Technological Evolution According to TRIZ

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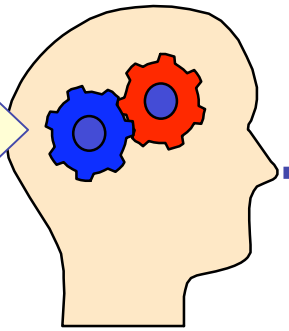
Foundation: TRIZ, the Theory of Inventive Problem Solving

- Russian acronym for the Theory of Inventive Problem Solving
- Systematic, structured way of thinking
- Results of over 60 years of research analyzing over 2 million worldwide patents within all engineering disciplines

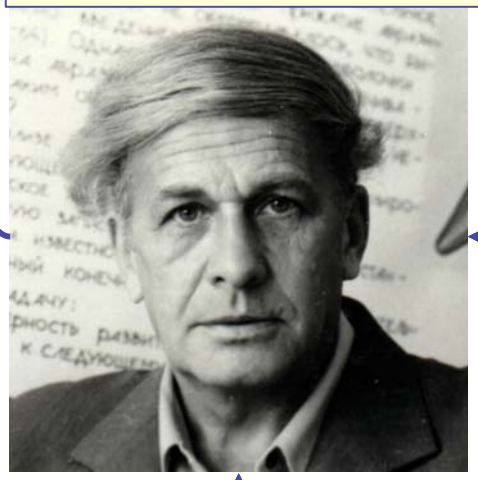
The foundation for structuring innovation-based knowledge.

TRIZ-based Idea Generation

Explicit knowledge –
How to create new ideas for system evolution



New Ideas, Concepts, Inventions, Innovations, etc.



Genrich Altshuller

Tacit knowledge = Intuition

Personal talent

Individual experience

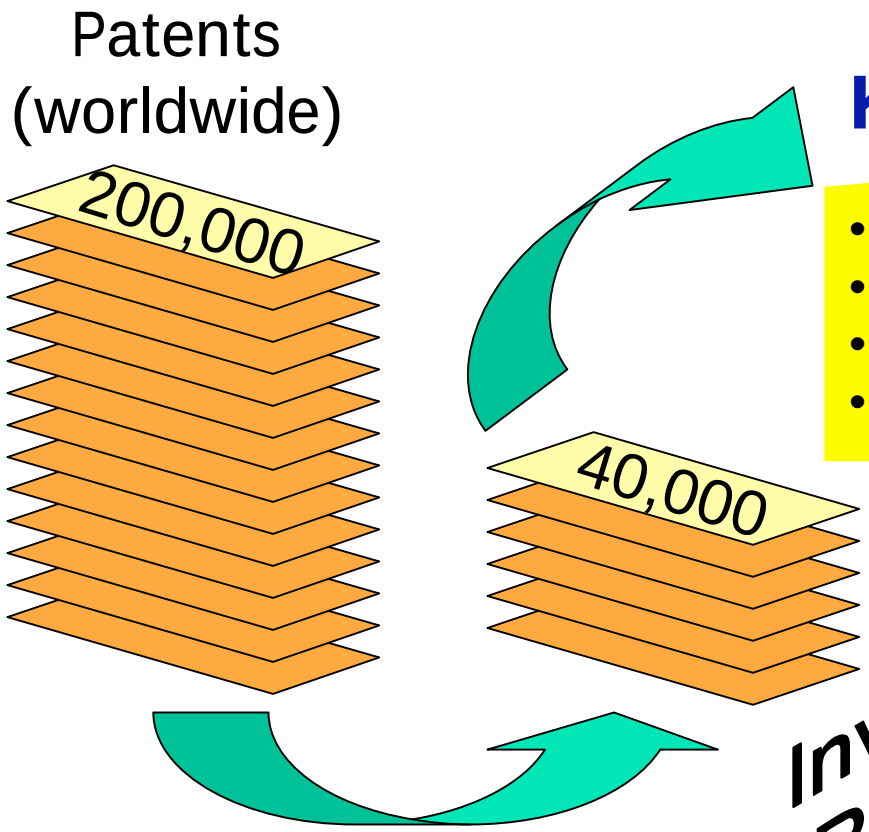
Generalized experience of inventors (patent fund)

History of evolution in technology, science, society, art, etc.

Why TRIZ was Created

- Provide a systematic step-by-step procedure
- Guide for an inventor through the solution space and direct him or her to the area with the best (ideal) solutions
- Provide an inventor with reliable and repeatable results that do not depend on personal (psychological) issues
- Proven knowledge (patent information) is accessible
- Accumulated human innovation experience is accessible

TRIZ is Based on Abstraction of Knowledge Rather than Guesswork



Key Findings

- Definition of inventive problem
- Levels of invention
- Patterns of evolution
- Patterns of invention

TRANSFERABLE

General Purpose Principles.

Discovery: Common thread between great innovations.

What is an Inventive Problem?

- Involves one or more contradictions
- Suggests no known ways or means of solution

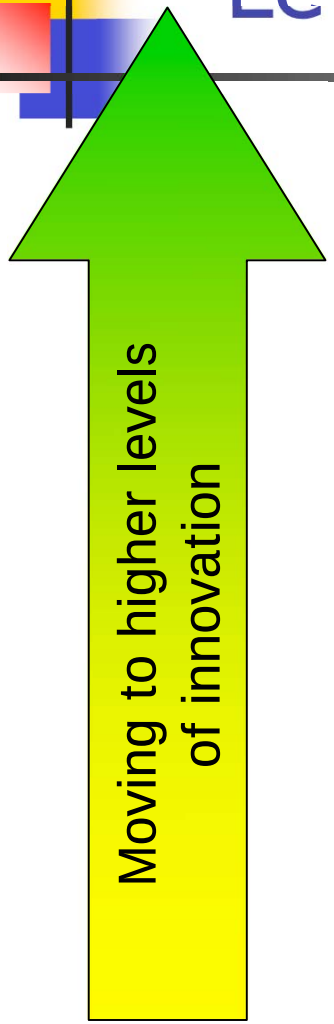
There are two types of contradictions: technical and physical

Convert

Apply 4 principles
- Separation in time
- Separation in space
- Separation between the parts & the whole
- Separation upon conditions

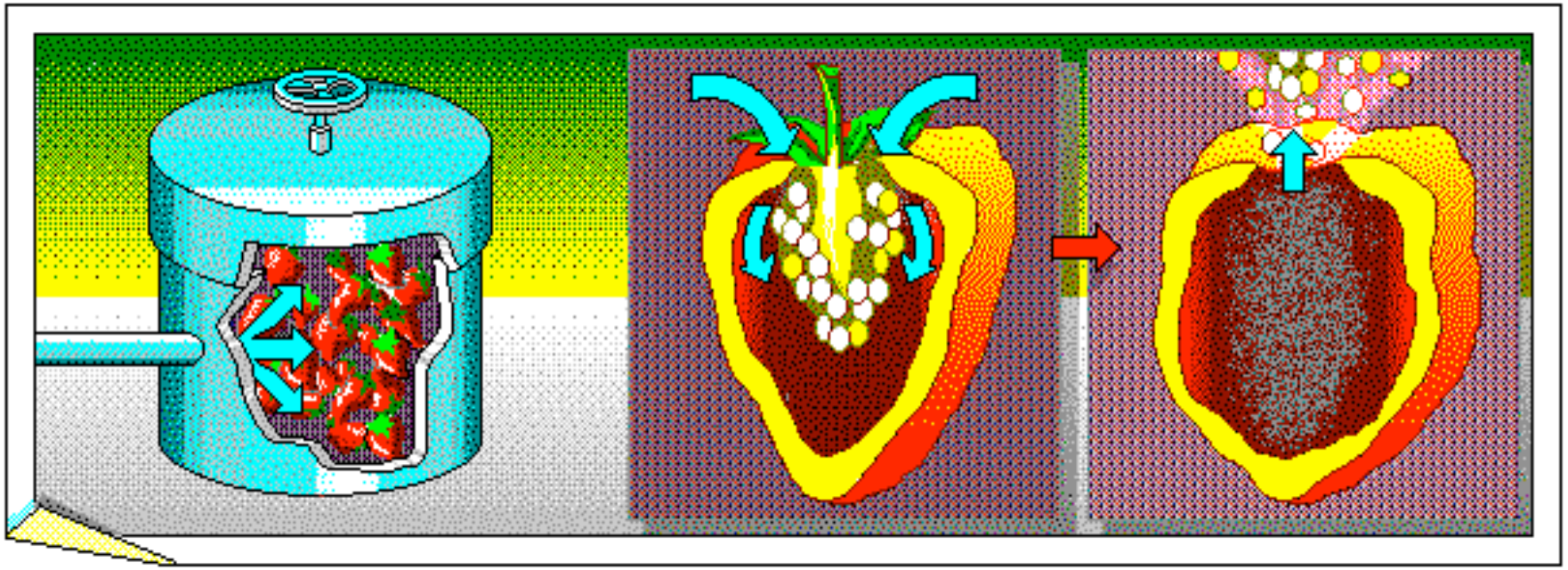
Classification of Solutions:
We need to raise innovation skills via methods and tools.

Levels of Invention (Solution)



- **Level 5: Discovery**
  - Pioneering of an essentially new system
    - Laser, radio, airplane
- **Level 4: Invention outside the paradigm**
  - A concept for a new generation of an existing system, based on changing the principle of performing the primary function
    - Jet aircraft, integrated circuit
- **Level 3: Invention inside the paradigm**
  - Essential improvement of an existing system
    - Automatic transmission, radio telephone
- **Level 2: Improvement**
  - Small improvements of an existing system, usually with some compromise
    - Bifocal glasses, beeper
- **Level 1: Apparent (no invention)**
  - Established solutions; well-known and readily accessible

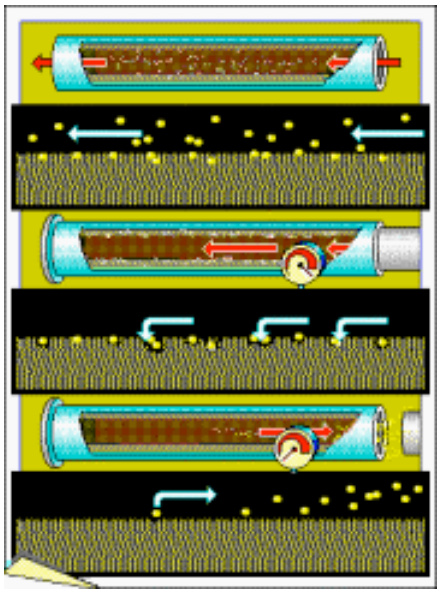
Patterns of Invention: Processing Sweet Peppers



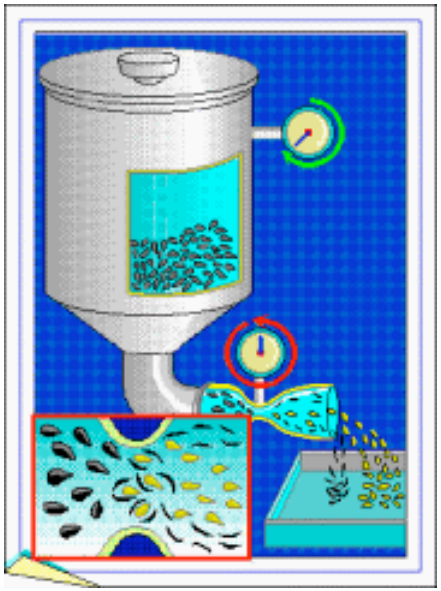
Pattern of Invention – Other Examples

- Splitting diamonds

- Cleaning filters



- Shelling sunflower seeds



I-TRIZ Operator: Slowly increase then abruptly drop pressure

Patterns of Invention

Discovery: There is repetition in the way people solve creative problems.

- Altshuller recognized that the same fundamental problem (contradiction) had been addressed by a number of inventions in different areas of technology
- He also observed that the same fundamental solutions were used over and over again, often separated by many years
- He reasoned that if the latter innovator had had knowledge of the earlier solution, their task would have been straightforward
- He sought to extract, compile, and organize such information

Patterns of Evolution: The Primary TRIZ Postulate

- Systems evolve not randomly, but according to objective patterns
- These patterns can be revealed from the research of the history of technology, markets, and society then purposefully used for systems development thus reducing the number of blind trials

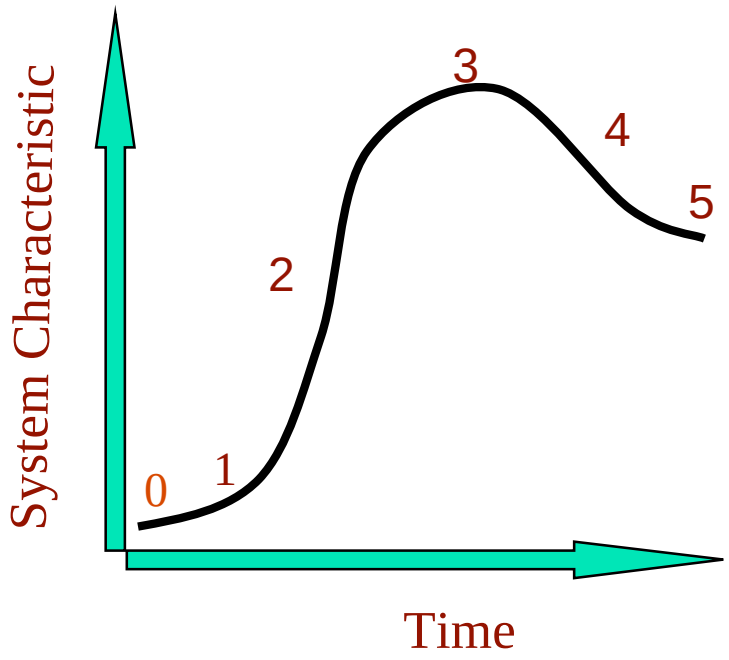
Patterns of Evolution: Common threads among systems.

Basic Patterns of Evolution

Patterns of Evolution: Common threads between evolving systems.

1. Stages of Evolution along an S-curve
2. Evolution toward Increased Ideality
3. Non-Uniform Development of System Elements
4. Evolution toward Increased Dynamism and Controllability
5. Increased Complexity Then Simplification
6. Evolution with Matching and Mismatching Elements
7. Evolution toward Micro-level and Increased Use of Fields
8. Evolution toward Decreased Human Involvement

Stages of Evolution



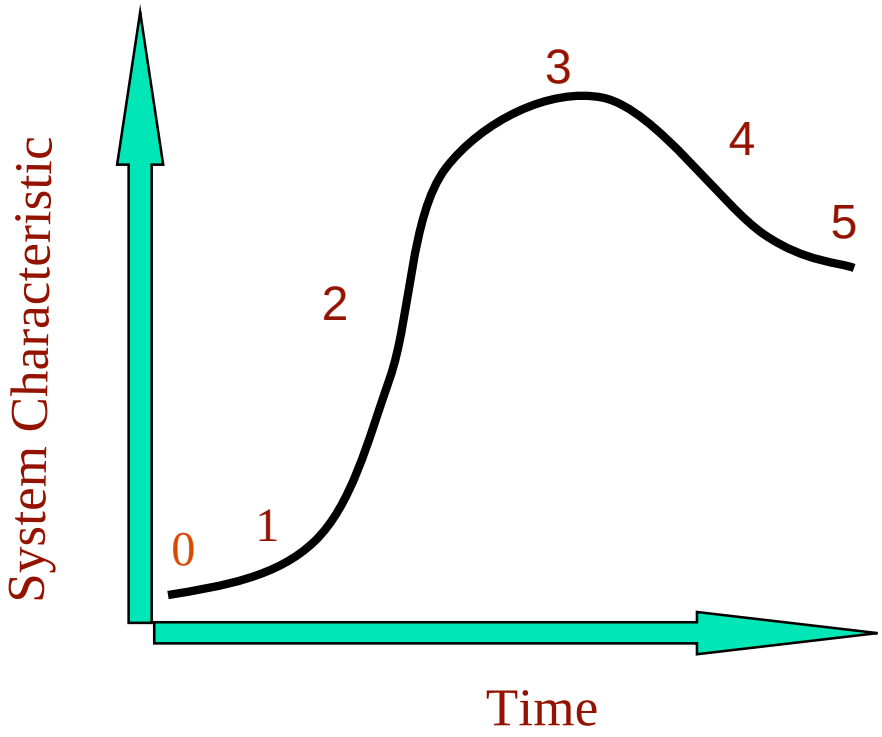
- S-Curve Analysis
- Analysis of the stage of a product or system development

Objectives of S-Curve Analysis

- Analysis of main system's parameters development in time.
- Analysis of subsystem's development in time.
- Estimation of the system's position on the S-curve according to the number of patents.
- Estimation of the system's position on the S-curve according to "citations".
- Estimation of the system's position on the S-curve according to group or organization features and according to market evolution lines.
- Revealing main mistakes, typical for definite stage of evolution, and determining directions for proper development.
- Revealing "bottle necks" – subsystems, preventing system further development and causing system's shift to maturity.
- Revealing future "bottle necks" and looking for possibilities of their preventing.

Objective is to develop understanding not detailed documentation.

Evolutionary Positioning: S-Curve Analysis



Stage 0 - a system does not yet exist but important conditions for its emergence are developing

Stage 1 - a new system appears due to a high-level invention and begins developing slowly

Stage 2 - begins when society recognizes the value of the new system

Stage 3 - begins when the resources on which the original system is based are mostly exhausted

Stage 4 - begins when a new system (or the next generation of the current system) emerges to replace the existing one

Stage 5 - begins if the new system does not completely replace the existing system, which still has limited application

2. Evolution Toward Increased Ideality

- Every system performs functions which generate useful effects and harmful effects
- The general direction for system improvement maximizes the ratio of ideality
- We strive to improve the level of ideality as we create and choose inventive solutions

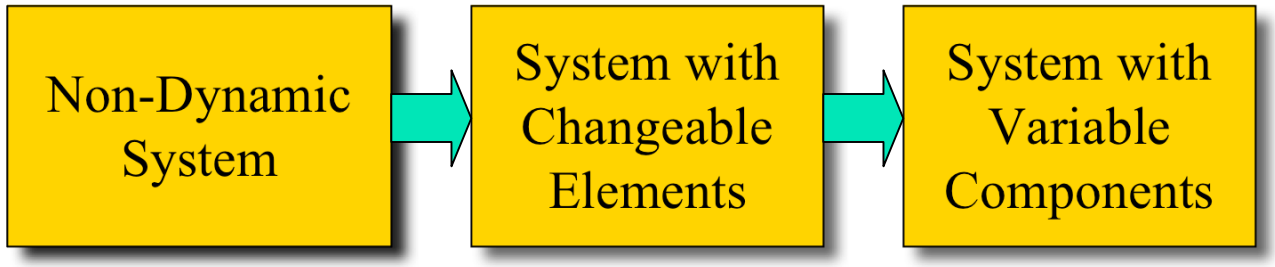
$$\text{Ideality} = \frac{\text{All } \textbf{\textit{Useful}} \text{ Functions}}{\text{All } \textbf{\textit{Harmful}} \text{ Functions}}$$

3. Non-Uniform Development of System Elements

- Each system component has its own S-curve
- Different components usually evolve according to their own schedule
- Different system components reach their inherent limits at different times, resulting in contradictions
- The component that reaches its limit first is “holding back” the overall system
- Elimination of contradictions allows the system to continue improving

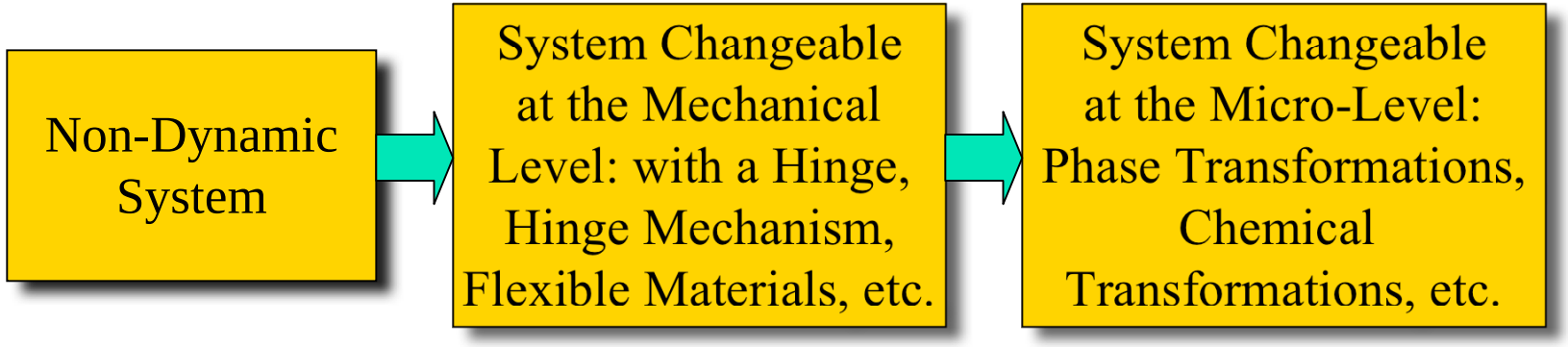
4. Evolution Toward Increased Dynamism and Controllability

Transition to Multifunctional Performance



Increasing system dynamism allows functions to be performed with greater flexibility or variety

Increasing Degrees of Freedom



5. Increased Complexity Followed by Simplification (Reduction)

- Technological systems tend to develop first toward increased complexity (i.e., increased quantity and quality of systems functions), and then toward simplification (where the same or better performance is provided by a less complex system).
- This may be accomplished by transforming the system into a bi- or poly-system, as shown here in two of the lines of evolution related to this pattern.

Mono-system	***Bi-system***	**Improved (Simplified) Mono-system**
Mono-system	***Poly-system***	**Improved (Simplified) Mono-system**

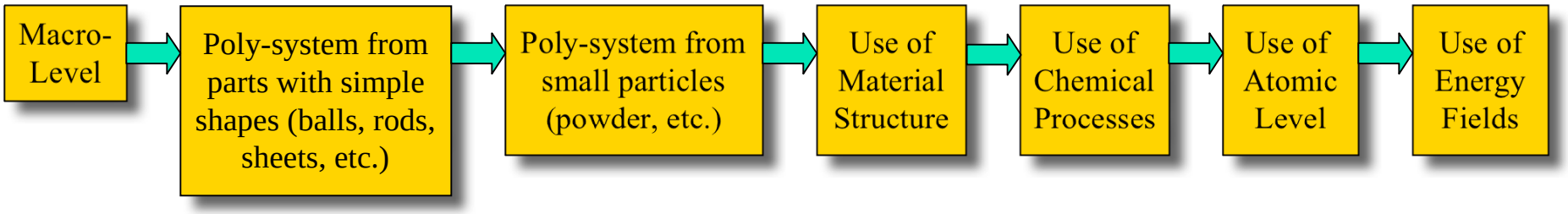
6. Evolution with Matching and Mismatching Elements

- System elements are matched or mismatched to improve performance or to compensate for undesired effects. A typical evolution might be:
  - a. Unmatched elements
  - b. Matched elements
  - c. Mismatched elements
  - d. Dynamic matching and mismatching
- Example: Automobile suspension system development
  - a. Springs attached between wheels and body
  - b. Shock absorber and spring tuned to damp out impact forces
  - c. Semi-rigid rubber isolation mounting between body and shock
  - d. Active suspension system automatically adjusts to road conditions

7. Evolution Toward the Micro-level and Increased Use of Fields

- Technological systems tend to transition from macro systems to micro systems. During this transition, different types of energy fields are used to achieve better performance or control
- Example of related Line of Evolution: Cooking oven development
  - a. Large cast iron wood stove
  - b. Smaller stove fired by natural gas
  - c. Electrically-heated oven
  - d. Microwave oven

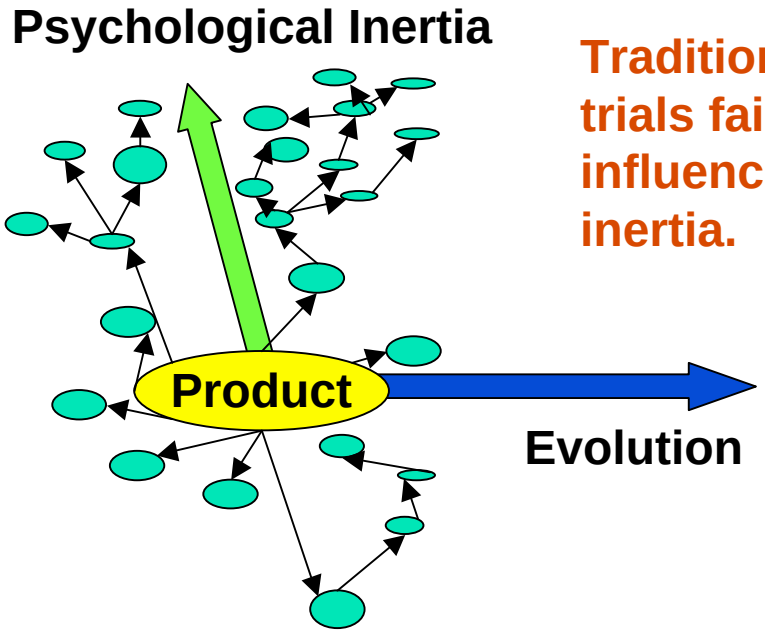
Line of Evolution



8. Evolution Toward Decreased Human Involvement

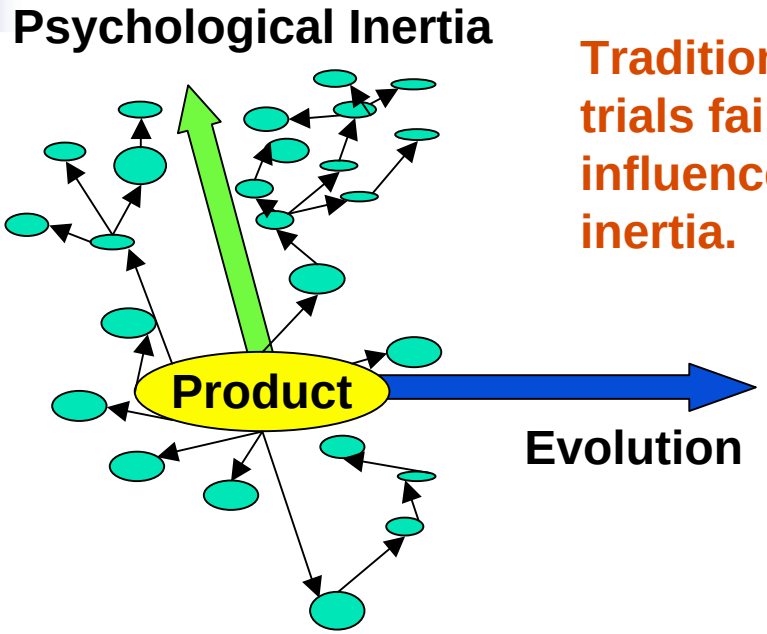
- Systems develop to perform tedious functions that free people to do more intellectual work
- Example: Clothes washing
  a. Tub and washboard
  b. Ringer washing machine
  c. Automatic washing machine
  d. Automatic washing machine with automatic dispensing of bleach and fabric softener

Traditional Trial and Error Method



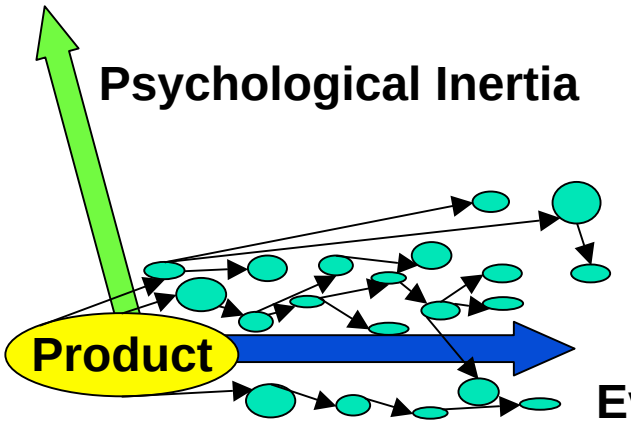
Traditionally, the majority of trials fail because they are influenced by psychological inertia.

Evolutionary Approach versus Traditional Trial and Error Method



Traditionally, the majority of trials fail because they are influenced by psychological inertia.

The majority of trials are productive because they follow Patterns of evolution.



TRIZ Differentiation

- TRIZ is the only innovation methodology that is:
  - Innovation knowledge based
  - Evolutionary directed
- I-TRIZ also incorporates many other techniques utilized in appropriate innovative processes and tools

Technological Evolution Activity

- A timeline of the evolution of a technological system is a useful tool in the technology classroom.
- **Objective:** to observe and understand the evolution of technological systems, and to predict their further development.
- **Assignment:** Complete a web quest and construct a timeline of the history of _____ technology.

Technological Evolution Activity

- **Analysis:** Identify and briefly describe major systems used in the technology. Examples in sound recording like plastic disks, magnetic tape, compact disks, and memory chips. Identify the advances that were made within each system. Examples for magnetic tape include reel to reel, eight-track cassette, large cassette, micro-cassette, and so forth.
- **Graph** the timelines with dates and changes in the characteristics and features of the systems.

Technological Evolution Activity

- **Predict** the next development in evolution and justify your prediction. Use the Laws of Technological Evolution to assist in your prediction.
- **Construct** a mockup of the expected technology and explain its features, benefits, and the law of evolution that suggests its development.
- **Present** your graph or chart, explanation, prediction and justification with a computer slide show and narration.[1] Examples can be posted on the bulletin board.

Technological Evolution Activity

- **Evaluation** is based on a rubric designed by the class.
- **Standards**
- Learning the methods and tools of TRIZ will directly assist in meeting STL standards 8-11 and will assist in nurturing standards 14-20.

TRIZ, pronounced as trees, is the world's most powerful inventive methodology.

Most people have never heard of TRIZ, but it's imperative that our students learn its basic concepts.

Please, help spread the word!

Learn more about TRIZ at:

- Halliburton Associates, LLC
- http://www.halliburtonassociates.com
- Contact Cal Halliburton at:
- info@halliburtonassociates.com or
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