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**Comprehensive Analysis of Engineering Systems at the
Transitional Stage of Their Evolution**

Abstract of thesis for Master's Degree in TRIZ
(TRIZ Master)

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St. Petersburg, Russia
2012

GENERAL DESCRIPTION OF THE THESIS

This research relates to the Theory of Inventive Problems Solving (TRIZ).

The thesis consists of six sections.

The first section is a substantiation of the author's statement that an analysis of Engineering Systems (ES), specifically at the Transition-From-First-To-Second Stage of their evolution¹, should be comprehensive; that is, it should include not only an analysis of the ES technical part, which most TRIZ-projects are focused on, but also analyses of other factors that may affect the ES's marketability, such as:

- Analysis of the ES market
- Analysis of intellectual property (IP) associated with the ES
- Analysis of the business that monetizes the ES.

Analyzing all of these factors will make it possible to identify all hidden problems and harmful/undesirable effects² that may impede monetizing the ES. The lack of such a Comprehensive Analysis is most likely the reason why only a small percentage of concepts developed by TRIZ-consultants is actually implemented by their customers.

In the second section of the thesis, specific features of the ES at the Transitional Stage are investigated. These features are further taken into account in the proposed methodology for Comprehensive Analysis, thereby increasing the efficiency of this type of analysis.

The remaining four sections describe the four parts of the proposed methodology for Comprehensive Analysis:

¹ Further in the paper "Transition-From-First-To-Second Stage" will be referred to as Transitional Stage.

² Identification of the hidden harmful/undesirable effects is a typical goal of the Failure Anticipation Analysis (FAA) methodology, first introduced by B. Zlotin and A. Zusman. Therefore, the Comprehensive Analysis methodology described in this thesis could be called a Comprehensive FAA.

- Specialized algorithm, developed by the author, for Failure Anticipation Analysis (FAA) of the technical part of the ES, which is optimized for analyzing the ES specifically at the Transitional Stage
- Analysis of the ES market
- Analysis of IP associated with the ES
- Analysis of the business that monetizes the ES.

An example of the practical implementation of the proposed methodology for Comprehensive Analysis is presented in the Appendix.

IMPORTANCE OF THIS RESEARCH

Any ES at the Transitional Stage presents a good opportunity to apply all of the TRIZ methodology tools because the ES at this stage is obviously imperfect and needs a lot of improvement. At the same time, such an ES is normally difficult to analyze using “classical TRIZ”, since at this stage a laboratory prototype of the ES already operates reasonably well; but because the ES has not gone to market its harmful/undesirable effects have not yet manifested themselves.

Existing FAA methodology is specifically intended for revealing hidden problems in the ES and harmful/ undesirable effects created by the ES. The FAA is a powerful TRIZ tool because of the following unique features:

- FAA makes it possible to solve scientific and research problems concerning the explanation of various phenomena and effects, the causes of which are unclear.
- FAA makes it possible to identify hidden flaws in the ES, which may cause faults and failures in the ES operation, and then to eliminate these flaws using other TRIZ tools.
- FAA makes it possible to identify potential harms in the ES supersystem that may be created by the ES at different stages of its life cycle, from development to recycling.

FAA makes it possible to effectively solve scientific and research problems as well as “detective” (e.g. crime) problems, and also to identify causes of production defects, i.e. to find causes of known harmful/undesirable effects.

As to identifying hidden flaws in the ES, when harmful effects are as yet unknown, experience in consulting projects shows that the use of the existing FAA to solve this type of problem is fairly laborious and does not guarantee identification of the most important hidden flaws. This is because these methods are too universal and therefore overly cumbersome for practical purposes. In addition, the current FAA is described too generally which makes it difficult to use. Perhaps this explains why FAA is, undeservedly, underused in TRIZ consulting.

Besides the technical perfection or imperfection of the ES, there are other factors, including non-technical, that greatly influence monetization of the ES, for example: competitive environment and potential volume of the ES market; strength of protection of IP associated with the ES and potential infringement on third party IP by the production and sales of the ES; business situation during the ES monetizing period and ability of the company that owns the ES to actually monetize it. Any of these factors may contain hidden problems that could impede monetizing the ES.

The exhaustive set of these factors has hardly ever been taken into account in any TRIZ consulting project. This is because there is no methodology for an efficient, comprehensive analysis of the ES. Thus, there is a real need for such a methodology capable of identifying all critical technical and non-technical hidden flaws in the ES that may impede its monetizing.

GOALS OF RESEARCH

The goal of this research is to universalize a new approach that was successfully implemented in a consulting project, and, at least partially, address the above-mentioned flaws in the existing FAA methodology for revealing hidden problems in the ES:

- Develop Roadmap and methodology for Comprehensive Analysis capable of identifying both technical and non-technical hidden problems that may affect the monetization of the ES.
- Develop an efficient specialized FAA methodology for identifying hidden harmful/ undesirable effects in the ES at the Transitional Stage of evolution in order to make it less laborious without reducing the quality of analysis³.

SCIENTIFIC NOVELTY OF RESEARCH

According to the author, the scientific novelty of this research is as follows:

- A Roadmap and methodology for Comprehensive FAA capable of identifying both technical and non-technical hidden problems that may affect the marketability of the ES has been developed (Fig. 1). This methodology, in addition to the FAA of an ES, includes an analysis of the business that monetizes the ES, analysis of the ES market; and analysis of intellectual property associated with the ES.
- The scientific novelty of the ES market analysis is that it includes the simultaneous analysis of both technical and market potential of the ES (i.e. its competitiveness and potential market share), which takes into consideration the evolutionary trends of the supersystem components using the ES (Fig. 2).
- Analysis of the business monetizing the ES is based on elements of the Quantum-Economical Analysis (QEA), which is new for TRIZ consulting projects. This analysis increases the efficiency of TRIZ consulting because it allows TRIZ-consultants to identify and deliver the most promising solutions in terms of monetization by the client.
- The specialized FAA methodology provides a fast and reliable way to identify hidden harmful/undesirable effects in the ES at the Transitional Stage of

³ Quality of analysis is the ability of the methodology to guarantee identification of the hidden harmful effects, which are critical to eliminate at this stage of ES evolution.

evolution (Fig. 3). This has been accomplished by reducing the field of hidden harmful effects to be identified to those that relate to the Main Function (MF) of the ES and by differentiating the depths of analysis depending on just how harmful an effect is.

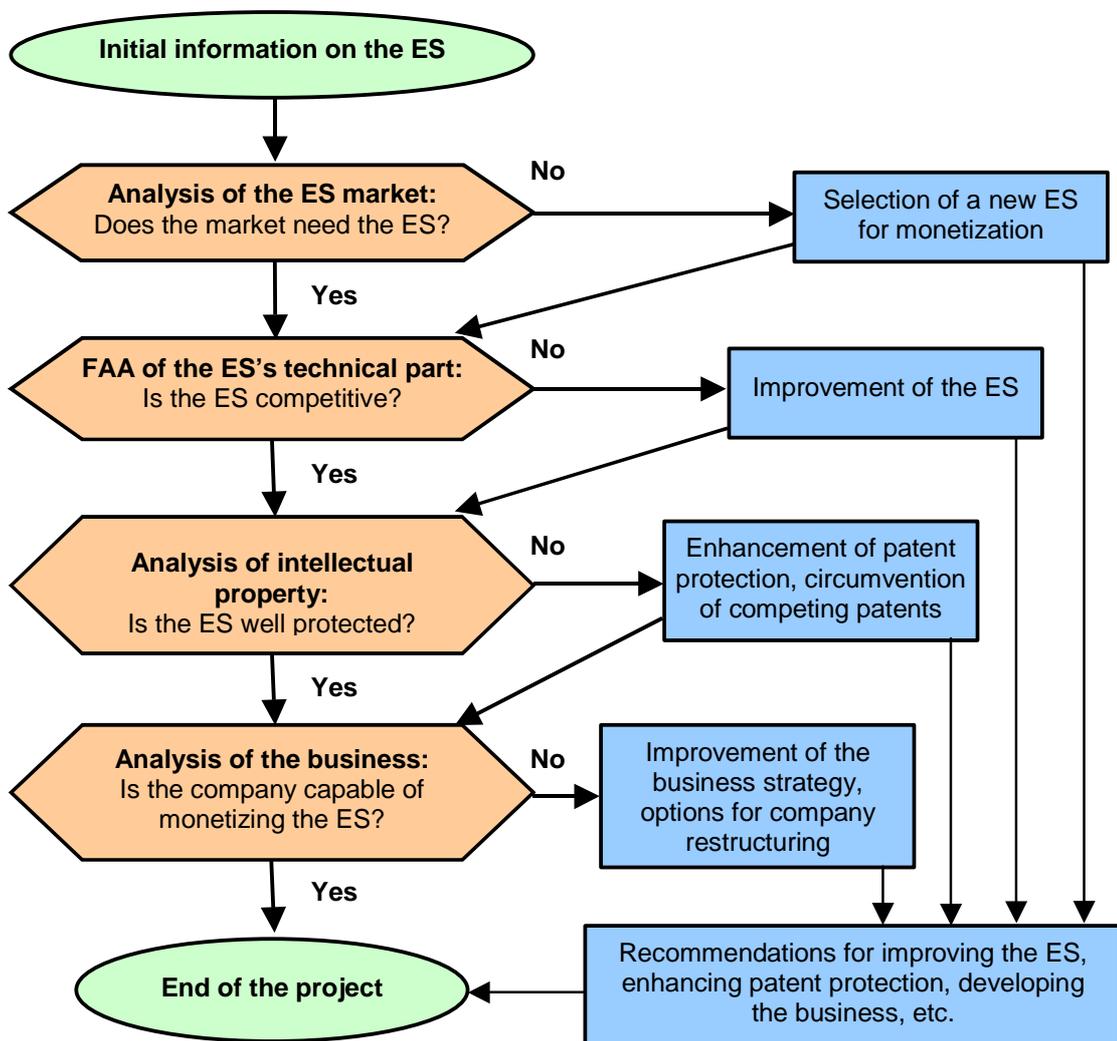


Fig.1. Roadmap of Comprehensive Analysis of ES at the Transitional Stage

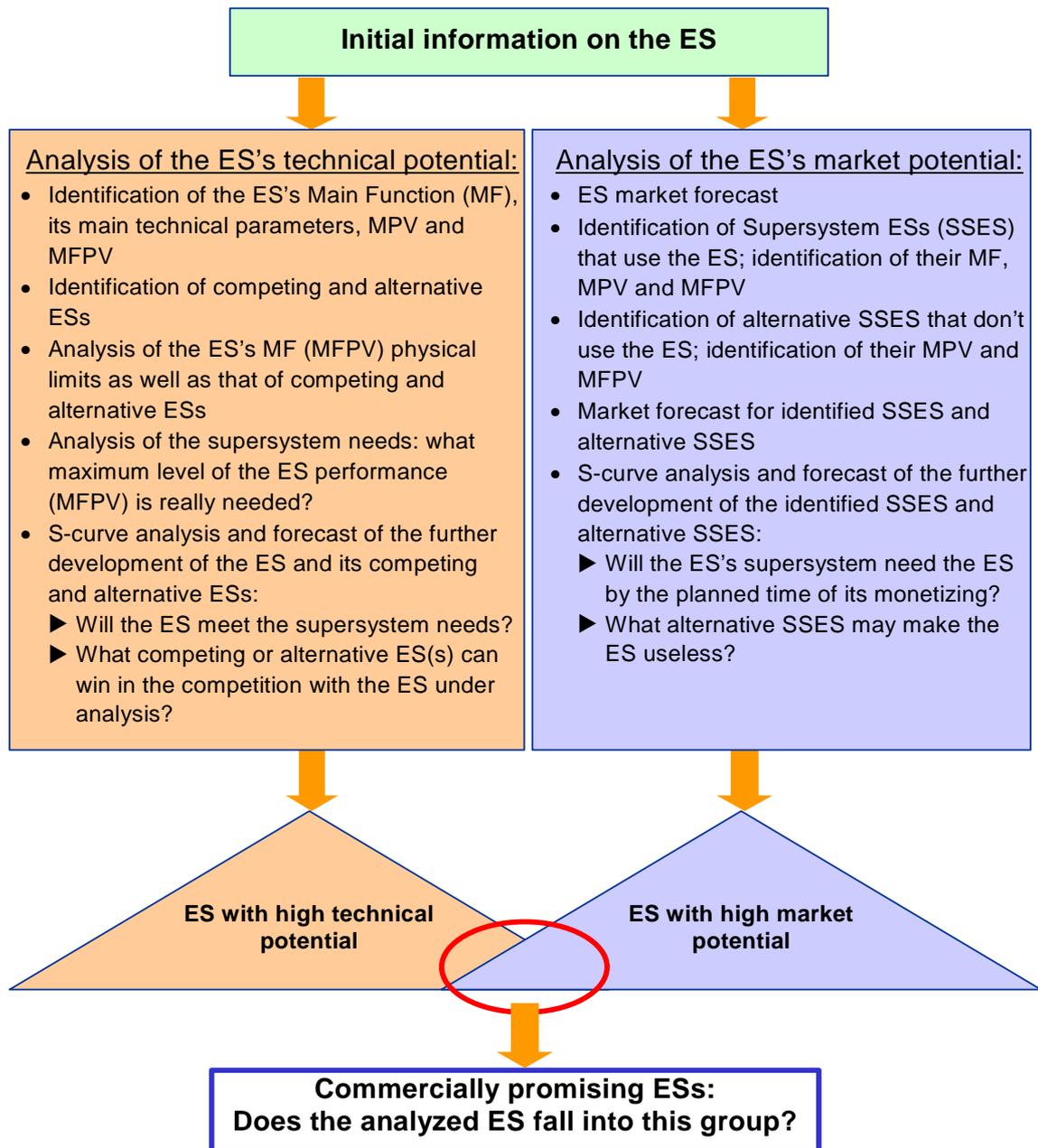


Рис. 2. . Flowchart of proposed algorithm for the ES market analysis

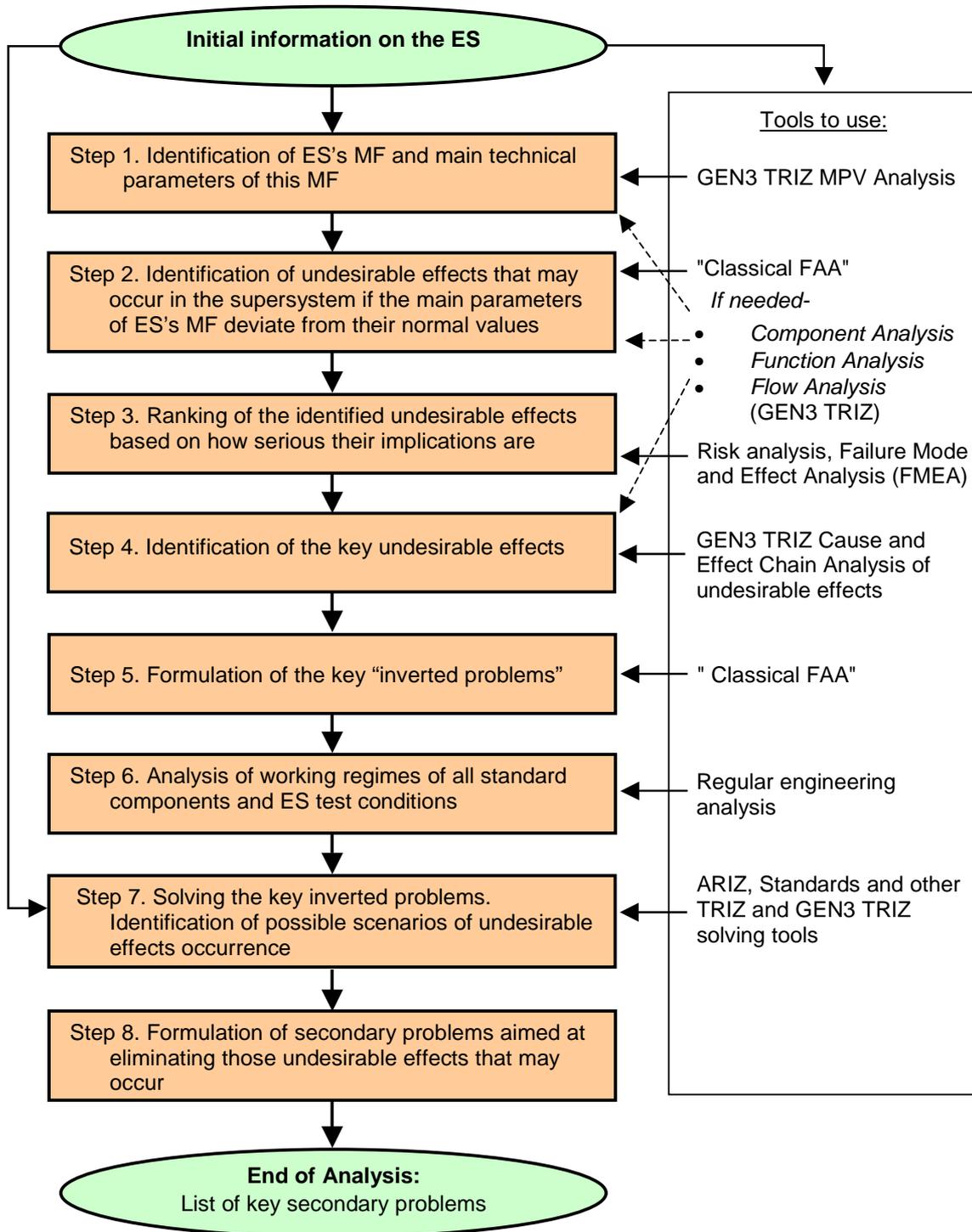


Fig.2. Flowchart of proposed FAA algorithm for analyzing technical part of ES

- The developed methodology (Fig. 3) combines the most efficient tools used in “classic FAA” and in GEN3 TRIZ methodology (e.g. Function analysis, Flow analysis, Cause-Effect Chain analysis of disadvantages), resulting in direct identification of the key secondary problems that are to be solved in order to eliminate the most important hidden harmful/ undesirable effects.

PRACTICAL SIGNIFICANCE OF THIS RESEARCH

This Comprehensive Analysis of the ES at the Transitional Stage significantly enhances the effectiveness of ES analysis and drastically reduces the analysis time because:

- It eliminates the time normally spent on identifying harmful/undesirable effects that are insignificant at this stage;
- It also eliminates the time normally spent on using analytical tools that are excessive in a given situation;
- It immediately yields key secondary problems aimed at eliminating the most important hidden harmful/undesirable effects;
- It identifies hidden harmful/undesirable effects of a non-technical nature, which could negatively affect the success of the ES on the market.

All of the above makes Comprehensive FAA a practical tool that is convenient to use in TRIZ consulting projects, even in express projects⁴.

The usefulness of Comprehensive FAA is substantiated in detail by an example of its application in a consulting project.

⁴ An express project is a short project with duration of approximately 2-3 weeks.

MAJOR STATEMENTS TO BE DEFENDED

- A Roadmap and methodology for Comprehensive Analysis of ES has been developed, and include an analysis of the technical part of the ES along with an analysis of the ES market; an analysis of intellectual property associated with the ES and analysis of the business monetizing the ES.
- For the first time a specialized algorithm for FAA of ES at the transitional stage of their evolution has been developed. This algorithm has the following features:
 1. It takes into consideration the specifics of ES evolutionary stage;
 2. It uses different depths of harmful/undesirable effect analyses depending on how harmful an effect is;
 3. It combines the most efficient tools of classical FAA and GEN3 TRIZ, which provides for reliable identification of key secondary problems.
- An FAA of the ES market that includes a simultaneous analysis of both technical and market potential of the ES has also been developed.

PERSONAL CONTRIBUTION OF THE AUTHOR

The author has personally researched issues related to the specifics of the analysis of ES at the Transitional Stage, and developed a Comprehensive Analysis roadmap and algorithms for the FAA of both the ES market and the technical part of the ES.

The FAA of intellectual property associated with the ES is a summary of practical experience derived from dozens of consulting projects headed by the Author for Algorithm, Ltd.

APPROVAL OF THESIS

The main results of this thesis were reported at the following scientific conferences:

- TRIZ Developers' Summit "Identifying Secondary Problems". St. Petersburg, 2012.
- Scientific conference "TRIZ. Practical Application of Methodological Tools". Moscow, 2011.
- TRIZ Developers' Summit "Development of Tools for Solving Inventive Tasks". St. Petersburg, 2008.
- TRIZ Developers' Summit "Methods for Analyzing Problem Areas and Identifying Innovation Tasks". Moscow, 2007.
- Regional theoretical and practical conference "Three Generations of TRIZ". St. Petersburg, 2003.
- Theoretical and practical conference "Creativity for a Decent Life". Veliky Novgorod, 2001.
- Scientific conference "Innovative Technology of Design Today and Tomorrow". St. Petersburg, 1999.

The Comprehensive Analysis methodology has been implemented successfully by the author in a consulting project. Moreover, the author has taught this methodology to employees at Algorithm, Ltd.

PUBLICATIONS RELATED TO THESIS

1. O. Abramov, A. Kislov. Cause-Effect Analysis of Engineering System's Disadvantages / Handbook on Methodology (Guide), Algorithm, Ltd., 2000 (in Russian)
2. O. Abramov. Application of Failure Anticipation Analysis in Engineering TRIZ-consulting / Three Generations of TRIZ / Proceedings of conference, October 25,

2003.- Regional public organization "TRIZ-Petersburg". St. Petersburg: 2003, pp.104-110. (in Russian)

3. O. Abramov. Alternative Choice of Engineering System to be Improved / TRIZ Analysis. Methods for Analyzing Problem Areas and Identifying Innovation Tasks: Collected articles. Library of TRIZ Developers' Summit. Issue 1. Moscow, 2007, pp. 31-34. (in Russian)

<http://www.trizland.ru/trizba/pdf-books/TRIZ-summit2007.pdf>

4. O. Abramov. Market-Oriented Forecasting of Engineering Systems Evolution. - Journal of TRIZ, №2, 2006, pp. 13-17.

5. O. Abramov. Excessiveness in Engineering Systems / Innovative Technology of Design Today and Tomorrow / Proceedings of conference 1999. - Algorithm, Ltd. St. Petersburg: 1999, p. 81. (in Russian)

See also O. Abramov. Excessiveness in Engineering Systems / Proceedings of theoretical and practical conference "Creativity for a Decent Life". Veliky Novgorod: July 11-12, 2001. (in Russian)

<http://www.triz.natm.ru/articles/abram/abram01.htm>

6. O. Abramov. Operation of the Trends of Engineering Systems' Evolution in Data Transfer and Data Processing Systems / Development of Tools for Solving Inventive Tasks: Collected articles. Library of TRIZ Developers' Summit. Issue 2. St. Petersburg, 2008, pp. 276-280. (in Russian)

7. O. Abramov. Modified Algorithm for Failure Anticipation Analysis of Engineering Systems at the Transitional Stage of Their Evolution. Case Study. / Proceedings of III conference "TRIZ. Practical Application of Methodological Tools". Moscow: October 29, 2011, pp. 6-11. (in Russian)

<http://www.metodolog.ru/node/1186>

8. O. Abramov. Identifying Secondary Problems in Engineering Systems at the Transitional Stage of Their Evolution / Identifying Secondary Problems: Proceedings of TRIZ Developers' Summit 2012. St. Petersburg: July 31, 2012.

<http://www.triz-summit.ru/ru/section.php?docId=5291>

STRUCTURE AND VOLUME OF THESIS

The thesis consists of an introduction, six main chapters, a conclusion and three appendixes including an example of practical implementation of the proposed methodology of Failure Anticipation analysis. The total volume of the thesis is 80 pages, which includes 42 figures, 3 tables and a list of 30 references that includes the author's papers related to this research topic.