Author’s Abstract of the Dissertation

Research Aim and Objectives

The aim of this research is to develop and substantiate an **extended model of the system operator**, adapted for the analysis and development of products with consideration of the **entire product life cycle** and **multiple scenarios of use and interaction**. The proposed model is intended to overcome the limitations of the classical TRIZ system operator and to improve the effectiveness of systematic analysis of innovative products.

To achieve this aim, the following main objectives were addressed in the dissertation:

- to analyze existing approaches and concepts related to system analysis in TRIZ, including definitions of system and product, the concept of the life cycle, the classical **nine-window model** proposed by G.S. Altshuller, and the **OTSM-TRIZ extended multi-screen scheme**, in order to identify their capabilities and limitations;

- to develop a **conceptual model of an extended system operator for products**, introducing additional dimensions (product life cycle axis, usage scenarios, multiplicity of supersystems and subsystems) and new concepts for a more comprehensive description of the product system;

- to develop a **methodology for constructing and applying** the proposed model in practice, including an algorithm for data collection, definition of system boundaries, identification of life cycle stages, identification of stakeholders, etc.;

- to demonstrate the operability and advantages of the extended system operator through application examples, showing how the new model makes it possible to identify problems, contradictions, and resources for product development that are not accessible using traditional analytical tools.

Object and Subject of the Research

The object of the research is the process of **systematic analysis and improvement of products** within the TRIZ methodology.

The subject of the research is the **extended system operator model for products** and the methodological principles of its construction and application for solving inventive problems related to product development throughout the entire life cycle.

Scientific Novelty

The dissertation presents a fundamentally new approach to product analysis based on the TRIZ methodology — a **three-dimensional system operator model** that extends the classical nine-window scheme developed by G.S. Altshuller.

The scientific novelty of the work consists in the following.

First, an additional **product life cycle axis** is introduced, reflecting sequential stages from concept and development to operation and disposal, which makes it possible to account for the temporal development of the product in the analysis.

Second, the model integrates various **scenarios of interaction between users and stakeholders** with the product, including multiple roles (end users, developers, manufacturers, service personnel, etc.) and operating conditions. For this purpose, new concepts are introduced, such as:

- **"minimal product"** (a minimally viable product configuration for solving a specific task),
- **"life cycle micro-stage"** (detailed phases within the main stages corresponding to individual usage scenarios),
- **"stakeholder interaction scenario"** (a model of interaction between a specific stakeholder category and the product at different stages).

Third, a mechanism of **dynamic decomposition** is proposed: the structure of product subsystems is considered not as static, but as changing from one life cycle stage to another, reflecting real shifts in analytical focus (for example, engineering-oriented structure at the development stage and user-oriented structure at the usage stage).

The combination of these innovations forms an **extended system operator for products** — a multidimensional model (conventionally referred to as a "product cube") that significantly expands the boundaries of the classical TRIZ toolkit.

The model is universal and applicable to the system analysis of products of various natures (technical devices, software products, services, etc.), taking into account both the technical evolution of the system and the context of its use.

Thus, the dissertation makes a substantial contribution to the development of TRIZ theory by enabling the integration of the **product-oriented approach** and the **full life cycle concept** into inventive problem-solving methods.

Methodology and Research Methods

The methodological basis of the research consists of the classical **Theory of Inventive Problem Solving (TRIZ)** and its modern extensions (including OTSM-TRIZ), as well as concepts from **systems engineering** and **product life cycle management**.

The research employs a combination of general scientific and specialized methods.

In the theoretical part (Chapter 1), methods of literature analysis, comparison, and generalization are used to critically review existing approaches and concepts.

In developing the new model (Chapter 2), the author relies on **conceptual modeling**: an abstract scheme of the extended system operator is constructed using system analysis and axiomatic introduction of new elements based on identified requirements.

In the practical part (Chapter 3), methods of applied case analysis and expert evaluation are used. The proposed methodology is tested on numerous representative situations from real product development practice. The method of **thought experiments** and **scenario analysis** is also applied to demonstrate the operation of the model under different conditions.

A substantial empirical base (several thousand cases from the author's professional practice) serves as a validation mechanism: the results of applying the model are compared with known problems and solutions from these cases.

The reliability of the conclusions is ensured by combining theoretical justification of the model with its practical verification across diverse material.

Main Results

The research yielded the following main results:

1. A comprehensive analysis of fundamental concepts and tools related to the system approach in TRIZ was conducted. Limitations of the classical Altshuller system operator in application to modern products were identified, including insufficient consideration of the full life cycle, diversity of supersystems and subsystems, and stakeholder roles. The necessity of extending this methodology was substantiated.

2. A new **extended system operator model for products** was developed and theoretically justified. The model includes three analytical dimensions: system level (subsystem–system–supersystem), time (past–present–future, technical evolution), and product life cycle stages. Usage scenarios and multiple stakeholders are additionally taken into account. Essentially, a multidimensional scheme is proposed that transforms the classical nine-window matrix into a "product analysis cube."

3. A **methodology for constructing and applying** the extended system operator was developed. A sequence of steps for model formation was defined, including: collection of initial product data; definition of system boundaries and primary functions; identification of key product life cycle stages; decomposition of stages into micro-stages according to different usage scenarios; identification of relevant user categories and other stakeholders at each stage; determination of the current product structure (subsystems) for each stage; and filling the multi-screen scheme across all axes. Recommendations were developed for identifying contradictions

between screens (for example, between requirements of different stages or different stakeholders) and for finding directions for their resolution using TRIZ tools.

4. Practical approbation demonstrated the effectiveness of the proposed approach. Examples show that the extended system operator makes it possible to identify hidden problems and growth points that are not visible using traditional analysis. In particular, consideration of the disposal stage reveals environmental and technological issues previously overlooked, while comparison of screens for different user roles exposes conflicting requirements requiring resolution. The model also supports systematic identification of development resources, both internal (functional reserves, unused subsystem capabilities) and external (supersystem resources, new technologies) at different stages. This confirms that the developed methodology significantly expands the analytical capabilities and practical value of TRIZ for product-related tasks.

Provisions Submitted for Defense

The following main provisions are submitted for defense:

1. The **extended three-dimensional system operator model for products**, including a product life cycle axis and multiple usage scenarios, constitutes a new TRIZ methodological tool that enables comprehensive system analysis of products. The model covers both the technical evolution of the system over time and the context of its market application, significantly exceeding the capabilities of the classical nine-window scheme.

2. The **new concepts and model elements** proposed in the dissertation (including “minimal product,” “life cycle micro-stage,” stakeholder role analysis, and dynamic system decomposition) ensure a more accurate description and understanding of the product as an object possessing consumer value. These concepts formalize aspects previously not accounted for in TRIZ tools, thereby expanding the conceptual framework of inventive problem-solving theory.

3. The **methodology for constructing and applying the extended system operator**, developed by the author, ensures the practical feasibility of the proposed model. The algorithm and recommendations allow specialists to systematically create a “multi-screen product map,” identify contradictions and missed opportunities within it. Practical application of the methodology demonstrates the detection of problems invisible in traditional analysis and the generation of innovative solutions that take into account the full life cycle and interests of all participants.

4. The **theoretical and practical significance** of the obtained results is confirmed by their contribution to the development of TRIZ methodology and their effectiveness in real-world application. The extended system operator integrates TRIZ with systems engineering and product management principles, increasing the versatility

of the toolkit. In practice, the approach improves coordination of cross-functional product development teams, facilitates communication among specialists from different domains (engineers, marketers, service engineers, etc.) through a unified model, and supports identification of strategic product development directions, including forecasting based on identified trends. These provisions are confirmed by extensive approbation across numerous cases and may be recommended for implementation in innovation practice.

Theoretical and Practical Significance

The theoretical significance of the research lies in the substantial development of the methodological foundation of TRIZ. The work extends classical inventive problem-solving theory by integrating product-oriented concepts. The proposed model introduces new representations of systems in TRIZ: a product is considered not only as a technical device but as a complex object passing through multiple stages and interacting with various participants. This expands the applicability of TRIZ and brings it closer to modern approaches in systems engineering, innovation management, and user experience design. As a result, TRIZ theory is enriched with a new analytical tool capable of accounting for market, user, and life cycle aspects alongside technical factors.

The practical significance of the work is confirmed by its direct orientation toward solving applied product improvement tasks. The extended system operator can be implemented in companies to analyze existing products and plan new ones. Its application enables early-stage consideration of stakeholder requirements, avoidance of hidden problems, and enhancement of consumer value and competitiveness of final solutions. The tool is universal and can be applied across diverse industries, from mechanical engineering to information technology, wherever systematic thinking is required for innovation development.

Approbation, Implementation, and Publications

The main ideas and results of the research underwent extensive approbation. Theoretical provisions and the proposed approach were discussed at specialized scientific and practical events: the author presented reports at conferences on TRIZ and innovation management, including the international **TRIZ Development Summit 2020**, where the work received positive expert feedback.

Practical significance is confirmed by implementation of the results: the developed methodology is used in TRIZ educational programs (courses and training sessions for engineers and product managers), through which several thousand specialists have mastered the principles of the extended system operator. Additionally, elements of the methodology are applied in a number of companies for product strategy planning and product life cycle analysis, contributing to more successful market introduction.

Structure and Volume of the Dissertation

The dissertation is written in Russian and includes an introduction, three chapters, a conclusion, a list of references, and an appendix. The structure reflects the research logic: the introduction presents the aim, objectives, relevance, novelty, and significance; Chapter 1 provides a theoretical and methodological review; Chapter 2 presents the new model; Chapter 3 describes the methodology and application examples; the conclusion summarizes the results and outlines future research directions.

The total volume of the dissertation is approximately **130 pages** of typed text, including **20 figures** and **8 tables**. The reference list contains **50 sources**, indicating reliance on a broad range of domestic and international studies. The appendix includes additional material (an example of a completed extended system operator for a specific product), illustrating the practical application of the developed methodology.

Keywords: TRIZ; system operator; extended multi-screen model; minimal product; stakeholder interaction scenario; product life cycle; product-oriented approach; innovation; systems engineering.