Methodology Patent Analysis and Improvement

General methodology
1. Step 1. Evolutionary analysis of Prior Art
   - Patent claims visualization by building a graphical diagram using the IP Validation and Enrichment Software (IPVES), in particular, Problem Formulator™ software module
   - Automatic formulation of possible directions for
     ▪ Invention circumvention
     ▪ Invention improvement
   - Development of new ideas based on directions for invention improvement
3. Step 3. Weaknesses and strengths of the patent
4. Step 4. Level of invention definition
5. Step 5. Using Evolution Patterns for comparison between Main Idea and Prior Art
6. Step 6. Evaluation of the Main Idea from the point of view of the patterns of evolution, and evolutionary resources, identifying directions for further evolving the technology and/or its market potential.
7. Step 7. Description of Inventive results of the project
Step 1. Evolutionary analysis of Prior Art

General Evolutionary analysis

Evolutionary analysis of Prior Art is being performed for the purpose of identifying the evolutionary position of the system/technology the invention relates to and thus to make a reasonable prediction of the future of the system and the invention.

Evolutionary analysis is based on:

- Information about Prior Art described in the invention and additional relevant materials obtained on the Internet and other selected published documents.
- IPBI proprietary knowledge base containing information about standard evolutionary stages and typical tasks and typical mistakes in evolution on each stage.

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

Each stage and sub-stage of evolution is characterized by its own:
- Descriptions
- Objectives
- Mistakes
Transitions from Stage to Stage

From Stage 0 to Stage 1
Result of emergence of new technological capability to better satisfy customer needs (new product, service, etc.)

From Stage 1 to Stage 2
Result of the positive feedback between the system development and its market. In certain situations this creates an avalanche growth in sales and production ("tornado effect").

From Stage 2 to Stage 3
Result of exhaustion of evolutionary resources, including saturation of market, technological limitation, etc.

From Stage 3 to Stages 4 and 5
Result of supplanting the given system with another, more effective one

Typical deviation in evolution

Stage 0

Stage 1 (beginning)

Stage 1 (middle)

Stage 1 (end)

Artificial Stage 3

Crocodile Back

Stage 2 (beginning)

False Stage 3

Stage 3 (beginning)

Stage 3 (middle)

Stage 3 (end)

Stage 4

Stage 5
Step 2. Mapping the Invention

Mapping objective is to build a visual diagram(s) that allows obtaining a complete yet very economic (without repetitions and unimportant details) graphical description of the invention. Once these diagrams are built, we can use automatic formulation of possible directions (problem statements) that indicate the ways for inventing around, avoidance of infringement, technology enhancement and new inventions. Mapping of Invention is based on utilization of the Ideation Problem Formulator™ System.

Ideation Problem Formulator™ System provides the following three basic functions necessary for solving inventive problem:

- Slicing of the initial problem situation into many smaller tasks which can be addressed one by one.
- Organizing the thinking process to ensure no potential opportunity is missed.
- Offers for each problem statement a relevant group of Operators - recommendations for potential solutions resulting from statistical analysis of patent library and other sources of technical information.

Ideation Problem Formulator™ System is an artificial Intelligence software designed to support inventors in analysis and “deconstruction” of complicated situations and patents using the following steps:

- Building Cause-Effect and/or Purpose-Means visual model (diagram) for various situations, focusing on interactions between harmful and useful nodes (boxes), where:
- Each node contains certain information, for example, names of certain objects and/or systems, actions, functions, parameters, conditions, etc.
- Two types of links (arrows) connecting nodes (boxes) named produces and counteracts.

<table>
<thead>
<tr>
<th>Useful Factor 1</th>
<th>produces</th>
<th>Useful Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful Factor 1</td>
<td>produces</td>
<td>Harmful Factor 4</td>
</tr>
<tr>
<td>Useful Factor 3</td>
<td>counteracts</td>
<td>Useful Factor 1</td>
</tr>
<tr>
<td>Useful Factor 3</td>
<td>produces</td>
<td>Harmful Factor 4</td>
</tr>
<tr>
<td>Harmful Factor 4</td>
<td>produces</td>
<td>Harmful Factor 5</td>
</tr>
</tbody>
</table>
• Visual re-organization and analysis of the diagram, unveiling and correcting various discrepancies, mistakes, missing nodes and/or links.
• Automatic conversion of visual diagram into a nearly exhaustive set of all possible directions for Innovation (solution paths).
• Analysis of Directions for Innovation and selection of the most promising ones for further consideration.
• Searching for ideas along selected directions using Operators. Each Operator represents a potential recommendation for resolving selected type of a problem situation. As a result, the user can obtain a practically exhaustive set of possible ideas and concepts, relevant to the situation described on the diagram.
• Documenting and categorizing ideas into groups.
• Integration of obtained ideas via adding them into original diagrams or building new diagrams reflecting relationships between obtained ideas and concepts.

Typically, patent analysis is limited to independent claims. All claim elements can be divided into two groups:

- Elements that cannot be a reason for infringement, including:
  - Elements that are well-known, do not comprise new combinations nor are being utilized in a new way.
  - Elements that have no regard to the area the client is interested
  - Elements that are not important for the realization of invention described in the given patent(s).
  - Elements that cannot be changed under any circumstances, for example, physical constants, natural conditions, etc.
  - Elements that can be subjects of infringement (colored green) including the ones that represent essential novelty.

In the case when a group of patents or a single patent with several independent claims is analyzed, it is useful to work with so-called Integral Solution Space System (ISSS).

ISSS is built based on analysis and integration of elements comprising all independent claims of the given patents. In this case, identical, practically identical or equivalent elements belonging to different claims are combined\(^1\). As a result, ISSS represents a sum of elements protected by different patents and includes (but not limited to) the following key elements contained in the majority of patents /claims responsible for the design novelty and benefits:
- Key elements of design
- Key elements of manufacturing

Step 3. Weaknesses and strengths of the given inventions and patent documents

Invention or patent document weakness is represented by element(s) of the independent claim(s) that allow for the possibility of patent circumvention. A patent can be circumvented via creation of a new modification of a product or process to avoid infringement. This modification should exclude one or more elements described in independent claim(s) of the given patent.

\(^1\) Although legally there is a difference between identical and equivalent elements, for the purpose of this work they could be considered the same as they are going to invent around them anyway.
The position could be strengthened further if exclusion is complemented by including one or more elements different from the elements described in independent claim(s) of the given patent(s) or better yet, is provided in a non-obvious way and, therefore, provides results substantially different from those claimed in the given patent.

For the purpose of this work a set of independent claims from the given patents is assumed to be an adequate representation of the infringing product. The said independent claims are then analyzed in order to identify technical possibility of providing claimed results without one or more claimed elements. The procedure of excluding elements is provided in an innovative way with application of IP Validation and Enrichment Software (IPVES), in particular, Problem Formulator™ for patent mapping, and relevant Operators and/or Evolutionary resources for obtaining technical solutions.

This module provides automatically generated questions for checking the correctness and completeness of the graphical description.

Based on graphical diagram(s) resulted from mapping of independent claim(s) the module allows for formulation of possible directions for the given invention circumvention.

For example, for the diagram 1 the following directions for circumventions have been formulated:

Diagram 1. Method for control of a multi-phase, reversible, rotating electrical machine for a motor vehicle with a heat engine

Computer formulated questions for validity check of the description
1. Does (alternator/starter a multi-phase, reversible, rotating electrical machine) produce useful results besides (operating as an electrical alternator) and (operating as an electric motor)?
2. Does (alternator/starter a multi-phase, reversible, rotating electrical machine) produce harmful effects?
3. Does (alternator/starter a multi-phase, reversible, rotating electrical machine) require useful or harmful functions besides (a motor vehicle with a heat engine)?
4. Is (alternator/starter a multi-phase, reversible, rotating electrical machine) influenced by useful or harmful functions?
5. Does (a motor vehicle with a heat engine) produce useful results besides (start the heat engine) and (alternator/starter a multi-phase, reversible, rotating electrical machine)?
6. Does (a motor vehicle with a heat engine) produce harmful effects?
7. Does (a motor vehicle with a heat engine) require useful or harmful functions?
8. Is (a motor vehicle with a heat engine) influenced by useful or harmful functions?
9. Does (operating as an electrical alternator) produce useful results?

Computer formulated directions for patent circumvention:
1. Find a way to exclude (alternator/starter a multi-phase, reversible, rotating electrical machine) without deterioration of the system functioning.
   1.1. Obtain the useful result without the use of (alternator/starter a multi-phase, reversible, rotating electrical machine).
   1.2. Consider resources to provide the useful factor (alternator/starter a multi-phase, reversible, rotating electrical machine).
2. Find an alternative way to obtain (alternator/starter a multi-phase, reversible, rotating electrical machine) that offers the following: provides (operating as an electrical alternator) and (operating as an electric motor), does not require (a motor vehicle with a heat engine).
   2.1. Improve the useful factor (alternator/starter a multi-phase, reversible, rotating electrical machine).
   2.2. Increase effectiveness of the useful action of (alternator/starter a multi-phase, reversible, rotating electrical machine).
   2.3. Apply universal Operators to provide the useful factor (alternator/starter a multi-phase, reversible, rotating electrical machine).
   2.4. Synthesize the new system to provide (alternator/starter a multi-phase, reversible, rotating electrical machine).
3. Find a way to exclude (a motor vehicle with a heat engine) without deterioration of the system functioning.
   3.1. Obtain the useful result without the use of (a motor vehicle with a heat engine).
   3.2. Consider resources to provide the useful factor (a motor vehicle with a heat engine).

As a result, for the given claim 34 basic directions (problem statements) have been automatically formulated. After analysis of obtained directions, 12 have been selected as the most promising and have been addressed with relevant Operators (for each selected direction from 4 to 10 Operators have been suggested by the software). Work with suggested Operators has resulted in 8 ideas, 3 of which have showed enough potential and have been included in the final report.

**Step 4. Level of invention evaluation**

The level of the given invention is determined via evaluation of the amount of creative efforts applied in the invention creation, its degree of novelty and the impact it can exert on the overall level of technology and/or society. Inventions of higher levels usually result in higher overall profit; however, their development and implementation are associated with higher risk and require longer times for a return on investment.

The following levels of Solution are identified:
<table>
<thead>
<tr>
<th>Level</th>
<th>% of inventions</th>
<th>Effect on product or process</th>
<th>Implementation time (estimation)</th>
<th>Inventors and results</th>
<th>Ideation tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68.3%</td>
<td>Small cost reduction and/or improvement of the existing generation</td>
<td>Months</td>
<td>About 90% of engineers. Profitability and increased market share, short term plans</td>
<td>Ideation Cost/Quality Engineering, IWB, TRIZY, Failure Analysis</td>
</tr>
<tr>
<td>2</td>
<td>27.1%</td>
<td>Medium improvement of the existing generation</td>
<td>1-3 years</td>
<td>R&amp;D personnel. Intellectual property, medium and long term plans</td>
<td>DE, IWB, Failure Analysis and Failure Prediction</td>
</tr>
<tr>
<td>3</td>
<td>4.3%</td>
<td>Essential improvement or transition to next generation within the same paradigm</td>
<td>1-5 years</td>
<td>Selected R&amp;D personnel, Intellectual property, medium and long term plans</td>
<td>DE</td>
</tr>
<tr>
<td>4</td>
<td>0.24%</td>
<td>Develop a brand new generation based on new paradigm</td>
<td>5-10 years</td>
<td>Selected R&amp;D individuals from industry and universities</td>
<td>DE plus luck, no guarantee</td>
</tr>
<tr>
<td>5</td>
<td>0.06%</td>
<td>Develop a brand new products and technologies</td>
<td>10-20 or more years</td>
<td>Selected R&amp;D individuals from industry and universities</td>
<td>DE plus luck, no guarantee</td>
</tr>
</tbody>
</table>

Normal Distribution of Invention Levels

\[ F(x, \mu, \sigma) = \frac{1}{\sigma \sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \, dx \]

Levels of Invention

- Level 1: 68.3% inventions
- Level 2: 27.1% inventions
- Level 3: 4.3% inventions
- Level 4: 0.24% inventions
- Level 5: 0.06% inventions

Number of trials with using Trial-and-Error method for creativity

Units: \(\sigma\)  
Dozens: \(2\sigma\)  
Hundreds: \(3\sigma\)  
Thousands & Dozens: \(4\sigma\)  
Hundreds Thousands & Millions: \(5\sigma\)  

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Ideation methodology for identifying the level of invention is a multi-criterion method embedded into the software module. It involves the following criteria:

Level of invention is defined as a highest level achieved on all criteria. For example, if an invention is estimated level 1 or 2 on most of criteria and 3 on one of them, its level will be 3.

If the invention scores the highest level more than once, its level is elevated by 0.5 points. For example, if an invention scored level 3 on three criteria, its final score will be 3.5.

Return on Investment and Risk for different levels
As one can see from the diagrams, none of the levels is ideal: low level inventions are easy to implement with low risk, however, the return on investment is not high; high level inventions, on the contrary, are capable of high return, however, risk, time and cost of implementation are the highest as well.

For each type of invention various tools of the Ideation methodology offer different strategies that could be recommended to compensate for main disadvantages; for example, how to increase the return for low level inventions or lower risk associated with high level inventions.

Applications for Ideation TRIZ Tools

<table>
<thead>
<tr>
<th>Typical level of invention</th>
<th>Applications</th>
<th>Target audience</th>
<th>Ideation Software Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 2) - over 95% of all inventions</td>
<td>Inventive Problem Solving, Cost/Quality Engineering, Failure analysis</td>
<td>All engineers, 3 days of education per each application</td>
<td>IWB, TRIZY, Failure Analysis™</td>
</tr>
<tr>
<td>(2 – 3) - about 30% of all inventions</td>
<td>Inventive Problem Solving, Failure analysis, Failure Prediction, Research Problem Solving</td>
<td>Research and Development engineers and scientists</td>
<td>Innovation WorkBench®, Failure Analysis™, Failure Prediction™ Research WorkBench</td>
</tr>
<tr>
<td>Non technical problems (any level)</td>
<td>Inventive Problem Solving, Failure analysis, Failure Prediction</td>
<td>Managers, business and marketing people</td>
<td>Knowledge Wizard™, Failure Analysis™, Failure Prediction™ Directed Evolution™</td>
</tr>
<tr>
<td>(3 – 4) - about 4% of all inventions</td>
<td>Directed Evolution, Control of Intellectual property</td>
<td>The best engineers and people working with Strategic Planning</td>
<td>Directed Evolution™ Research WorkBench</td>
</tr>
<tr>
<td>(4 – 5) – less than 0,5% of all inventions</td>
<td>Long-term future vision</td>
<td>People working with Strategic Planning Top level scientists</td>
<td>Directed Evolution™ Research WorkBench</td>
</tr>
</tbody>
</table>
Step 5. Comparison between Main Idea and Prior Art

Utilized Patterns/ Lines of Evolution

For the purpose of expeditious evaluation and comparison of inventions, the following 12 basic Patterns of Evolution representing a compilation of major trends that document strong, historically-recurring tendencies in the development of man-made and natural systems have been selected:

1. **Evolution of useful functions**
   In the process of evolution, technological systems improve their Ideality, which can be thought of as the ratio of all the useful features of a system over all its harmful (undesired) ones. The Ideality ratio could be increased via improvement or expansion of useful functions/features.

2. **Elimination of harmful functions**
   In the process of evolution, technological systems improve their Ideality, which can be thought of as the ratio of all the useful features of a system over all its harmful (undesired) ones. The Ideality ratio could be increased via elimination or reduction of harmful functions/effects.

3. **Evolution of applications**
   In the process of evolution, technological systems tend to become more universal and multi-purpose, in order to provide convenience and to satisfy multiple needs. This pattern is accompanied by increased dynamism, because greater universality requires greater flexibility and "adjustability."

4. **Integration/structuring**
   Technological systems tend to improve through integration into a super-system of higher rank. This may be accomplished by transformation into a bi-system (the combination of two identical or different systems) and/or into a poly-system (the combination of more than two systems).

   Technological systems tend to improve through the development of material (substance) structure. As a result, the structure becomes more heterogeneous in accordance with the heterogeneous distribution of forces, energy, substance flows, etc.

5. **Increasing of dynamism and controllability**
   Technological systems tend to improve by becoming more dynamic -- that is, they gain greater flexibility and variety to adapt to a changing environment and satisfy multiple requirements.

   Technological systems tend to become more controllable and capable of changing to meet multiple needs. This pattern of evolution is the complement to the "Pattern of Increasing Dynamism" of a system, because the higher the system's flexibility, the more controllable it should be.

6. **Evolution with matching/ mismatching**
Evolving technological system tends in turn to obtain matching (adjustment) of its parts, functions, materials, parameters followed by purposeful mismatching of its parts, functions, materials, parameters.

7. **Evolution of resources application**
   Technological systems tend to utilize more resources starting with available ones toward gradual utilization of derivative resources.

8. **Evolution of contradictions**
   The system transition from one evolutionary step to the next one is triggered by resolving a specific contradiction.

9. **Increasing complexity followed by simplification**
   Technological systems tend to increase their complexity followed by a trend to simplification. These “waves” repeat.

10. **Evolution of fields**
    Technological systems tend to utilize more effective fields (types of energy), starting with mechanical field toward electric, magnetic, radiation.

11. **Evolution towards multi-level**
    In the process of evolution, technological systems tend to improve via using in one system a set of different levels of object structure and/or different fields or via changing principle of operation from the utilization of mechanical principles to physical and/or chemical ones.

12. **Changes in human involvement**
    In the process of evolution, technological systems tend to reduce the necessity of human involvement starting from the level of execution toward the levels of management and control.

**Comparison technique**

The actual comparison is made in the following way:

- Defining the **Main Idea of the invention** (short description)
- Defining the **Prior Art(s)** (one or two, no more)
- Mapping both on each of selected 12 Patterns/Lines using the scale from 1 to 10 and placing the results in the table below.

### Comparison between the given invention Main idea and Prior Art

<table>
<thead>
<tr>
<th>#</th>
<th>Evolution Patterns</th>
<th>Prior Art</th>
<th>Invention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evolution of useful functions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Elimination of harmful functions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Evolution of applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Integration/ structuring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Increasing of dynamism and controllability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Evolution with matching/mismatching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Evolution of resources application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Evolution of contradictions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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2 The actual evaluation is made by Ideation International experts with the utilization of proprietary knowledge base.
Based on the results placed in the table above, table radar (spider) diagrams are built showing the given invention(s) or system(s) evolutionary position, for example:

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<table>
<thead>
<tr>
<th></th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increasing complexity followed by simplification</td>
<td>Evolution of fields</td>
<td>Evolution towards multi-level</td>
<td>Changes in human involvement</td>
</tr>
</tbody>
</table>
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Analysis of the table and the diagram allow for evaluation of evolutionary potential of the invention and obtaining prioritized directions for its further development.

**Step 6. Evolutionary resources of invention**

Resources are substances, fields (energy), their properties, functional characteristics and other attributes existing in a system and its surroundings, which can be utilized for system improvement. Readily-available resources are resources that can be used as they are, including:

- Substance resources
- Field resources
- Space resources
- Time resources
- Informational resources (Including knowledge from other areas of science and technology)
- Functional resources

Derived resources are resources that can be used after some kind of transformation.

Inventions become possible because an inventor has managed to find how:
Utilize resources available in the system that have not yet been utilized before
Utilize available resources in different way

Any invention creates new resources that could be further utilized for the system improvement, in particular:
- Changing design, shape, application method of a system (product or process) targeting enhancement of useful functions and reduction of cost and harmful functions associated with the system.
- Invention of new applications and markets for the given system

Given the above, unveiling and utilization of evolutionary resources allows for transformation of one invention into an array of related inventions for the purpose of:
- Enhancement and further development of the base invention
- Invention of new application for the base invention and thus market expansion (new markets).
- Creation of strong patents fence and patent blocks strengthening Intellectual property in the given area.

Study if the large amount of US and European patents shows that in the majority of cases, they protect more than 10 - 15 % of newly created resources. In fact, these patents disclose much more potential IP that protect. In other words, these patents are rather invitations to competitors to come and capitalize on new good ideas. They look like a house with locked doors but widely open windows and protect from lazy competitors only.

This effect of poor protection of significant inventions is caused by the lack of systematic approaches for revealing and identification of hidden resources. Today, the technology developed by IPBI can eliminate this gap. **Evolutionary resources** are documented via completing the table below.

<table>
<thead>
<tr>
<th>#</th>
<th>Evolution Patterns</th>
<th>Evolutionary resources</th>
<th>Possible realization of evolutionary resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evolution of useful functions</td>
<td></td>
<td></td>
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