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**Failure Anticipation 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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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 Failure Anticipation Analysis (FAA) is a critical tool for analyzing Engineering Systems (ES), specifically at the Transition-From-First-To-Second Stage of their evolution¹.

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 FAA, thereby allowing increased efficiency of FAA.

The remaining four sections describe the four parts of the proposed methodology for a Comprehensive FAA: FAA of the technical part of the ES; FAA of the ES market; FAA of intellectual property associated with the ES; and analysis of the business that monetizes the ES.

The main thrust of this research is on the FAA of the technical part of the ES and the FAA of the ES market.

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

IMPORTANCE OF THIS RESEARCH

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.
- There is a possibility that FAA may be used to analyze some TRIZ tools in order to identify and eliminate their hidden flaws.

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.

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

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 the 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.

This is a possible reason that FAA is, undeservedly, underused in TRIZ consulting.

At the same time, however, there is a real need to identify hidden flaws in the ES. This is particularly important as regards the ES at the Transitional Stage of evolution, 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.

GOALS OF RESEARCH

The goal of this research is to improve, at least partially, the above-mentioned flaws of the existing FAA by universalizing the new approach, successfully implemented in a consulting project, thereby making it a Comprehensive FAA:

- Customize the existing 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 analysis².
- Develop Roadmap and methodology for Comprehensive FAA capable of identifying both technical and non-technical hidden problems that may affect the marketability of the ES.

SCIENTIFIC NOVELTY OF RESEARCH

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

- The existing FAA methodology has been customized for improved identification of hidden harmful/undesirable effects in the ES at the Transitional Stage of evolution. 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). This approach makes the methodology more focused and effective in the analysis of an ES at the Transitional Stage of evolution.
- 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. 2). This methodology, in addition to the FAA of an ES, includes an analysis of the business that monetizes

² 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.

the ES, an FAA of the ES market; and FAA of intellectual property associated with the ES. The scientific novelty of the FAA of the ES market 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.

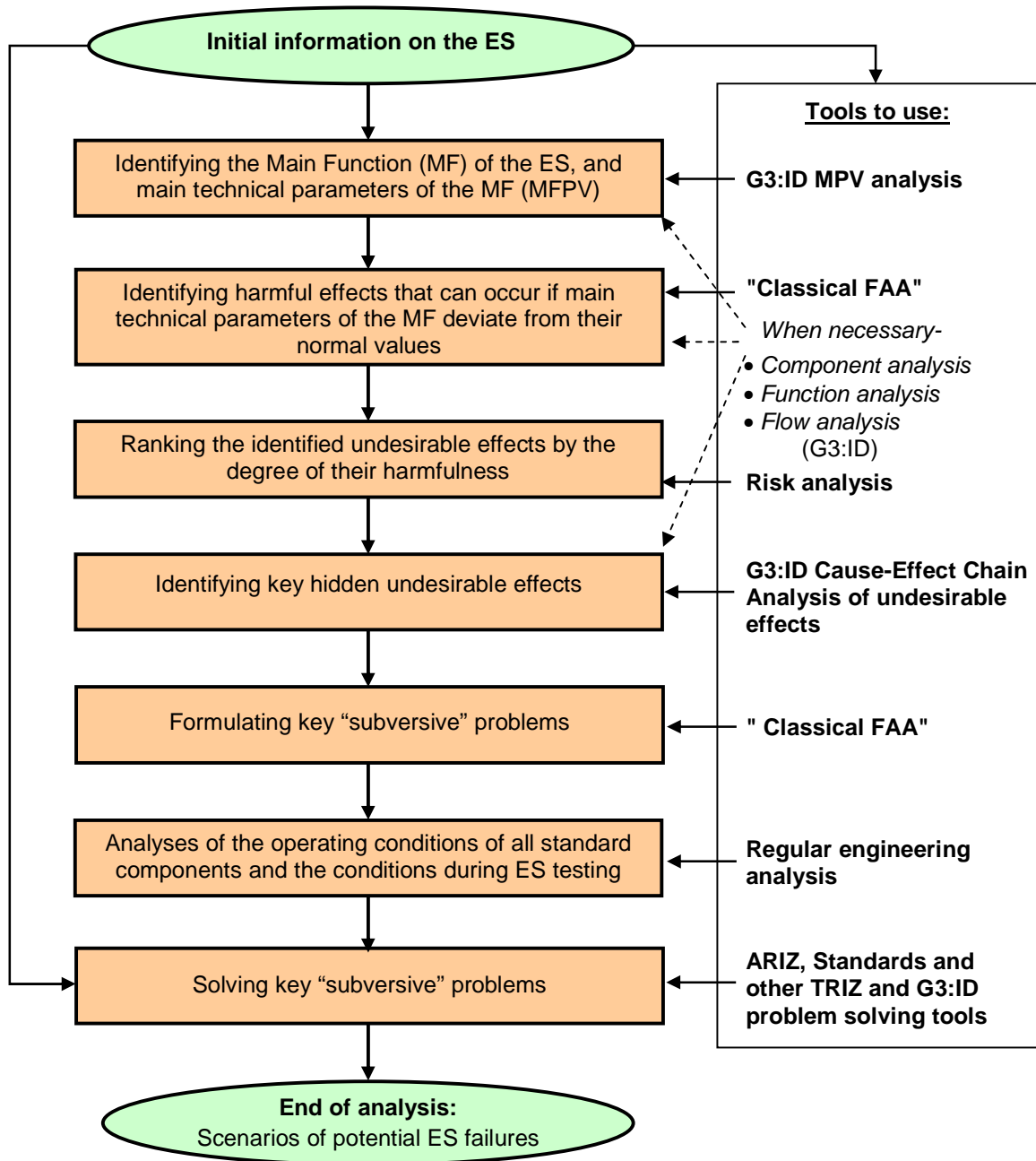


Fig.1. Flowchart of proposed FAA algorithm for analyzing technical part of ES

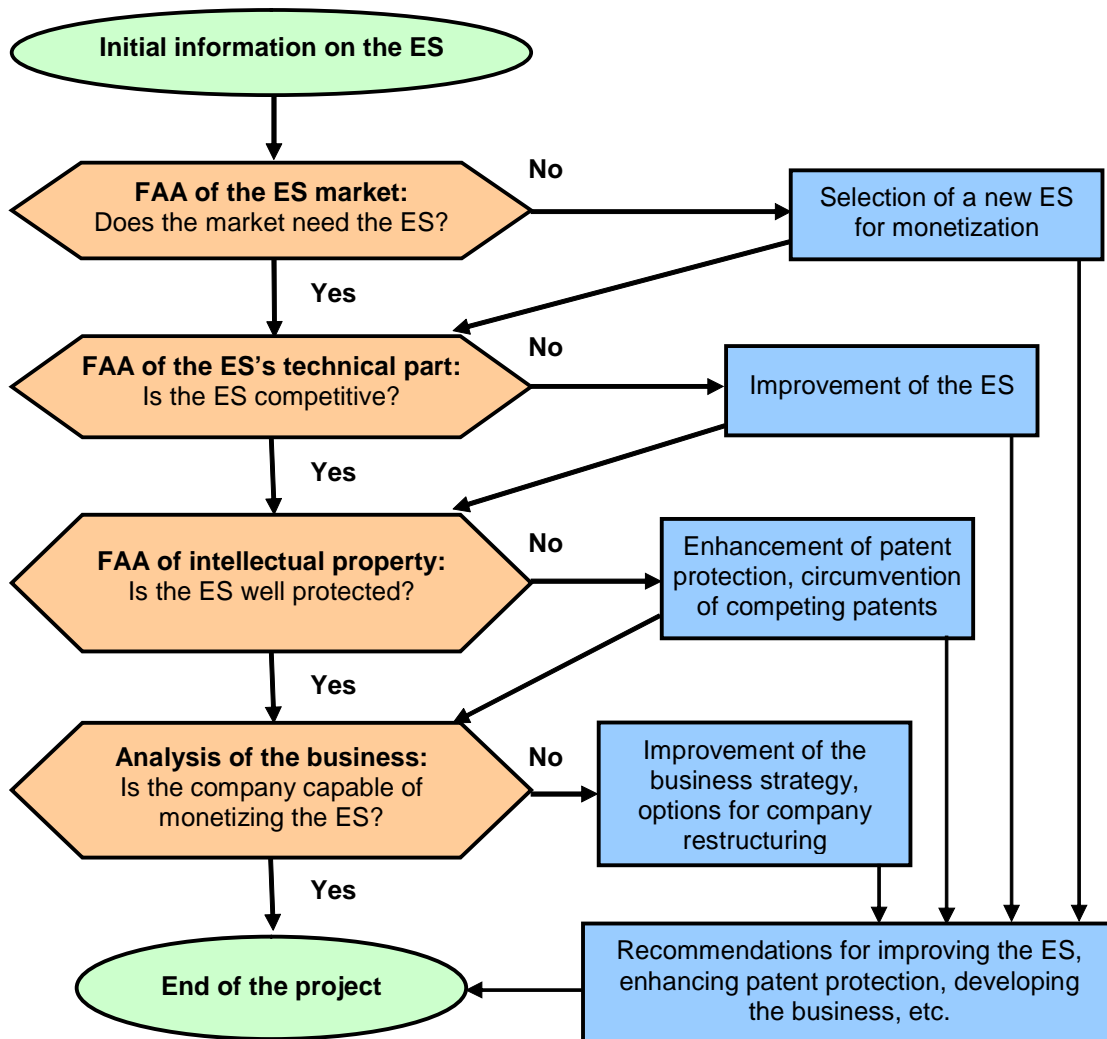


Fig.2. Roadmap of Comprehensive FAA

PRACTICAL SIGNIFICANCE OF THIS RESEARCH

This Comprehensive FAA of the ES at the Transitional Stage significantly enhances the effectiveness of ES analysis 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 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, particularly in express projects³.

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

MAJOR STATEMENTS TO BE DEFENDED

- For the first time a specialized algorithm for FAA that takes into consideration the specifics of ES evolutionary stage has been developed.
- Different depths of harmful/undesirable effect analyses should be used depending on how harmful an effect is.
- A Roadmap and methodology for Comprehensive FAA has been developed, and include the FAA of the technical part of the ES along with the FAA of the ES market; the FAA of intellectual property associated with the ES and analysis of the business monetizing the ES.
- The FAA of the ES market that includes the 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 FAA of ES at the Transitional Stage, and developed a Comprehensive FAA 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 "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.

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

- Scientific conference “Innovative Technology of Design Today and Tomorrow”. St. Petersburg, 1999.

The Comprehensive FAA methodology (excluding the analysis of business monetizing the ES) 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)

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 78 pages, which includes 42 figures, 3 tables and a list of 27 references that includes author's papers related to this research topic.