The Invention Machine

Computational adaptation of TRIZ, Value Engineering and the Semantic Web

Thanks to Invention Machine and

Dr. Mikhail Verbitsky for materials and consultation and

SDM04 students who participated

Our goal is to convert conventional qualitative methods of conceptual design into a formal approach:

predictable,

well defined,

reproducible,

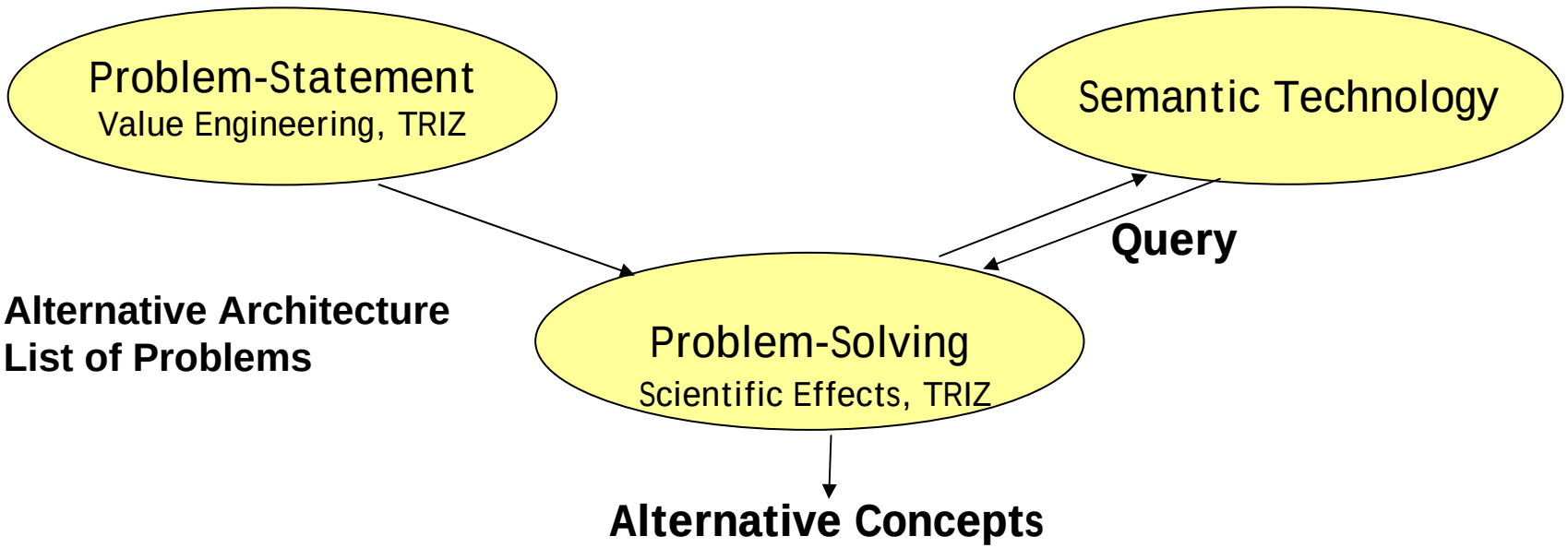
quantitative

process

Agenda

- **Overview of Innovation Tools: Problem Statement and Problem Solving tools, their logic and interaction**
- **Problem Statement Tools: Design Diagnostics, Ideal Design, Alternative Architecture Research**
- **Problem-solving tools: Traditional TRIZ**
- **Problem-solving tools: Semantic TRIZ**

Innovative Conceptual Design Applications



(1) Value = Function Rank/(Problem rank + Cost)

(2) Ideal system = Lim (Value)

Function Rank = const
Problem Rank = 0
Cost = 0

Roadmap of Innovative Conceptual Design

Process Milestones	Goal
1. Value Equation Development	To develop major criteria of design diagnostics, identify object of diagnostics
2. Function Modeling	To translate existing knowledge about current design into comprehensive product design functional model
3. Functional model verification and diagnostics	To verify model calculations (function rank, problem rank) against empirical knowledge, to identify relative component value
4. Strategy Synthesis	To explore and identify new configuration-architecture, which can increase overall design value. To identify what new physics is necessary to achieve this goal
5. Concept Generation	To research new Physics and existing technical solutions capable to solve problems which have been identified during Strategy Synthesis stage
6. Concept Selection	To select most feasible concepts

5710533 : Electrical transformer with reduced fan noise

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ASSIGNEES: **General Electric Company**, Schenectady, NY

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U.S. CLASS: **336/100**; 181/202;

FIELD OF SEARCH: **336-100,59,92** ; **181-202,204,208** ;

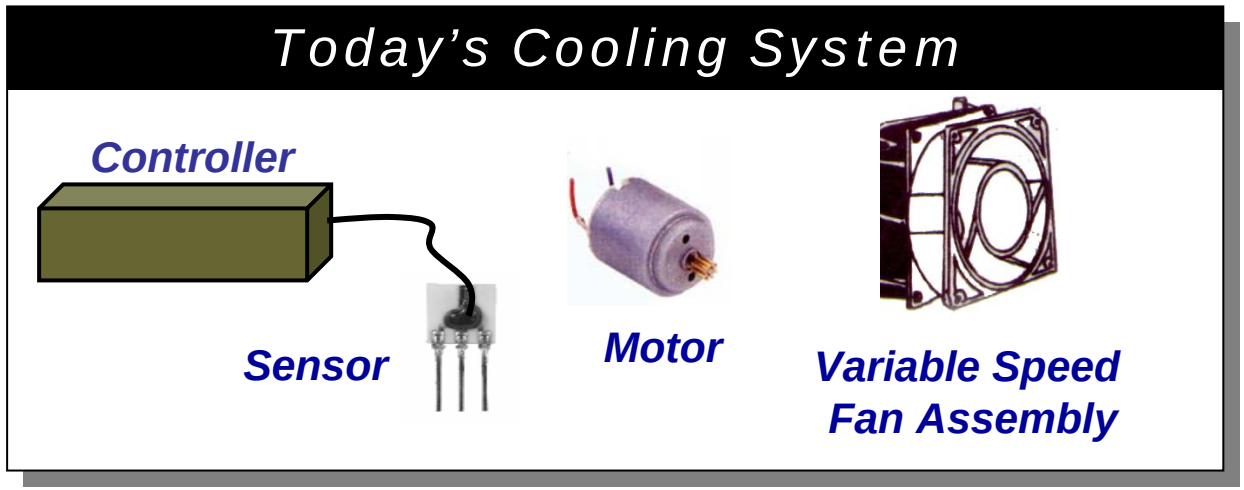
ABSTRACT: An electrical transformer includes a housing, a transformer core and winding subassembly located in the housing, and a cooling fan subassembly. The cooling fan subassembly includes a variable speed fan located outside the housing, a temperature sensor located near the housing, and a controller having an output port connected to the variable speed fan and an input port connected to the temperature sensor. The controller reduces the fan speed (and hence the fan noise) when a lower fan speed can maintain the desired temperature as sensed by the temperature sensor. Preferably, the electrical transformer further includes an active mount subassembly and/or (when the housing includes a tank containing transformer fluid) a mechanism for varying the dynamic pressure of such transformer fluid.

U.S. REFERENCES: (No patents reference this one)

- *Transformer*
- *Variable Speed Cooling Fan*
- *Temperature Sensor*
- *Controller*

Engineering Situation:

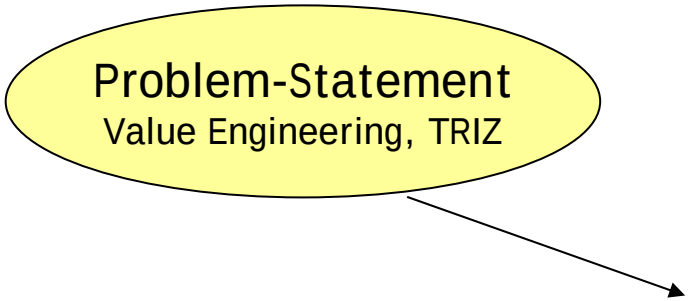
- *High warranty problems due to overheating*
- *Cooling system has a sensor & controller to activate & control fan for noise reduction & cooling.*



Today's Problems:

1) System does not cool well enough
2) Sensor is not accurate - leads to overheating
3) Customers complain about Noisy Fan
4) Management pressure to reduce costs

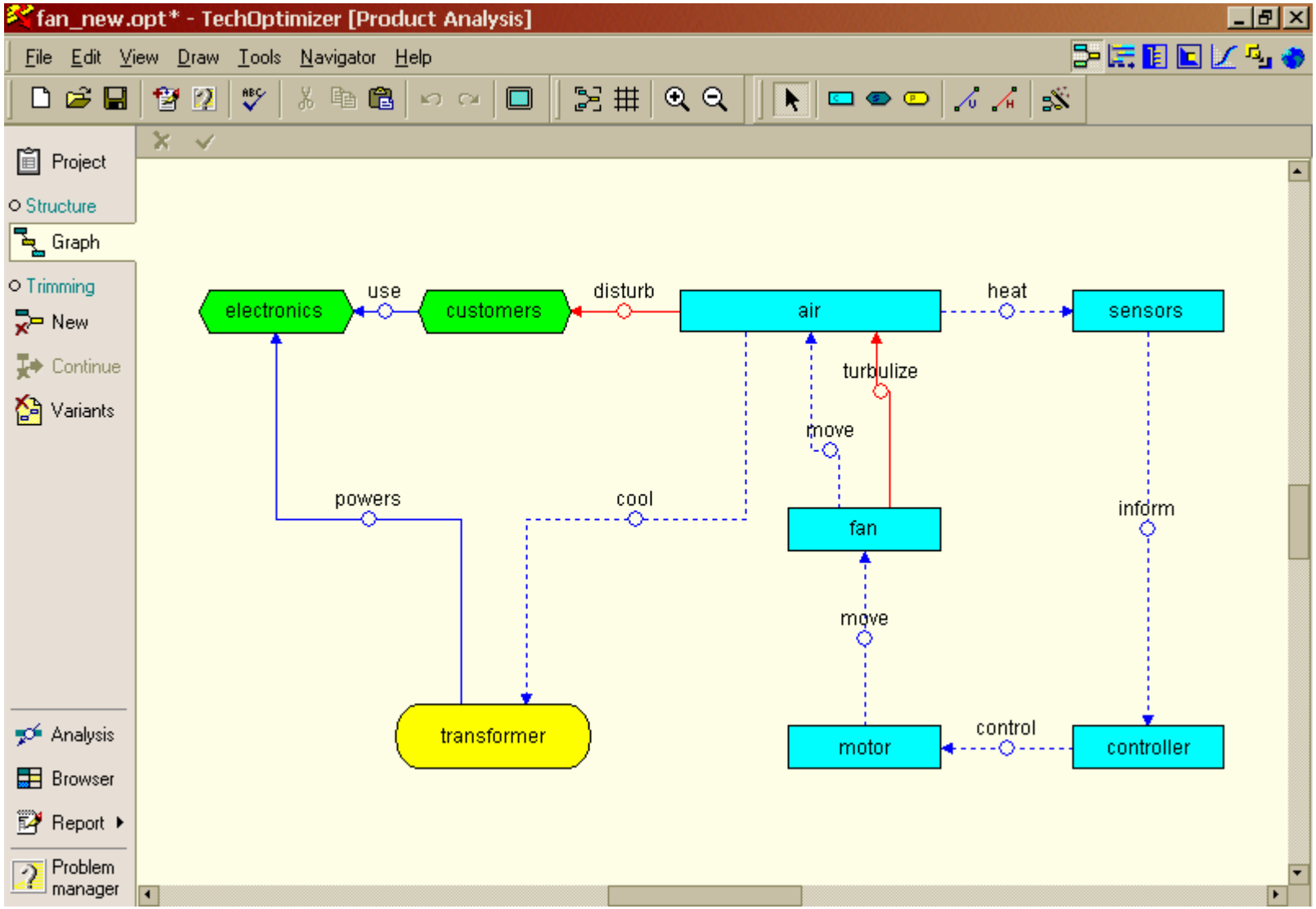
Step 1: Value Equation Development



Alternative Architecture
List of Problems

$$\textbf{Value} = F/(P+C)$$

Step 2: Function Modeling



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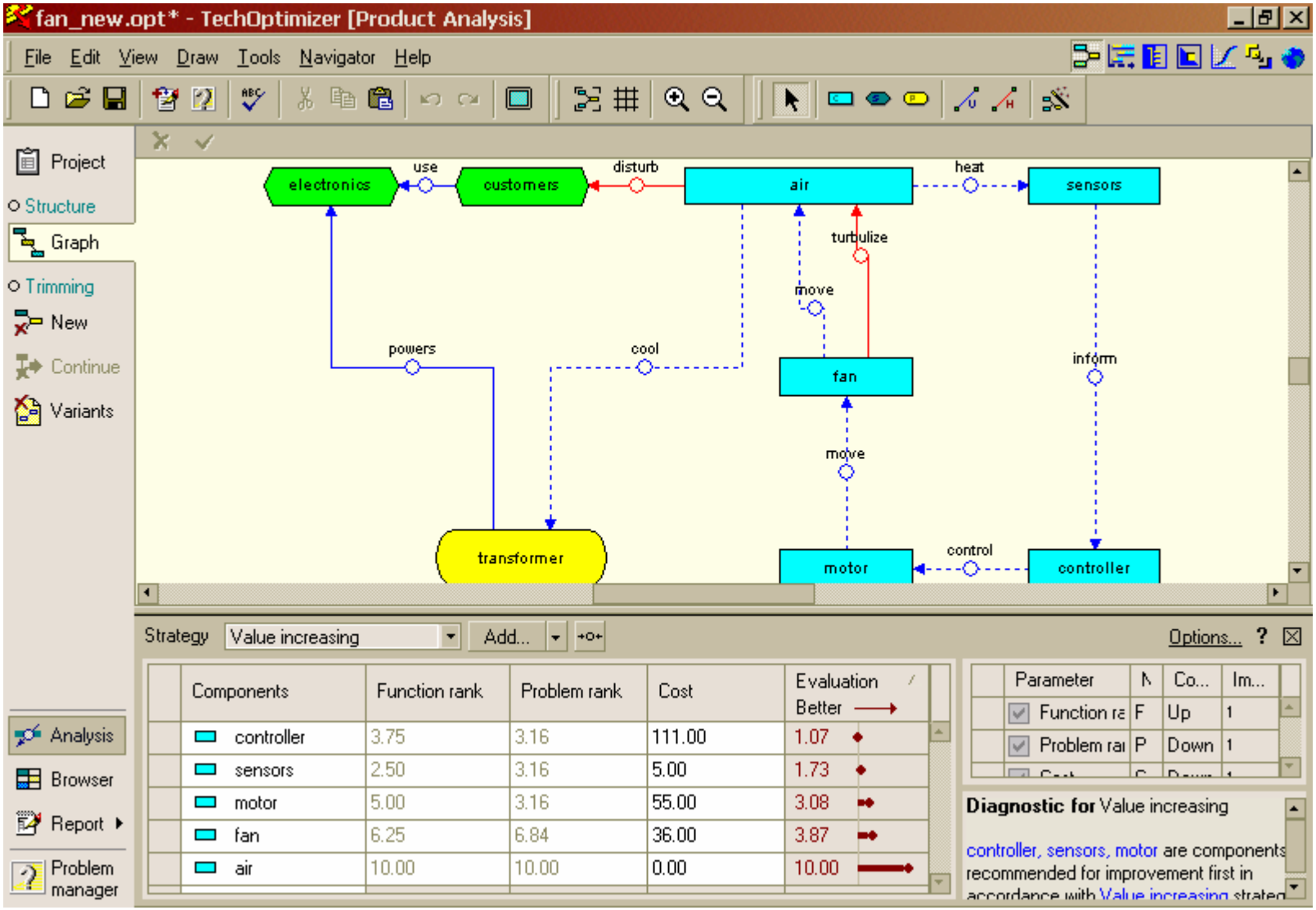
Step 3: Model Verification and Diagnostics



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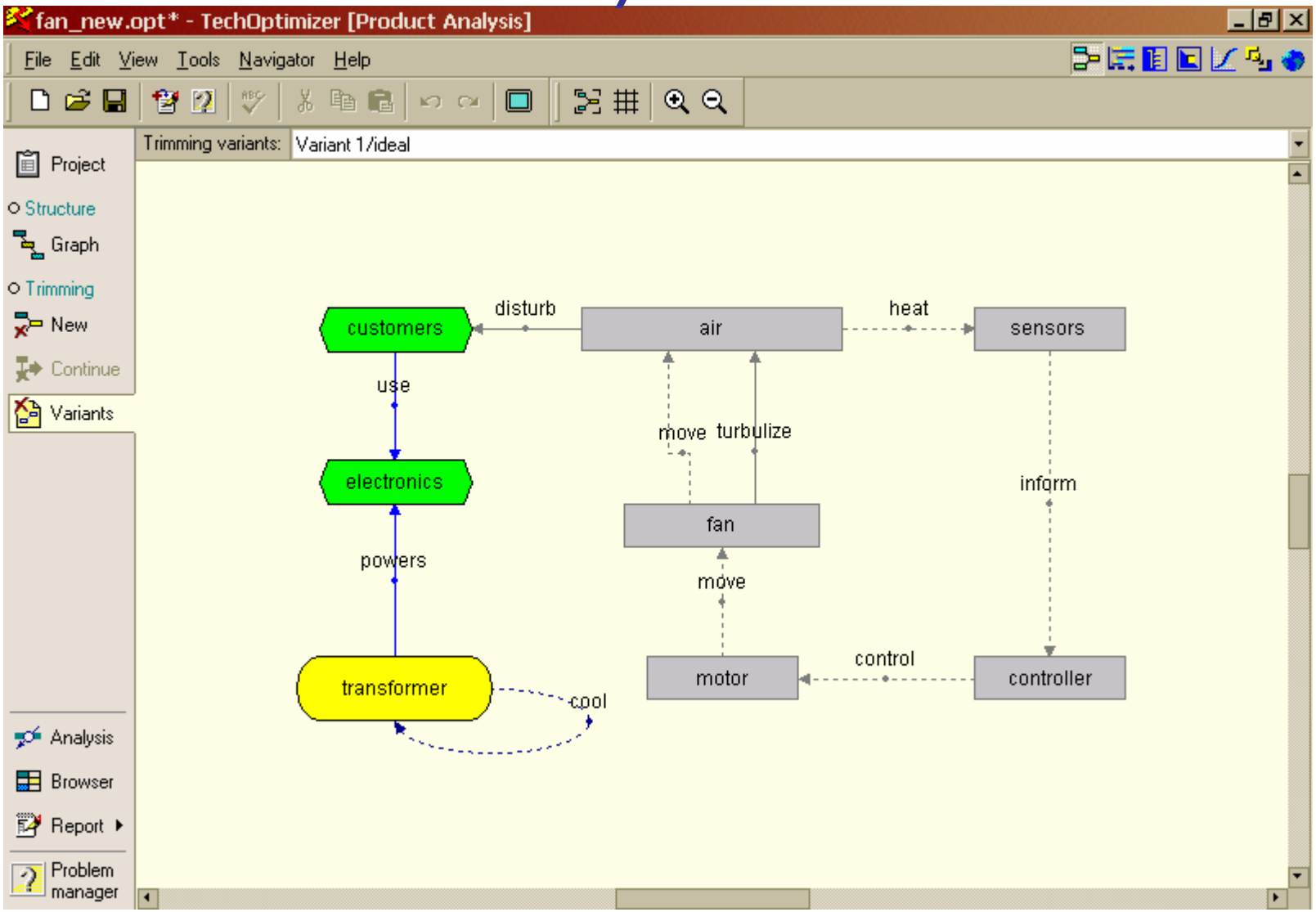
Step 4: Strategy Synthesis (Alternative Architecture Research)

Two strategies to approach Ideal System:

1. Improve low value components

2. Remove low value components from the design, but preserve their functionality

Step 4: Strategy Synthesis (Alternative Architecture Research)



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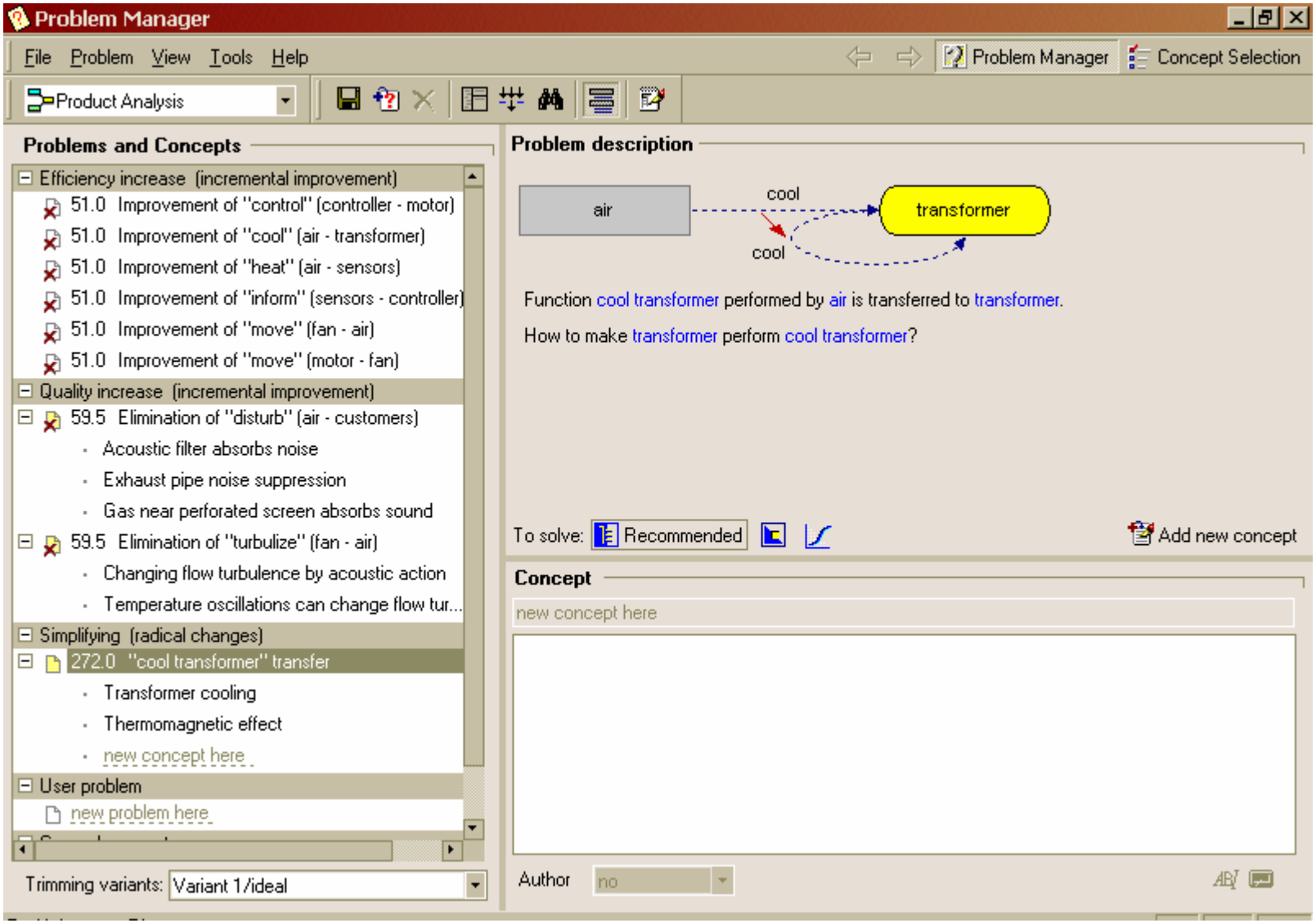
Step 5: Concept Generation



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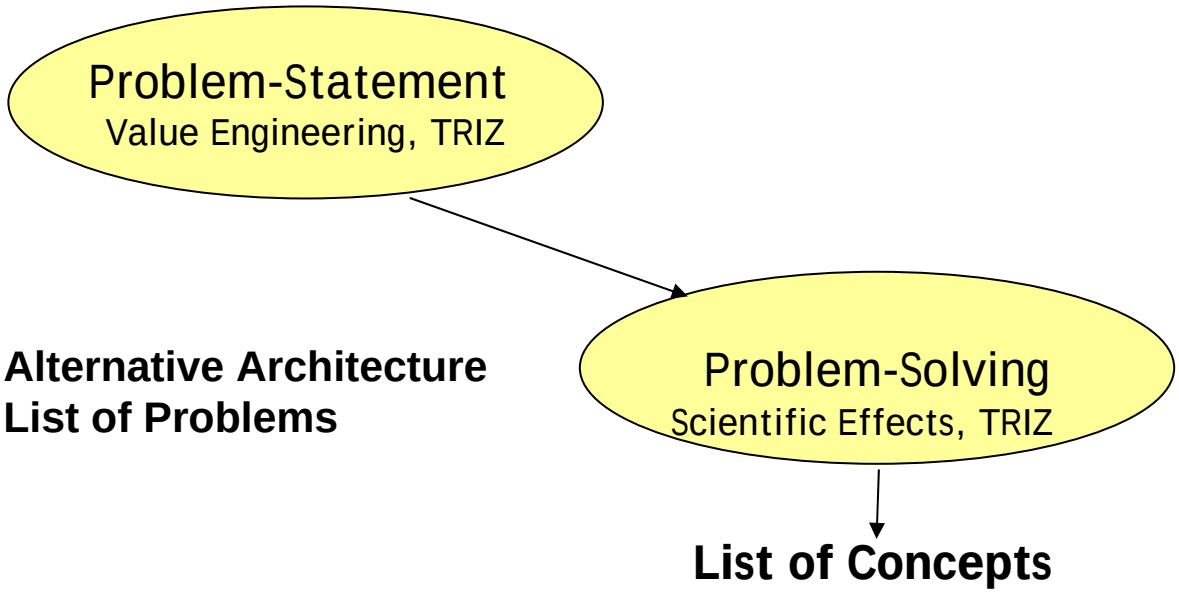
Problem-Solving (Concept Generation Process)



Postulates of Conventional TRIZ

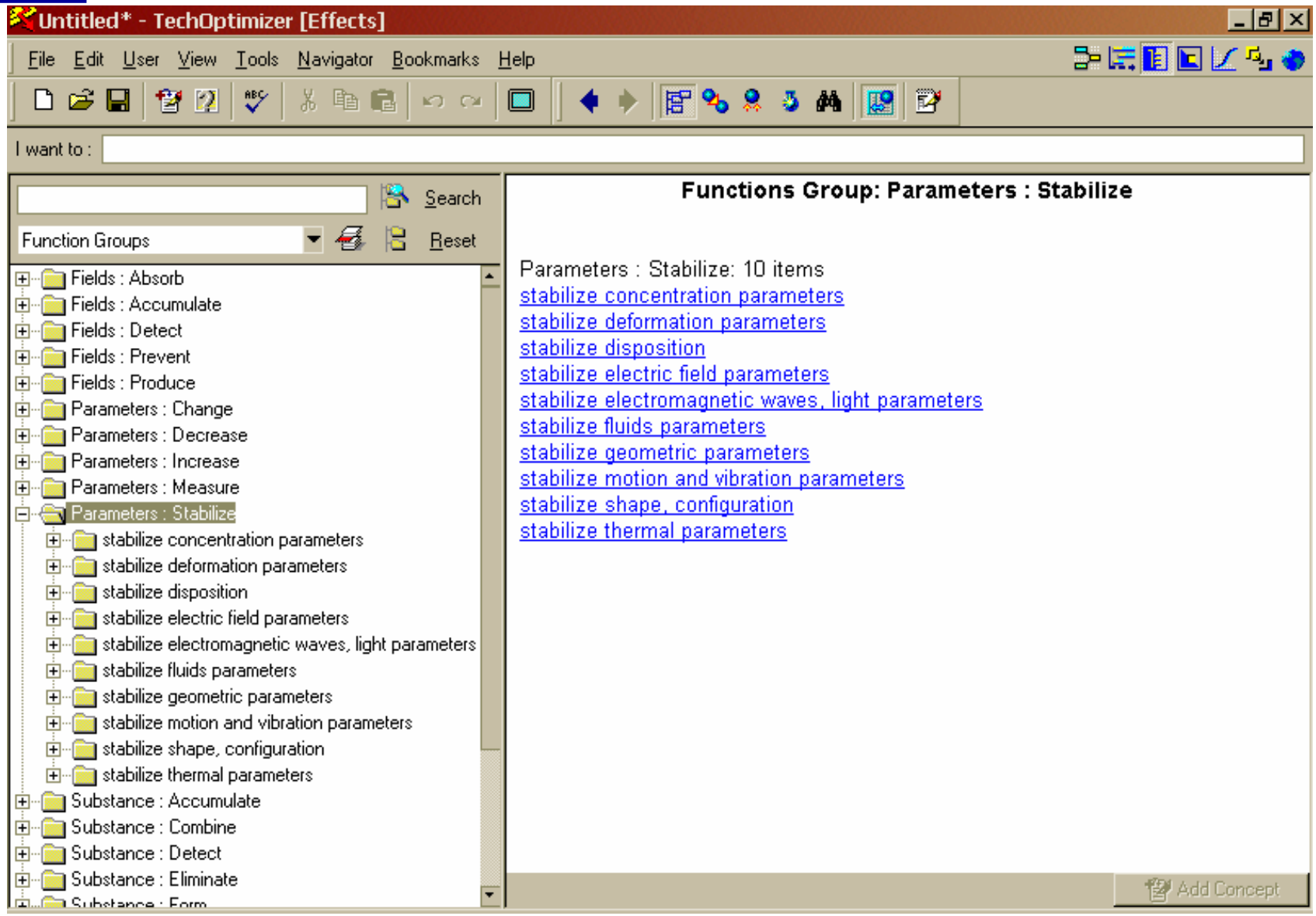
1. **Problems and solutions were continuously repeated across different industries: Different solutions solve the same contradictions**

2. **Patterns of technical systems evolution are repeated across different industries. Systems are being developed in the directions of:**

   (i) increased ideality; (ii) increased degree of flexibility

3. **Best innovations use scientific effects from different fields**

Traditional TRIZ: Effects



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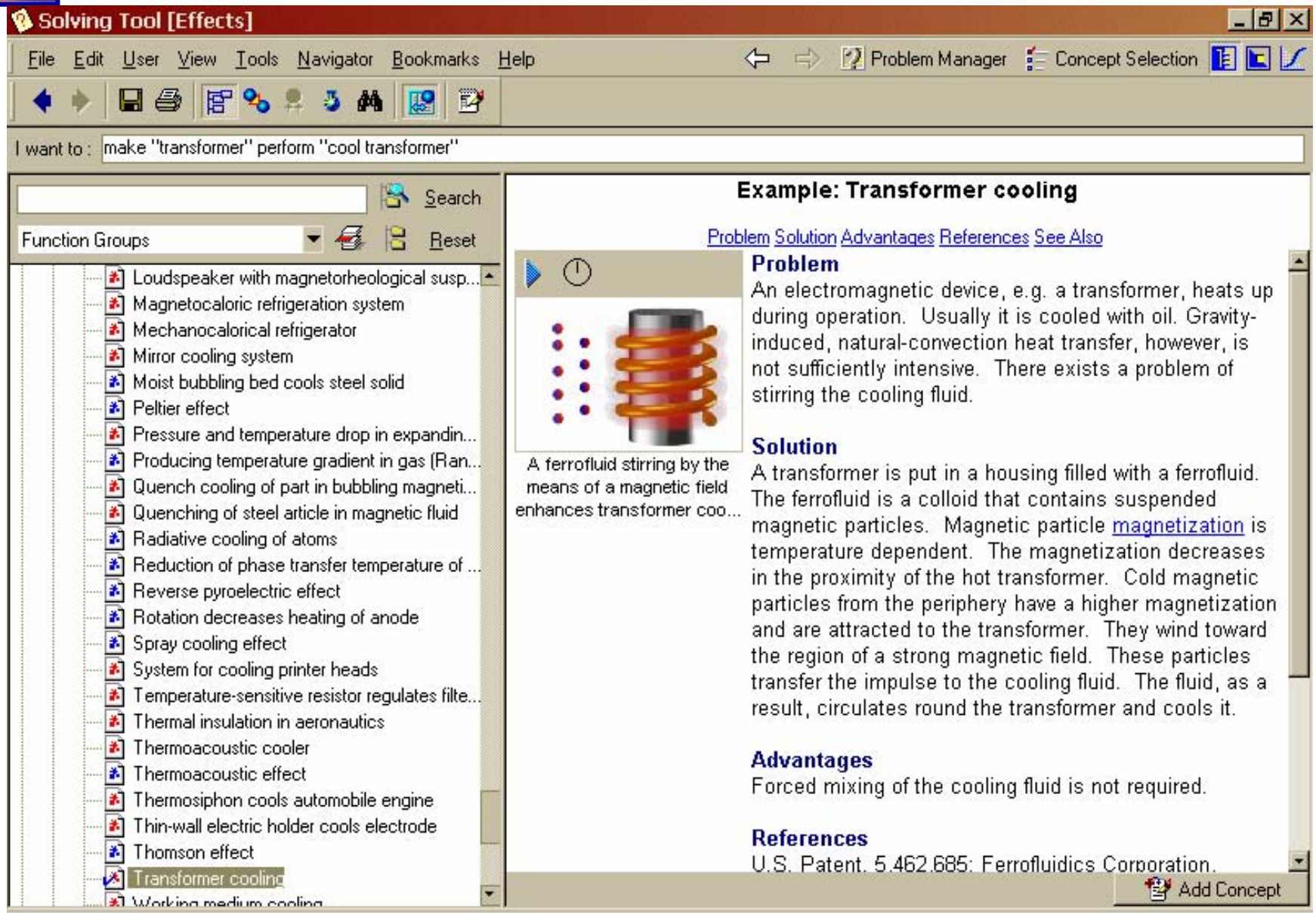
Traditional TRIZ: Effects



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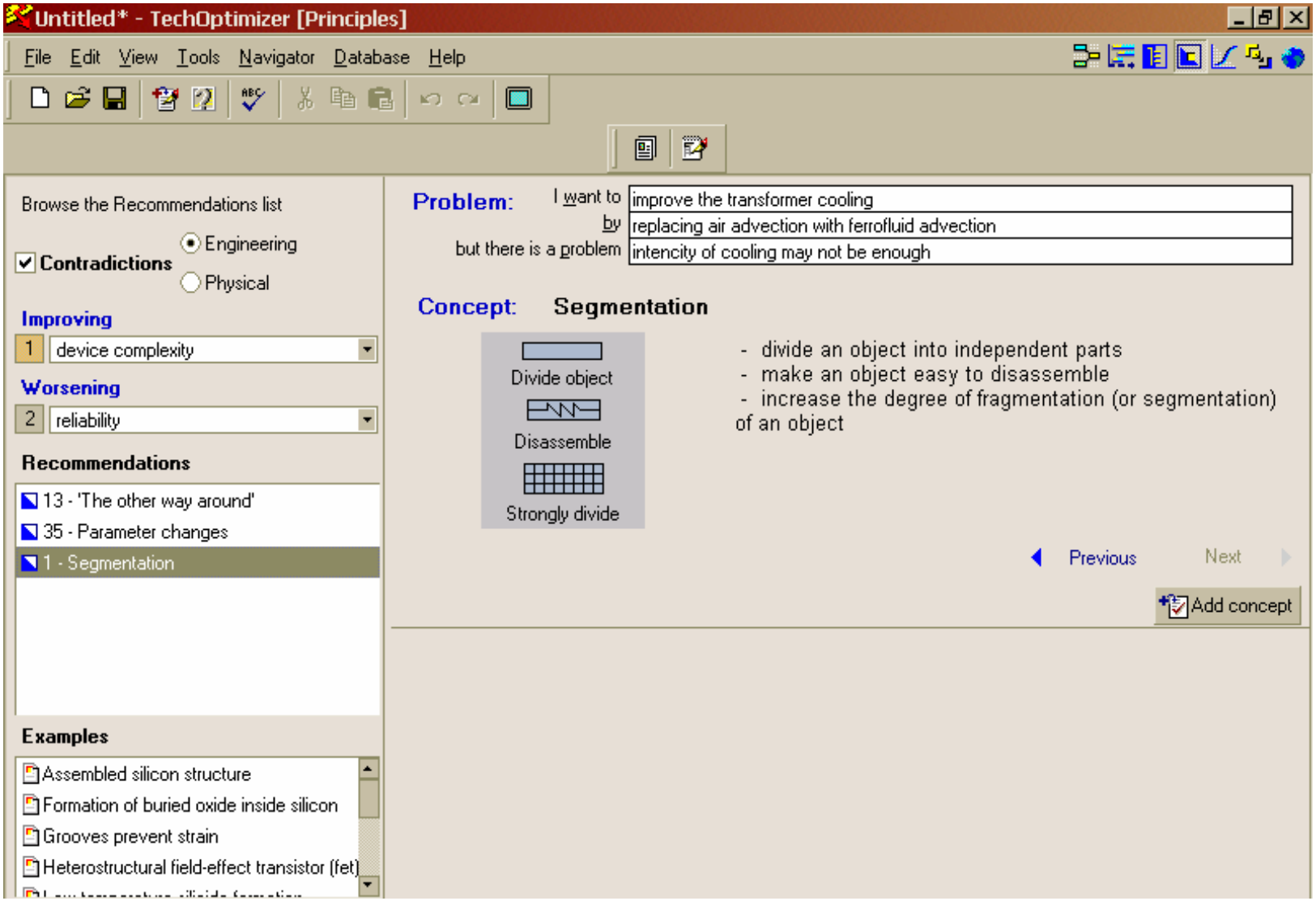
Traditional TRIZ: Matrix of contradictions



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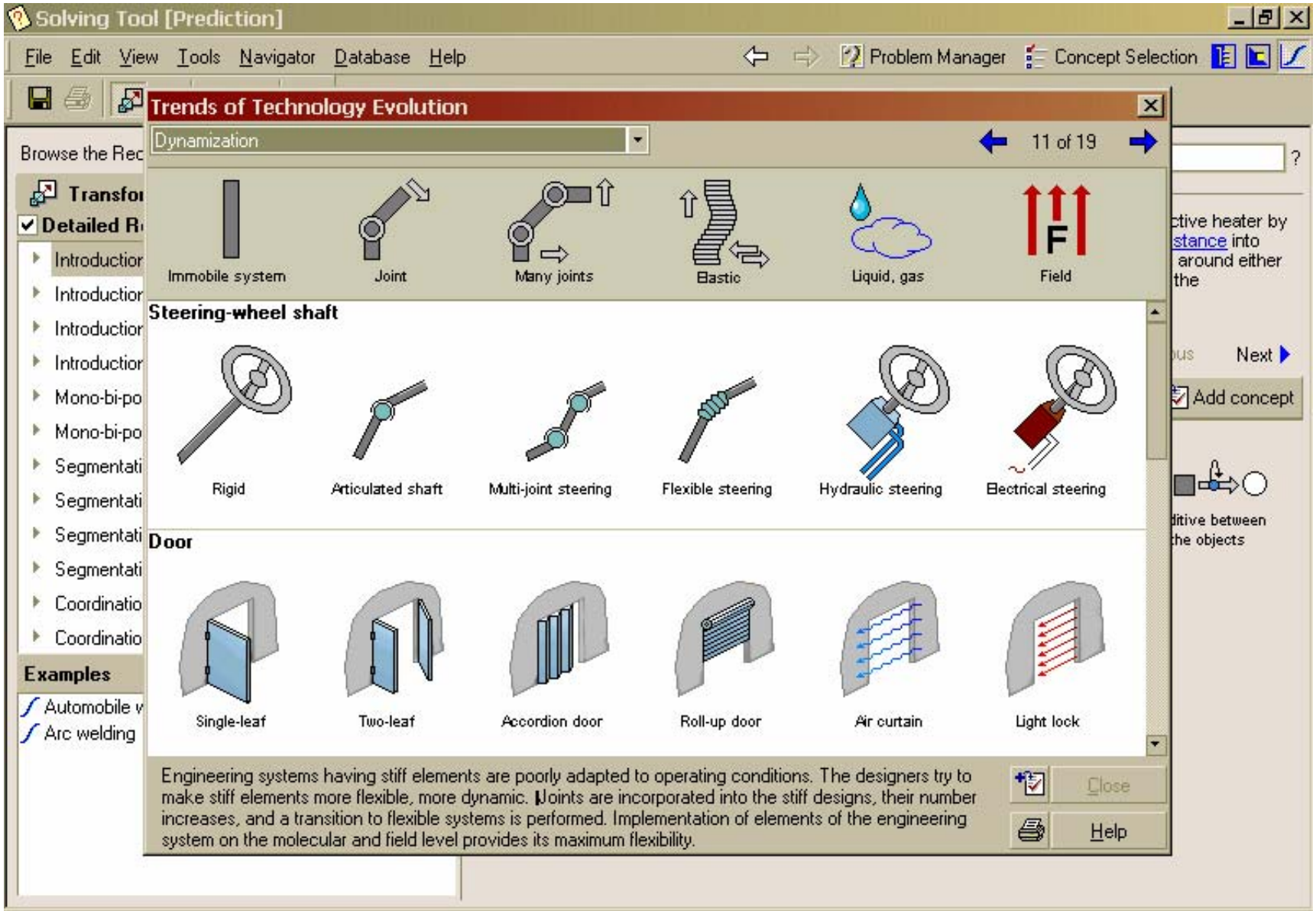
Traditional TRIZ: Trends of Evolution



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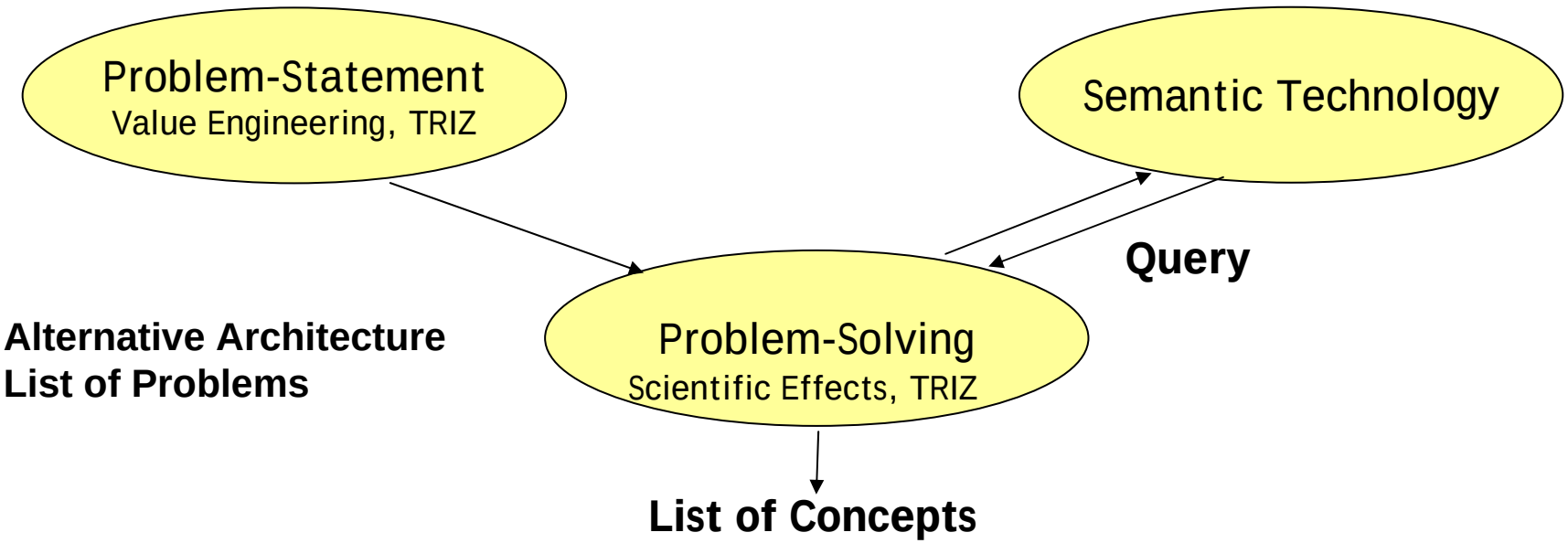
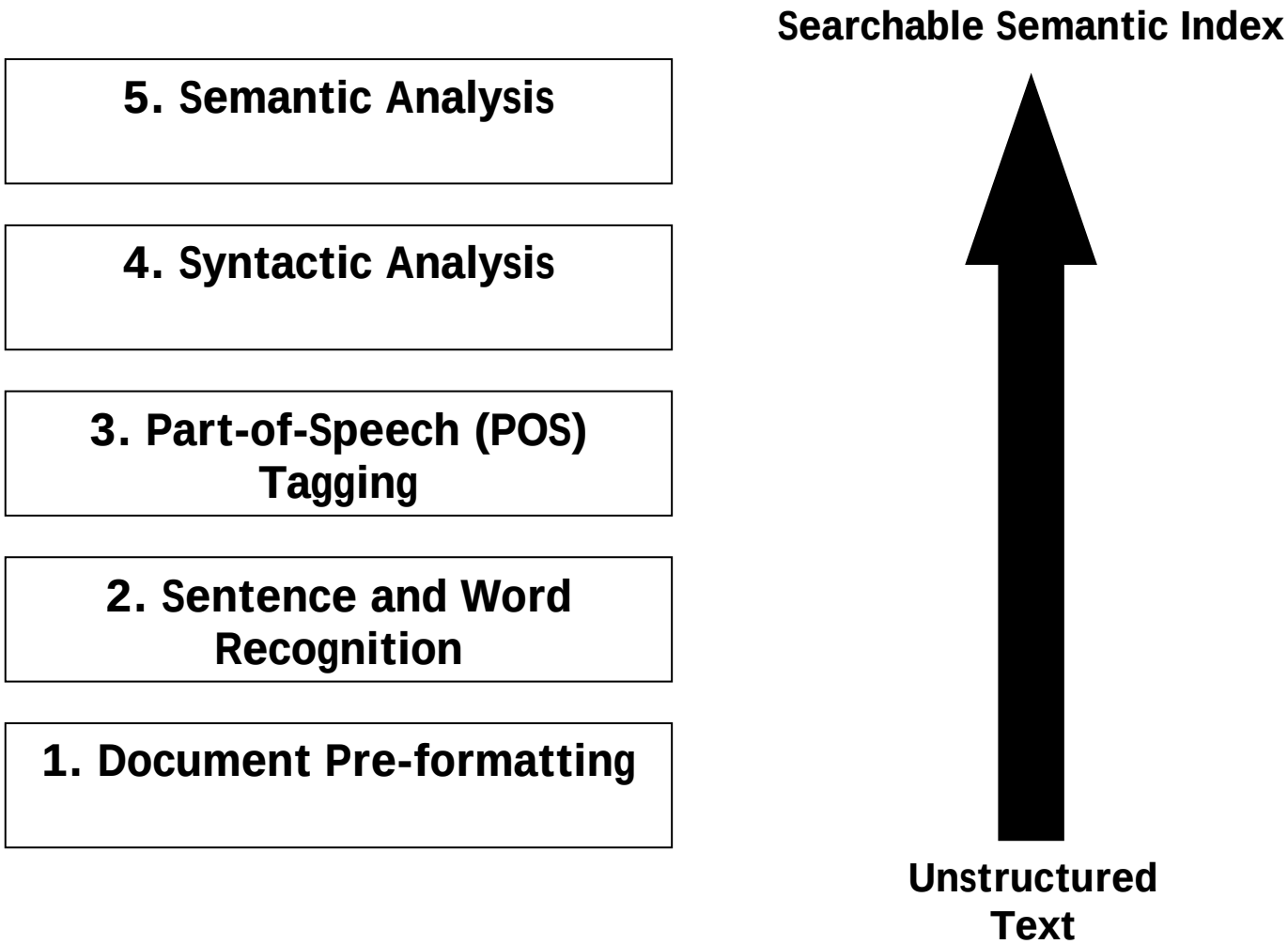
Some Questions…

- **Is the Contradictions Matrix statistically stable to a number of patents analyzed?**
- **Are discovered trends of technology evolution statistically stable to a number of patents analyzed? Do they cover all existing trends in the current world of technology?**
- **How does one cross a chasm from a general recommendation to a specific innovative idea?**

Semantic TRIZ



Semantic Processing Stages

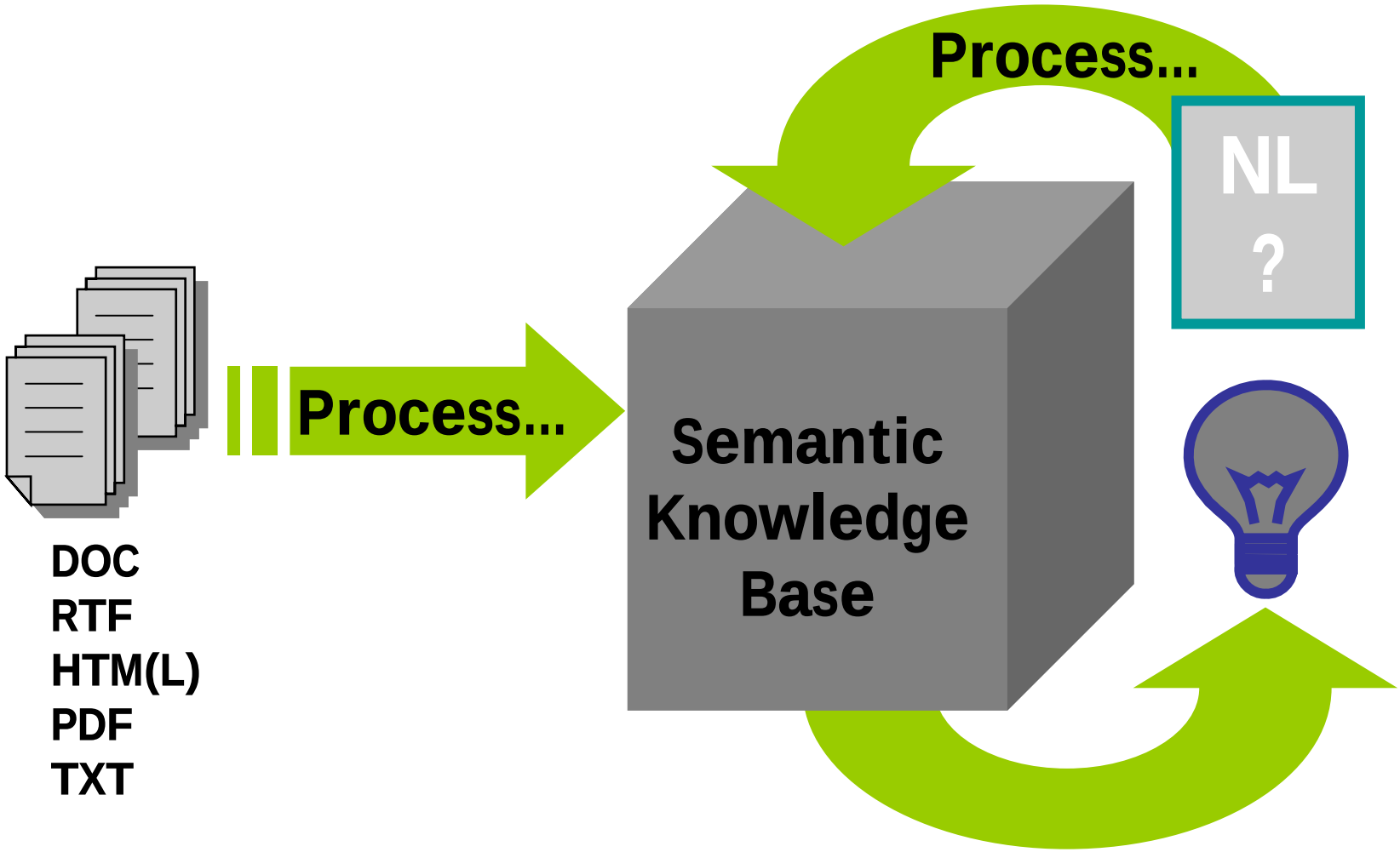


Sample content:

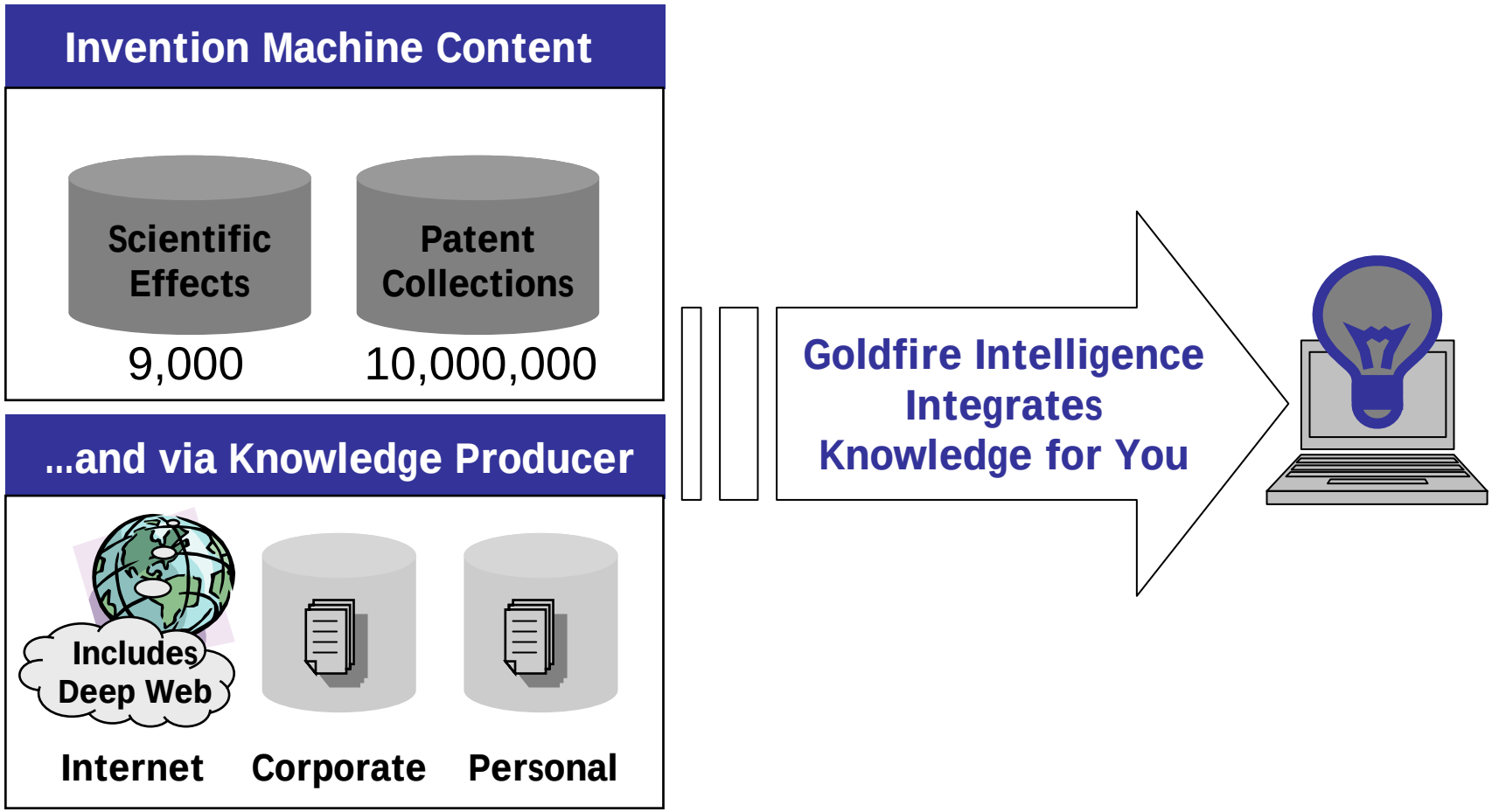
"Or the **Curie temperature** can be **controlled** by using **two or more rare earth elements** and adjusting the composition ratio between them."

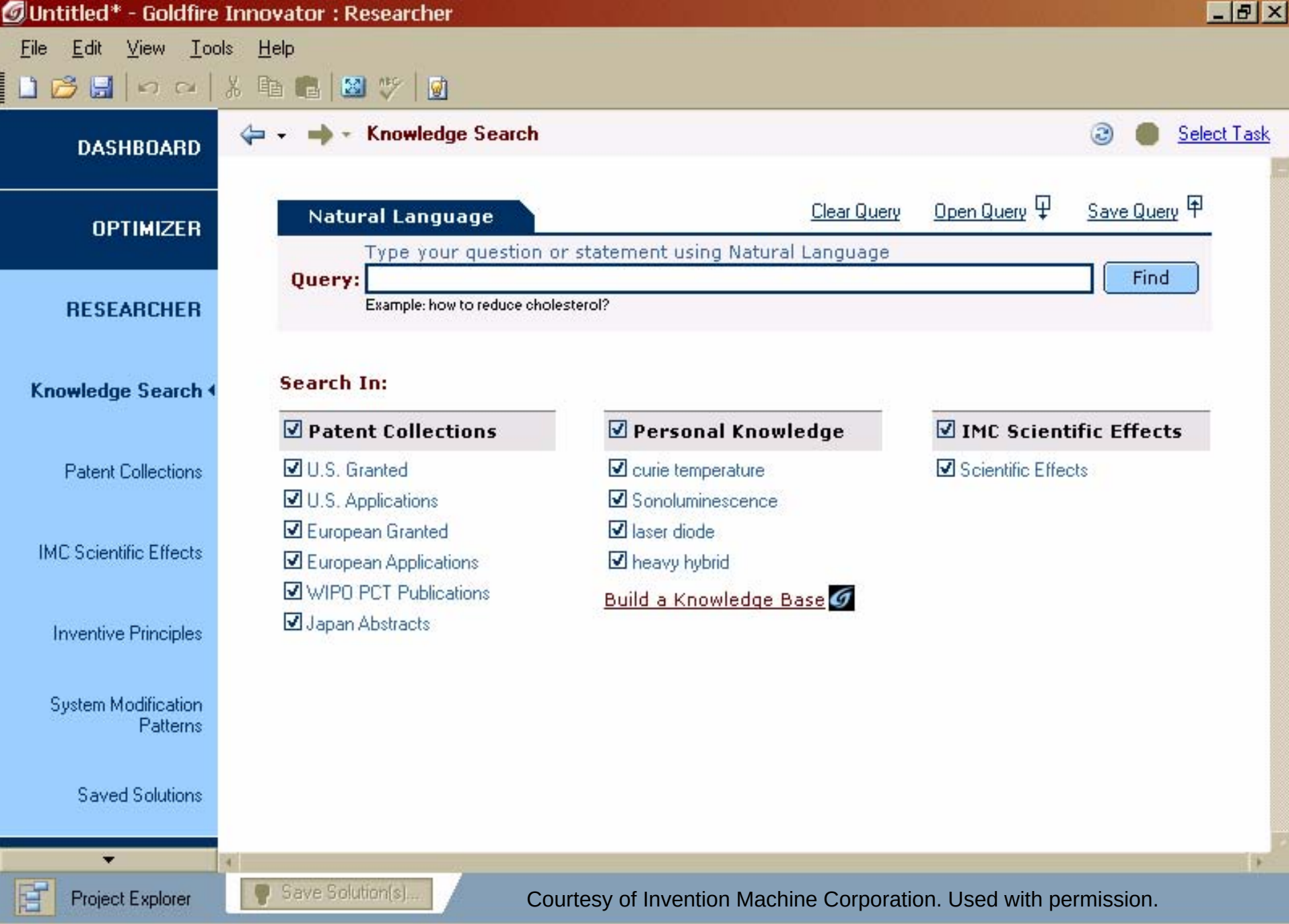
	Subject	Action	Object
	Earth elements	control	Curie temperature
1. What controls Curie temperature?	?	+	+

Goldfire Innovator matches the semantic structures of your query to the semantic structures in the Knowledge Base



Access to External and Internal Intellectual Assets





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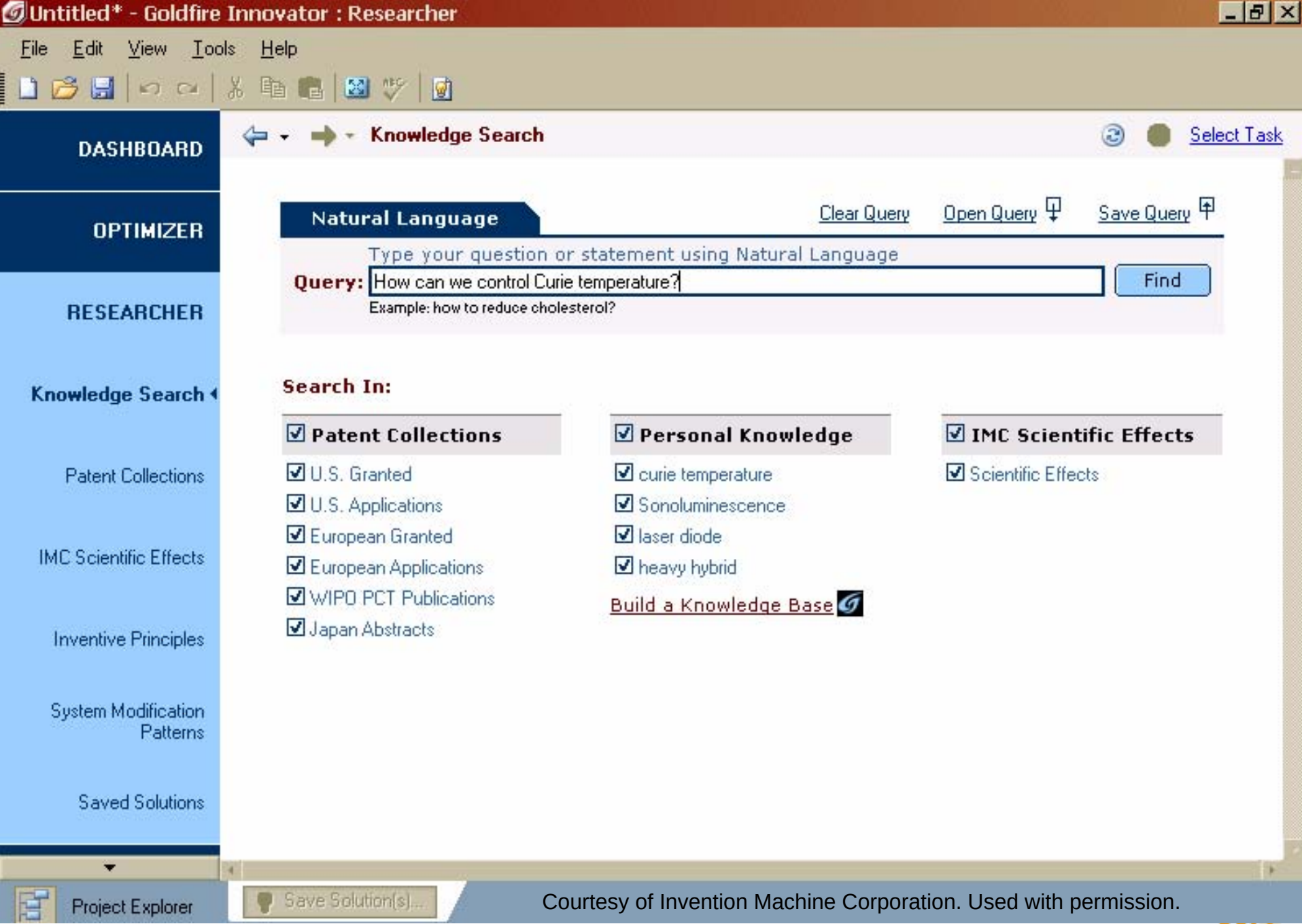

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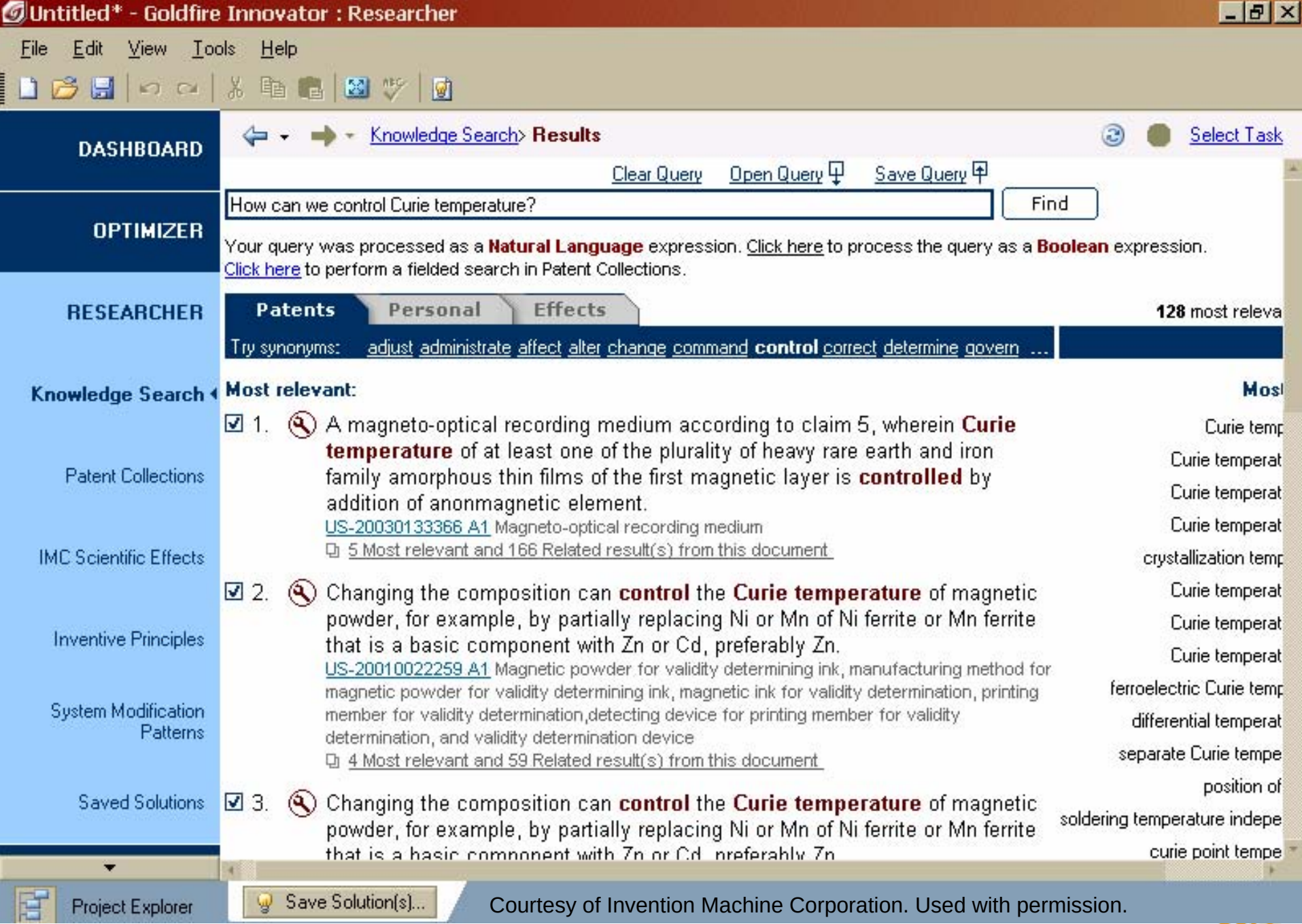

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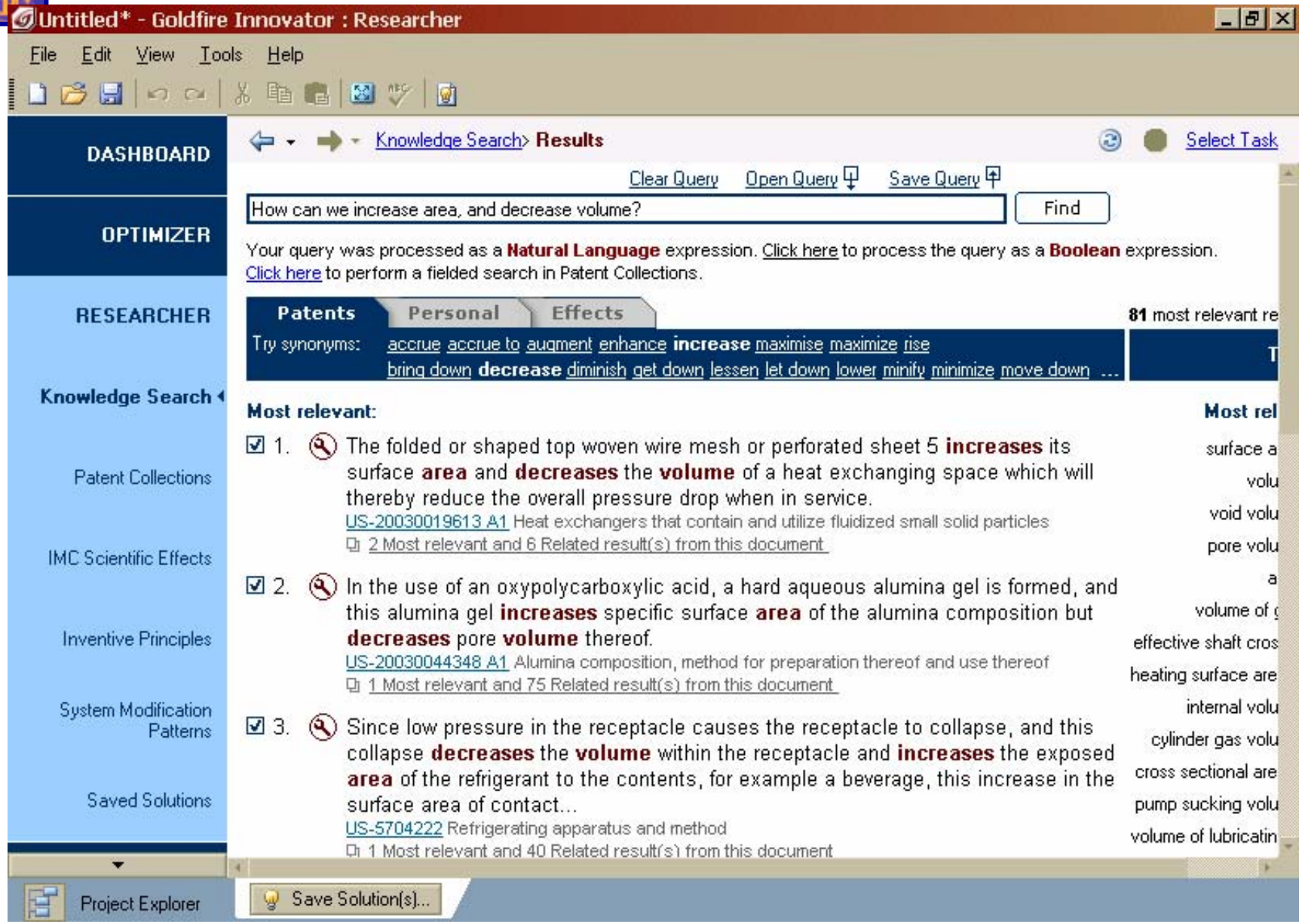
Innovator as a Contradiction Table



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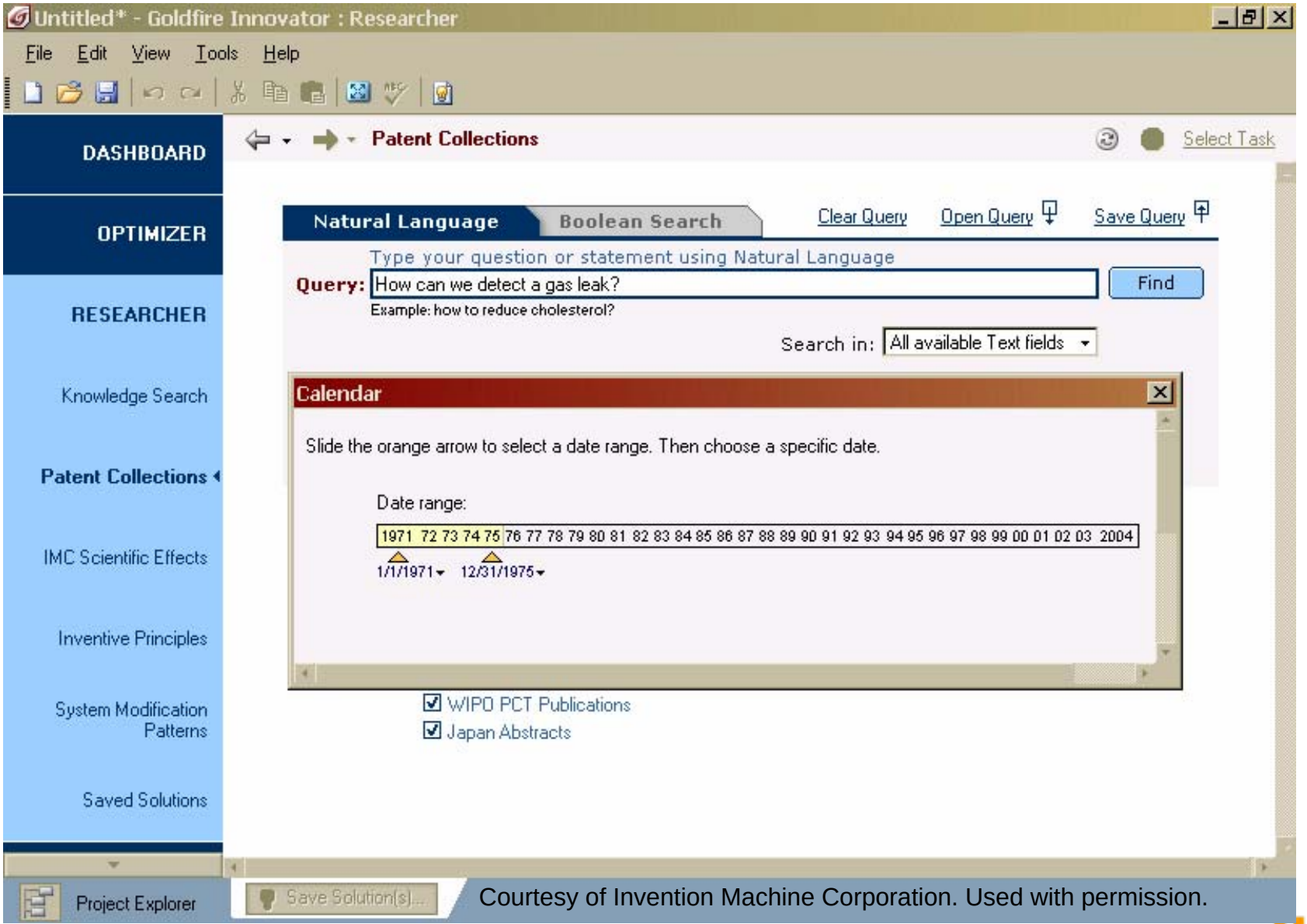
Innovator Generates Trends of Technology Evolution



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	A	B	C	D	E	F
1	**1971-1975**	**1976-1980**	**1981-1985**	**1986-1990**	**1991-1995**	**1996-2000**
2	15	24	39	98	99	137
3	acoustic		acoustic			acoustic
4	radiactive	radioactive				
5	heat	heat	heat	heat		heat
6	electro-magnetic	electro-magnetic	electro-magnatic	electromagnetic	electromagnetic	electromagnetic
7	mechanical	mechanical	mecahanical	mechanical	mechanical	mechanical
8	chemical	chemical	chemical	chemical	chemical	chemical
9		ionization		ionization	ionization	ionization
10		video system	video system			
11			optic, lasers, fiber optic	optic, lasers, fiber optic		
12				infra-red radiation	infra-red radiation	
13				flurocarbon tracers		odor tracers
14						audio-visual
15						mass spectrometra
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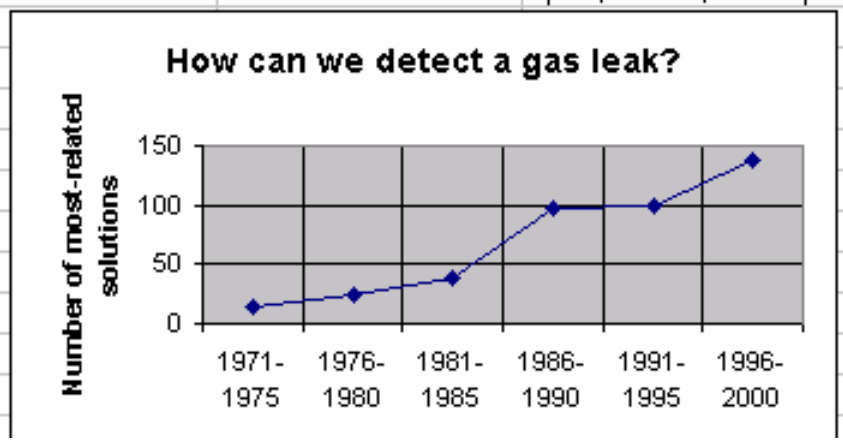

Conclusions

- Major steps of innovative design: (i) diagnostics of the current design; (ii) identification of the ideal design; (iii) moving current architecture closer to the ideal
- Traditional TRIZ tools: Physical Effects, Matrix of Contradictions, Trends of Technology Evolution
- If questions are formulated directly, Semantic TRIZ works as a customization of scientific effects data base;
- If questions are formulated as a contradiction, Semantic TRIZ works as a huge (currently $10^7 x 10^7$) matrix of contradictions providing specific answers on how this contradiction has been solved
- If questions are formulated relative to a specific time domain, Semantic TRIZ generates exact trends of technology evolution

-Theory (TRIZ, a theory of invention),
-Method (Altshuller's step-by-step creative process)
-Tool (ex. Goldfire[1]), SDM'rs evaluation

A theory of invention, as stated by Altshuller the inventor of TRIZ should:

- Be systematic, a step-by-step procedure
- Be inclusive to a broad solution space hoping to include the ideal solution
- Be repeatable and reliable independent of psychological tools
- Be able to access and add to the body of inventive knowledge
- Be close to the inventor's mindset, offering a general approach to solve problems

[1] Product of Invention-Machine

- The process of concept creation is the coupling of an intent-function pair with a form that performs it
- By the application of TRIZ principles, the software works as a mind teaser, in a similar way to De Bono's *Lateral Thinking*
- The automation comes from the use of a concept from a different context – but linked through the semantic engine – in order to solve a problem analogous.
- The form is the suggestion of these effects/patents/contradiction pairs

- The mechanics of the TRIZ principles make us think about what are the effects that have been separated, and the contradiction therefore eliminated
- It allows going into detail, because the separation of the whole into parts that are in contradiction, maps out the invention, but, also maps the benefits provided by each individual part on its own
- Contradiction: we want fresh air but to avoid light
  - Sol'n: Venetian shades separate the flow of air from the flow of light
- Semantic TRIZ methodology is structured, the statement of the problem has to be stated through a contradiction, and this requirement guides us through an exercise of identifying the problem with surgical exactitude, and dissects the different factors that intervene.

- understanding comes from playing with different concepts, patents, scientific effects, and technology trends.
- The fact that the intent is expressed in a high level allows thinking in a broad range of solutions.
- A deep web search on patents classified through the use of the semantic engine, again here the patents help to clarify the idea, but also allow to guide the search to areas that are “hot” in creativity, or where there has not been much advancement recently
- A set of organized scientific effects that are invoked when the problem statement is analogous to one of the effects in the family. While not all the effects will be effective, they allow to think in a higher level of abstraction, and to disengage from a form-linked need statement. The “customers” have sometimes problems making the needed abstractions for a higher-level statement, and, come looking for a validation of their idea. The scientific effects, coming from pure science, forces the “customer” to think “out-of-the-box”

How and where TRIZ can facilitate the creative processes in concept creation[1]

- The process of concept creation is the coupling of an intent-function pair with a form that performs it. There are several ways to do this, and some of us just have it as a talent. However, when trying to do this commercially, it is not feasible to trust in a group of artists that will invent when they feel like doing it. It is very important for a corporation to create "deliberatively." Companies have more demand for SA development than the number of SA wizards available. Therefore, improved education in SA (a la SDM) and tools will help satisfy the demand.
- By sketching steps, and using a systematic approach, some of the risk of not finding the right solution is reduced, and in a business environment, low risk and high productivity are important values. So, for the corporation as a stakeholder, the TRIZ software intent is to deliver a semiautomatic solution-finding machine, and while not finding the solution by itself, it increases the productivity of the people in charge of doing it. The value delivered are therefore solutions, which have the attribute of being novelties and with a steady flow. The process is therefore conceptualizing, and the operand will be the solution that changes from non-existent to existent, delivering value to the Corporation (the beneficiary)
- In the case of the user, the benefit is slightly different. Because of the exposure to many different ideas, the semantic TRIZ excites the creativity [puts you in the creative zone of thinking] and helps to increase the universe of reachable concepts, and also encourages the association of ideas, because of the quick presentation of lots of information from different sources.
- The value for this stakeholder is the inspiration, and it operates into the universe of ideas increasing its number and simultaneous availability. This stakeholder receives value when the showing of these ideas occurs.
- The automation comes from the use of a concept from a different context – but linked through the semantic engine – in order to solve a problem analogous. Here again the idea is to save time to the corporation, increasing the performance and efficiency, by "not losing time"
- Analyzing now the architecture of the semantic TRIZ itself is possible to see that the intent is to systematically approach the invention process, with a solution that has all the advantages of the intended effect, and none of the disadvantages of the counter effects, looking through the broadest possible field of concepts.
- The form is the suggestion of these effects/patents/contradiction pairs in the hope that the human brain will pick the needle in the hay.
- From my own experience with the software, the use is limited and perhaps more interesting than the application of TRIZ principles, the software works as a mind teaser, in a similar way than De Bono's *Lateral Thinking*.

[1] Friedenthal, Cantanzaro and Speller