible to write the strategies of the interpreting by the persons their own sufferingses - a successful experience, failures, creative inspiration and other straight on scheme 9-Windows /lit 2/. This will allow to express graphically the physiological difference between conditions of the person. and his behaviour, and to correct conciously its internal experience, construct the positive strategies of the behaviour.

2.3 10 typical plans of conflict situations

For the analysis of the problems of personalities, interpersonal relations it is comfortable to use TRIZ-tool "10 typical plans of conflict situations". However their also necessary "to increase" on one measurement - channels of representations (visual, audial, kinestetic). It will allow to express graphically, on what level of personalities are found the contradictions, and to solve them by means of other TRIZ-tools.

TRIZ-tool "10 typical plans of conflict situations" possible also use in NLP-model for definition of key elements of problem space SCORE. This will allow to add concreteness, directivity action specialist on discovery attribute key elements of problem space SCORE /lit4/.

3. The opportunities for TRIZ-specialists

"It is much more interesting to discuss not that someone has told or has written, but that we have seen in it or we can see and take for ourselves"
R.DILTS about loved phrase NLP-specialists

Brought above the analogies between the tools TRIZ and NLP allow to draw a conclusion that TRIZ develops that skills of the thinking, which NLP successfully uses for decision of the problems of personalities, groups, organization. It is possible say, that TRIZ-specialist even not visualizes that problems, which he can solve by itself and for improvement of the own life, however the volume this report even does not allow to enumerate them. Having familiarized in the literature with those tasks which solves by NLP, TRIZ-specialist will quickly master any NLP-tools. Thereby, TRIZ-skills of personalities are a resource which is not used at present for expansion of the social problems.

The transfer of their own "technical" skills of TRIZ-thinkings in personal context will allow a Personality:

- To overcome own limiting statements independently and to create successful positive strategy of behaviour in the varying world;
- To modeling and to use for itself successful behaviour of other people
- To solve internal and interpersonal conflicts;
- To expand own internal resources and "a map of the world";
- To increase a self-estimation;
- a Creative group TRIZ-specialists:
- To adjust the successful communication at the decision of the problems;
- To study the successful strategy each other, intensifying the potential of each and of groups as a whole;
- a Firm having TRIZ-specialists:
- To increase personal efficiency of employees;
- To create the internal facility of the organization and to develop dinamic even in disadvantage ambience.

NLP is widely used all over the world by the organizations (The World Bank, IBM Europe, BMW, ISVOR FIAT, ect.) for training employees to various marketing communications (sales, PR, advertising, etc.), and also in different areas of management /lit 7/. Some of these organization train other part of their own employee to TRIZ-method.

The Hypothesis is: if to train working in organizations TRIZ-specialist to NLP-tools, it will give a cinergetic effect for a firm. Business behind experiment.

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/Lit 7/ http://www.nlpu.com

TRIZ for people: psychological aspects

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Aachen, November 14, 2003

Figure 1

TRIZ: 9-Windows

Past	Present	Future
	The Technical System	

Source:

Figure 2

TRIZ: 9-Windows = The Map of the world?

Past	Present	Future
	?	
	I	
	?	

Source:

Figure 3

NLP (Bandler&Grinder, 1975)

Neuro-Lingvistic Programming (NLP) – system's solve the problems of the personality, formalization successful creative experience for learning people

For:

- **better understanding one's own identity and mission;**
- **helping people reach their full potential;**
- **sponsoring change and growth at the identity level;**
- **support personal growth in a business environment**

Source:

Figure 4

NLP: The Map of the world and TRIZ: 9-Windows

The Logical levels

Past	Present	Future
	Spiritual, Mission ⇓	
	Motivation ⇓	
	Identification I ⇓	
	Strategies and abilities ⇓	
	Actions ⇓	
	Environment, Situation	

Source:

TRIZ FUTURE 2003

Figure 5

NLP: The Map of the world

The Logical levels	The Questions
Spiritual, Mission ⇓	The particle what, much greater system I show? What is my mission? What is my spiritual destination?
Motivation ⇓	Why? My motives, value, beliefs
Identification ⇓	Who I am?

Source:

TRIZ FUTURE 2003

Figure 6

NLP: The Map of the world

The Logical levels	The Questions
Strategies and abilities	As? My strategies, abilities, characteristics
Actions	That to do? My behaviour, actions
Environment, Situation	Where, when, with whom, how much? Reactions on roving

Source:

TRIZ FUTURE 2003

Figure 7

NLP: The Map of the world and TRIZ: 9-Windows

Past	Present	Future
	Spiritual, Mission	
	Motivation Negative Beliefs	
	Identification I	Negative Future I
	Strategies and abilities	
	Actions	
	Environment, Situation	

Source:

TRIZ FUTURE 2003

Figure 8

NLP: The Map of the world and TRIZ: 9-Windows

Past	Present	Future
	Spiritual, Mission	
	Motivation Positive Beliefs	
	Identification I	Positive Future I
	Strategies and abilities	
	Actions	
	Environment, Situation	

Source:

Figure 9

NLP

Re-framing

is the transfer

Negative Beliefs → to Positive Beliefs

Negative Future → to Positive Future

Source:

Figure 10

NLP: Re-framing

**The Primary function is:
to teach people to realized switch attention**

from the frame of the problem → to the frame "result"

from the frame of the mistake → to the frame "feedback"

from the frame of impossibility → to the frame "as if"

Source:

Figure 11

NLP and TRIZ

14 principals of re-framing by R.Dilts
are analogies to

40 Altshuller's Inventive Principals;

9-Windows, the System Operator

Source:

Figure 12

NLP:The internal interpreting of the experience and TRIZ: 9-Windows

Visual + Audial + Kinestetic Axies

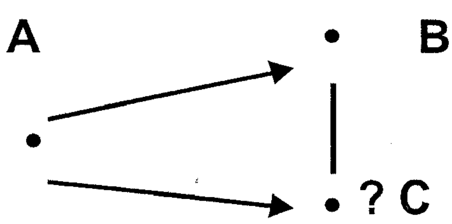
Past	Present	Future
	Spiritual, Mission	
	Motivation	
	Identification	
	Strategies nd abilities	
	Actions	
	Environment, Situation	

Source:

Figure 13

NLP:The internal interpreting of the experience and TRIZ: 10 typical plans of conflict situations

Visual + Audial + Kinestetic Axies



Source:

Figure 14

NLP- Problem solving and TRIZ:

The SCORE-model is

S - symptom,
C - couse,
O - outcome,
R - resouces,
E - effect.

Source:

Figure 15

NLP- Problem solving:

The Description of problem space

The SCORE-model

are analogies to TRIZ

S (symptom) = Undesirable effect;
C (couse) = Operative zone, Formulation of the contradiction;
O (Outcome) = Ideal Final Result;
R (resouces) = Resouces, X-element;
E (effect) = Primary function.

Source:

Figure 16

TRIZ- tools and NLP- tools

are analogies in:

The model of the world
Re-framing
Problem solving
Modeling of the abilities

Source:

Figure 17

TRIZ- tools and NLP- tools

May be connect

in:

The model of the world
Re-framing
Problem solving
Modeling of the abilities

Source:

Figure 18

The Stages of transfer
TRIZ-skills to NLP-skills

1. To apply TRIZ-skills for solve of social problems (tasks) realized

2. Learn to define "attribute ", "level" in the personal and organizing systems:
   - by NLP-seminares
   - by NLP-literature

3. To connect TRIZ-skills and NLP-skills for reach itself full potential

Source:

Figure 19

The Stages of transfer
TRIZ-skills to NLP-skills

«Training technique of TRIZ elements with the help of "Bob of toy»:

How to apply the Altshuller's Inventive Principle

- in close area (toys)
- in mean area (subjects of a household activities)
- and distant (social systems) areas.

Source:

Figure 20

The Stages of transfer
TRIZ-skills to NLP-skills

Project "The Exhibition of toys - inventions"

How to apply the Altshuller's Inventive Principles

- in toys - for children and its parents
- in mean areas - for parents
- in social systems - for parents

Source:

Figure 21

The NLP-opportunities for TRIZ-specialists

TRIZ-skills of personalities are a resource which is not used full at present for solve of the Social and Personality problems

TRIZ+NLP connect to allow

- To expand own internal resources and «a map of the world»;
- To create successful positive strategy of behaviour in the varying world;
- To modeling and to use for itself successful behaviour of other people;
- To solve internal and interpersonal conflicts;

Source:

Figure 22

The opportunities for a firms with TRIZ+NLP-specialists:

- To increase personal efficiency of employees;
- To study the successful strategy each other, intensifying the potential of each and of groups as a whole
- To create the internal facility of the organization;
- To develop dinamic even in disadvantage ambience

Source:

TRIZ FUTURE 2003

Figure 23

The end

" It is much more interesting to discuss not that someone has told or has written, but that we have seen in it or we can see and take for ourselves"

R.Dilts

Source:

TRIZ FUTURE 2003

Figure 24