UDC 629.017 DOI: https://doi.org/10.32515/2664-262X.2023.8(39).2.159-169

Olexandr Polyanskyi, Prof., DSc., **Yevhen Dubinin**, Prof., DSc., **Andrii Korobko**, Assoc. Prof., DSc., **Vladyslava Baidala**, assistent
Kharkiv National Automobile and Highway University, Kharkiv, Ukraine
e-mail: dubinin-rmn@ukr.net

Improving the quality of wheeled vehicle stability assessment using constraint theory

The article considers the problem of assessing the stability of wheeled vehicles, which is an important characteristic that affects traffic safety and the economic performance of wheeled vehicles. The paper analyzes existing decision-making algorithms using the theory of constraints in assessing the stability of wheeled vehicles, considering five types of logic trees and establishing rules for their application to analyze the dynamic stability of vehicles. It was found that these algorithms have limited accuracy due to the lack of consideration of all factors that affect the stability of wheeled vehicles, or cannot take these factors into account with sufficient accuracy. Based on this, rules for using logical trees for a more accurate study of the stability of wheeled vehicles have been developed, which allow taking into account more factors that affect the stability of wheeled vehicles with greater accuracy.

Using the solutions obtained in this work, it is possible to significantly expand the scope of measurements, allowing for a more objective analysis of vehicle parameters in various operating conditions. A study was conducted to evaluate the accuracy of the developed rules using various data sets, which included information on the parameters of wheeled vehicles and the results of dynamic stability tests. The results of the study showed that the developed rules can significantly improve the accuracy of assessing the stability of wheeled vehicles.

Recommendations for improving the quality of tests for the dynamic stability of wheeled vehicles have been developed, which relate to the choice of test parameters and data processing methods. It is emphasized that the use of the theory of constraints can significantly improve the quality of tests for the dynamic stability of wheeled vehicles by providing appropriate approaches and methodologies to improve this process.

The research results presented in this article are important for improving traffic safety and economic efficiency of wheeled vehicles.

wheeled vehicle, theory of constraints, test improvement

Formulation of the problem. Much attention is being paid to improving the quality of vehicle stability tests. The application of constraint theory is becoming one of the key areas for achieving high standards in testing, which affects the safety and reliability of road transport. The theory of constraints, which is based on the identification and management of the main constraints in the system, allows to identify the critical aspects that determine the stability of the vehicle position. The research is aimed at considering the practical aspects of implementing high-precision test methods using constraint theory. This is a necessary step to increase the efficiency and reliability of vehicle testing, which is important in the context of rapid technological progress and development of the road transport industry.

Analysis of recent research and publications. In [1], the author argues that true quality improvement is impossible without in-depth knowledge based on an understanding of the theory of cognition, knowledge of variation, an understanding of psychology, and understanding of the system. The author of [2, 3] has developed an approach to continuous improvement called the Theory of Constraints (TOC), which demonstrates the application of TOC logical techniques. This approach allows analyzing the reasons that keep the system from developing and developing a plan for its improvement. The author of [4, 5] describes five sequential steps developed by Goldratt that help to focus efforts on what will allow the entire system to be reorganized as soon as possible. The author of [6] discusses the concept of the theory and its principles, as well as examines the prescriptions, namely the five guiding steps.

Setting objectives. The aim of the work is to improve the algorithm for effective assessment of the stability of wheeled vehicles using the application of logical trees in the study of dynamic stability of vehicles.

Achieving this goal involves solving the following tasks:

– to analyze existing decision-making algorithms using the theory of constraints to assess the sustainability of wheeled vehicles;

– to establish clear and effective rules for the use of logic trees for a more accurate study of the stability of wheeled vehicles;

– to develop recommendations for improving the quality of tests for the dynamic stability of wheeled vehicles.

Presenting main material. In general, any system can be defined as a set of interconnected interdependent components or processes that interact, purposefully transforming the initial components (inputs) into a certain result (output). Systems influence the external environment and are subject to its influence. Obviously, quality (or lack thereof) does not exist in itself. Quality can only be discussed in the context of the system to which it is inherent. So, following Deming's reasoning, it is impossible to improve quality without a clear understanding of the system. He developed a 14-point "quality roadmap" that serves as a guide to achieve continuous improvement in process organizations. Many other theories based on the principle of continuous improvement also offer similar guidelines for success. It expands on the "...act to make the transformation happen" [1] by encouraging organizations to involve every employee, train everyone in the new philosophy, create a "critical mass" of like-minded people, and form initiative groups or teams to improve systems and processes.

TOC is a theory with recommendations, meaning that it can not only explain what factors keep a system from unlocking its potential, but also indicate how to act [2, 3]. Many theories answer the first question: what is the problem? Some can even provide specific advice, but usually these concepts focus exclusively on individual processes, not on the system as a whole. And they do not address the concept of system limitations at all.

Deming, using the term "transformation", actually means the introduction of significant changes in the functioning of the organization [7]. Goldratt's theory of constraints also focuses on changes and improvements. Following its principles, we can answer the three main questions it poses: What to change? (What is the limitation?); What to change to? (What to do with the limitation?); How to make changes? (How to get rid of the limitation?). It should be borne in mind that this question requires a systemic approach, not limited to looking at individual processes. While the answers may affect individual steps, they are formulated to identify where to focus efforts for overall system improvement. Processes have their place, but ultimately, the success or failure of organizations is driven largely by their functioning as a system as a whole.

It should be remembered that TOC and Total Quality Management (TQM [8]) are not mutually exclusive. Rather, TOC fills in the gaps that TQM has never paid due attention to: where to focus improvement efforts to achieve the maximum and fastest results. In other words, by using TOC in addition to TQM, the problem of waiting for results is solved. By effectively using TOC in conjunction with TQM, it is possible to find that TQM and quick results do not have to be mutually exclusive. Therefore, one should not abandon the TQM tools. In some cases, traditional quality management techniques can be very useful, as TOC will help decide when and how to use each of them most effectively.

Operational theories are usually divided into descriptive and prescriptive. Descriptive theories, such as the law of attraction, explain why a phenomenon occurs, but do not tell us what to do in this case. Prescriptive theories go further, not only describing but also advising how to act. TOC is a prescriptive theory, but before we look at its prescriptive parts, let's look at its descriptive aspect. Goldratt argues that the basis for the prescriptive part of the theory is a set of several principles. Table 1 provides an extensive list of principles that are particularly important.

Table 1 – Some principles of TOC derived from the fundamental ideas of the theory of constraints [1]

1. When implementing transformations and resolving conflicts, it is better to rely on systemic thinking rather than analytical thinking.
2. The effectiveness of optimal system solutions decreases over time as the environment changes. A continuous improvement process is required to keep track of the relevance and effectiveness of the solution.
3. When the system as a whole is operating at its maximum efficiency, only one of its elements is operating at its maximum capacity. The fact that all parts of the system are operating at the limit of their capabilities does not mean that the entire system is operating efficiently. The optimal state of a system does not consist of the optimal states of its individual elements.
4. Systems are like chains. Every system has a weakest link, which ultimately reduces the effectiveness of the entire system.
5. Strengthening any non-restrictive element does not make the chain stronger.
6. In order to make deliberate, reasonable changes, it is necessary to understand the current state of the system, its goals and the nature of the existing problems.
7. Most undesirable phenomena in a system are caused by several genuine problems.
8. Real problems are usually implicit. They manifest themselves as a series of undesirable phenomena connected by cause and effect relationships.
9. Eliminating individual undesirable phenomena gives a false sense of security, while the real cause remains undetected. Solutions of this kind are short-lived. Solving the key problem simultaneously eliminates all related undesirable phenomena.
10. The key problems are usually exacerbated by the underlying hidden conflict. To solve the problem, it is necessary to identify the main causes of the conflict and get rid of at least one of them.
11. System limitations can be both physical and organizational. Physical limitations are relatively easy to identify and eliminate. Organizational constraints are usually more difficult to identify and remove, but their neutralization usually entails more significant and important changes than removing the physical constraints of the system.
12. Inertia is the worst enemy of continuous improvement. Decisions gradually become important, overgrown with a mass of auxiliary details, which hinders further transformations.
13. Ideas are not solutions.

Source: developed by the author

In TOC, the basic idea is to represent a system as a set of chains. This means that if the system functions as a chain, the weakest link can be identified and strengthened. Due to the interdependence and variability, optimization of individual elements does not guarantee optimal functioning of the system as a whole. Thus, the efficiency of each element of the system does not always reflect the efficiency of the system as a whole. Most of the constraints faced in systems have organizational rather than physical causes. Physical constraints are relatively easy to identify and eliminate, while organizational constraints are usually more difficult to identify and harder to remove. However, their elimination usually causes more visible and significant changes than getting rid of physical constraints.

There are five guiding steps of TOC, which begin the prescriptive part of the theory of constraints and help focus efforts on what will allow the entire system to be reorganized as quickly as possible [4, 9].

1) Find the system's limitations. What element of the system contains a weak link? Is it physical or organizational in nature?

2) Reduce the impact of the system limitation. What Goldratt means is that we should maximize the use of the link capacity that is currently the system constraint. In other words, to answer the question: "How can we squeeze the maximum out of the limiting element without significant additional costs and thereby mitigate the negative impact of the limitation on the operation of the entire system?"

3) Focus all efforts on the system's limiter. Once the constraint is found (step 1) and we decide what to do with it (step 2), we adjust the entire system so that the constraint works at maximum efficiency. We may need to slow down some parts of the system and speed up others. Then we analyze the results of our actions: do we find out whether this limitation still delays the work of the entire system? If not, we get rid of it and proceed to step 5. If so, the restriction still exists, and we move on to step 4.

4) Remove the restriction. If steps 2 and 3 are not enough to remove the restriction, then more radical measures are needed. Only at this stage can we realize the idea of large-scale changes to the existing system. This stage may require a significant investment of time, effort, money, and other resources, so we must be sure that it is not possible to get rid of the constraint in the first three steps. Removing the constraint implies that we will take any measures to remove the constraint. As a result, the limiting element will definitely be removed.

5) Return to the first step, keeping in mind the inertia of thinking. If the constraints are removed in steps 3 or 4, we must return to step 1 and start the cycle again. Our task is to identify the next element that holds the system back. This is exactly what happens in the production example (Fig. 1). The inertia warning reminds us that we should not be complacent and satisfied with what we have achieved: the cycle never ends. We should look for and eliminate constraints, constantly remembering that due to the interdependence and variability, every change we make to the system will have some impact on the constraints we have already gotten rid of earlier. It may be necessary to pay attention to them again and make appropriate adjustments.

The five guiding steps are directly related to the three questions about transformation (what to change, what to change to, how to implement the change) [9]. To understand what to change, we look for constraints (step 1). To figure out what changes are needed, we decide how best to weaken the constraint. We subject the entire system to our decision (steps 2 and 3). If this does not lead to improvement, we consider increasing the capacity of the weak link and removing the constraint entirely (step 4). In steps 3 and 4, we also specify "how to implement the change".

Most researchers ask themselves the following questions: "How do we know if the removal of a restriction has had a positive impact on the entire system?", which can be formulated differently: "How can we measure the impact of local solutions on the system as a whole?" In such cases, TOC is particularly effective.

Part of the answer is to identify the weakest link (limitation) and ignore, at least temporarily, what does not limit the elements [9]. For example, in the most serious laboratory studies, the effect caused by a change in one variable is measured, while holding the others constant as far as possible. This "sensitivity analysis" is particularly useful for determining how much a result depends on a particular cause. Doing the same thing in an organization (i.e., working only with the constraints), we win twice:

– Maximize system improvements with minimal resource expenditures;
– Know exactly how much the improvement of individual elements affects the entire system.

Goldratt has developed a simple method for assessing the effectiveness of a particular management decision aimed at achieving the overall goal of the entire system [9].

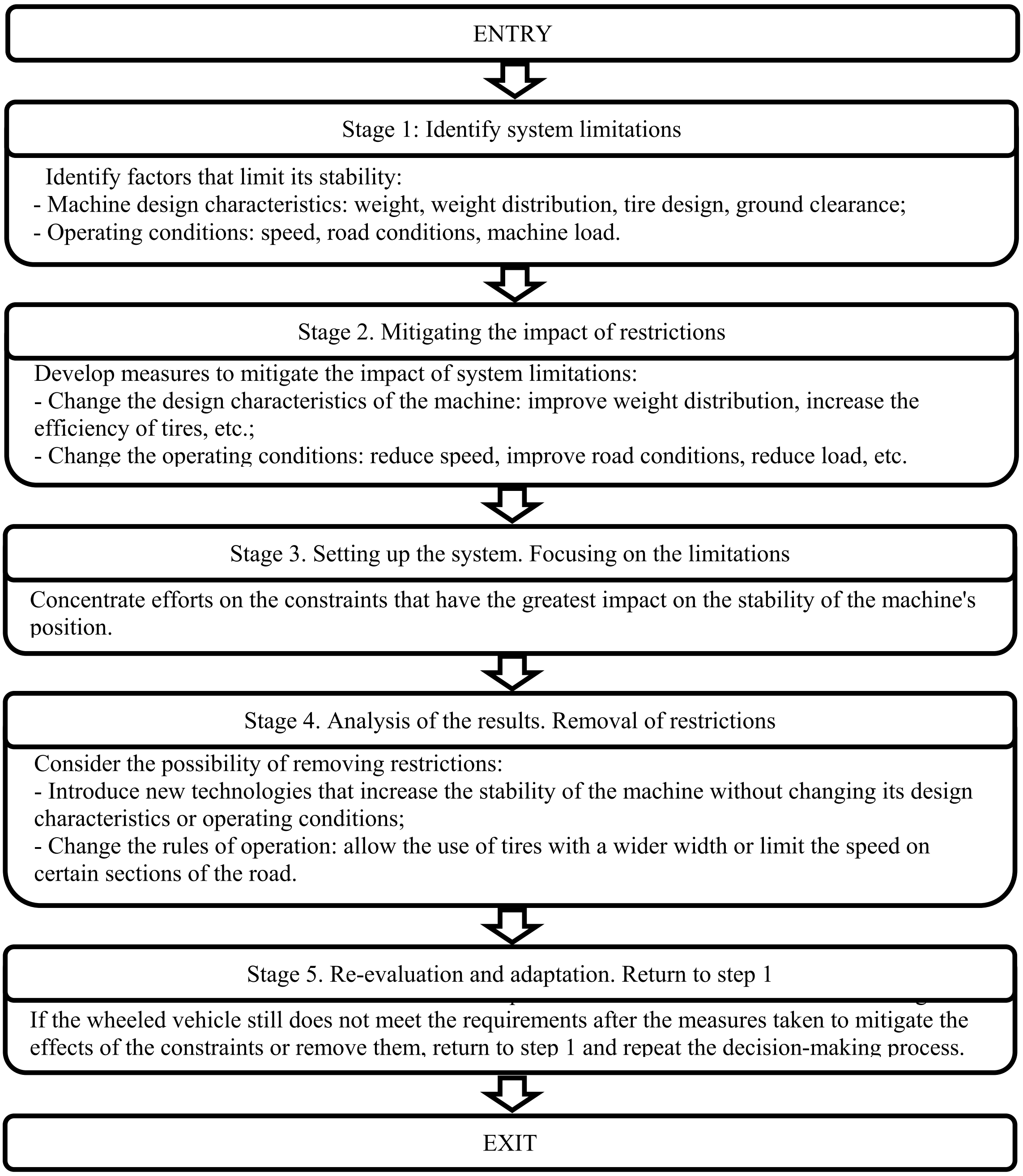

Figure 1 – Decision-making algorithm using the theory of constraints in assessing the stability of the position of wheeled vehicles

Source: developed by the authors

The theory of constraints is not only a theoretical concept, but a true paradigm and model that includes not only concepts that indicate the direction of recommendations and guidelines, but also its own methods and tools [6].

Initially, each TOC method is unique. Applying the theory to a new situation always leads to some unique solution. Often, some solutions become universal and are used as tools for transformation. The tools developed by Goldratt for the theory of constraints (TOC) are based on logical principles. They include five types of logic trees and rules that define their structure:

1) The Current Reality Tree (CRT) is a tool for analyzing problems. It can be used to study the cause-and-effect relationships that determine the current situation [11]. The CRT starts with identifying the existing undesirable phenomena in the system and helps to

determine the real causes or the key problem that caused all the undesirable phenomena we are facing. The key problem is usually the constraint that we try to find using the five guiding steps tactic. The CRT tells us what exactly needs to be reorganized – it identifies the smallest, simplest change in the system that will have the greatest positive effect.

In research to improve the stability of wheeled vehicles, it is possible to use this method as a tool for iterative analysis and improvement of the system, continuing to refine and test changes. For example, by using CRT to analyze the dynamic stability of a vehicle, undesirable phenomena such as instability during sharp turns can be identified, and factors that affect stability at different speeds can be identified. The branches of the tree can then be examined, representing possible causes of the phenomenon, and iterative changes to the system, such as suspension optimization or tire parameters, can be implemented and tested for their effectiveness to gradually improve dynamic stability.

2) The Conflict Resolution Chart (CRC) is a tool that allows visualizing a conflict to better understand its causes and possible solutions. It is designed to remove hidden conflicts that usually underlie long-standing "chronic" problems [12]. The CRC is based on the belief that most real problems are caused by some kind of opposition or conflict that prevents the problem from being solved in the usual way; otherwise, it would have been solved long ago. The CRC can also serve as a "creative engine" that allows us to generate new ideas that can provide a "breakthrough" in solving old problems.

The CRC allows systematizing and identifying hidden conflicts that may be the root cause of problems with the transverse dynamic stability of the vehicle, which helps to find creative solutions to solve them. For example, by applying CRC to analyze the dynamic stability of a vehicle, a conflict between the need for high maneuverability and the need for stability at high speeds can be identified. By analyzing the impact of various technical solutions, one can try to find the optimal balance between these requirements to improve the overall dynamic stability of the vehicle. For example, it is possible to: increase the stiffness of the suspension to improve stability at high speeds; install a stability control system to help prevent skidding; develop a new type of tire that can provide more traction. The choice of a particular solution depends on the specific requirements for the vehicle.

3) The Future Reality Tree (FRT) serves two purposes [13]: first, it allows us to make sure that the action we are going to take will really lead to the desired results, and second, this diagram makes it possible to determine what negative consequences our intended action may cause. These two points are very important and useful: we can logically "test" the effectiveness of the intended actions before we spend time, effort, or resources on them. This way, we can avoid worsening the situation. By confirming the effectiveness of the new configuration of our system, this tool answers the question "what should we change?". The FRT diagram can also be an invaluable tool for strategic planning.

FRT for sustainability studies can be used to effectively plan and avoid negative consequences of implementing selected actions and monitoring their results in real-world conditions. If problems arise, an iterative approach can be applied, making adjustments to the selected strategies. This approach will make it possible to systematically plan and solve the problems of dynamic stability of wheeled vehicles, avoid negative consequences and ensure effective and safe changes in the design or parameters of the vehicle. For example, by using it to plan improvements to vehicle dynamics, it can be determined that changes in suspension geometry can improve lateral stability. As these changes are implemented, monitoring can be used to collect data on the impact on agility and stability and adjustments can be made to optimize results if necessary.

4) A transition tree (TT) helps to implement a decision when a course of action is decided [10]. It identifies what may hinder our actions and how best to overcome these

obstacles. It also allows us to establish the sequence of actions required to achieve the goal. This diagram half-answers the question "how to make changes?".

The TT can be used to effectively implement decisions and overcome obstacles in improving the dynamic lateral stability of a wheeled vehicle. This approach helps to create a clear and systematic action plan to realize improvements in vehicle dynamics and overcome obstacles to achieving the goal. For example, using the TT, it is possible to identify an obstacle in the form of resource constraints for the introduction of a new suspension technology. Using this method, alternative solutions can be considered and strategies can be selected that will effectively overcome this obstacle and lead to an improvement in the vehicle's lateral dynamic stability.

5) A transformation plan [10] provides detailed step-by-step instructions on how to implement solutions and the logical justification for each step. In essence, it is a detailed roadmap for achieving a certain goal, which complements the answer to the question "how to implement changes?".

A transformation plan can provide a systematic and detailed approach to improving dynamic lateral stability, taking into account all aspects and possible risks. For example, using a conversion plan to improve the dynamic lateral stability of a wheeled vehicle, it may be determined that replacing certain suspension components can improve stability. The plan includes steps for selecting the optimal components, developing detailed instructions for their installation, and a logical justification for the impact of these changes on overall dynamic stability.

Criteria for verification of logical constructions (CLCC) are a "logical connection" that unites all the listed diagrams [4]. In fact, these are eight provisions that can be used to check, prove or refute the correctness of the constructed causal relationships: clarity; presence of an assertion; presence of a causal relationship; sufficiency of the reason given; checking for an alternative reason; inadmissibility of substituting a cause for an effect; search for a verifying consequence.

We use the CFCs when creating diagrams to make sure that our initial premises are logical. We use Boolean diagrams to understand the logic in a holistic way. Logic trees can also be used to analyze logic trees and, most importantly, they help to express constructive criticism to opponents and avoid conflicts, i.e., come to mutual understanding.

Goldratt's five logical tools can be used individually or collectively as a clearly organized process of logical thinking or "thought process" [14]. The three basic management questions about the change can be answered by using the five logic tools as a whole. Table 2 shows the relationship between these tools and the change management questions.

Table 2 – How logic tools relate to the three management questions about change

Stage of the change process	A suitable logical tool
What to change?	The tree of current reality
What to change to?	Diagram of conflict resolution, tree of future reality
How to make changes?	Transition tree, transformation plan

Source: developed by the authors

Figure 2 shows a general picture of the relationship of tools as elements of a single logical thinking process. Quantitatively complex problems that cannot be quantified should be subjected to logical analysis first.

Thus, the theory of constraints can help to improve the quality of wheeled vehicle dynamic stability tests by meeting the following criteria:

1. Using the search for optimal research parameters, which can be carried out using the theory of constraints. The main idea is to set constraints on various system parameters, such as suspension parameters and chassis geometry, and search for optimal values of these parameters that maximize the dynamic stability of the vehicle. This will allow important

parameters and constraints to be systematically considered to ensure optimal values, aimed at improving parameter quality definition.

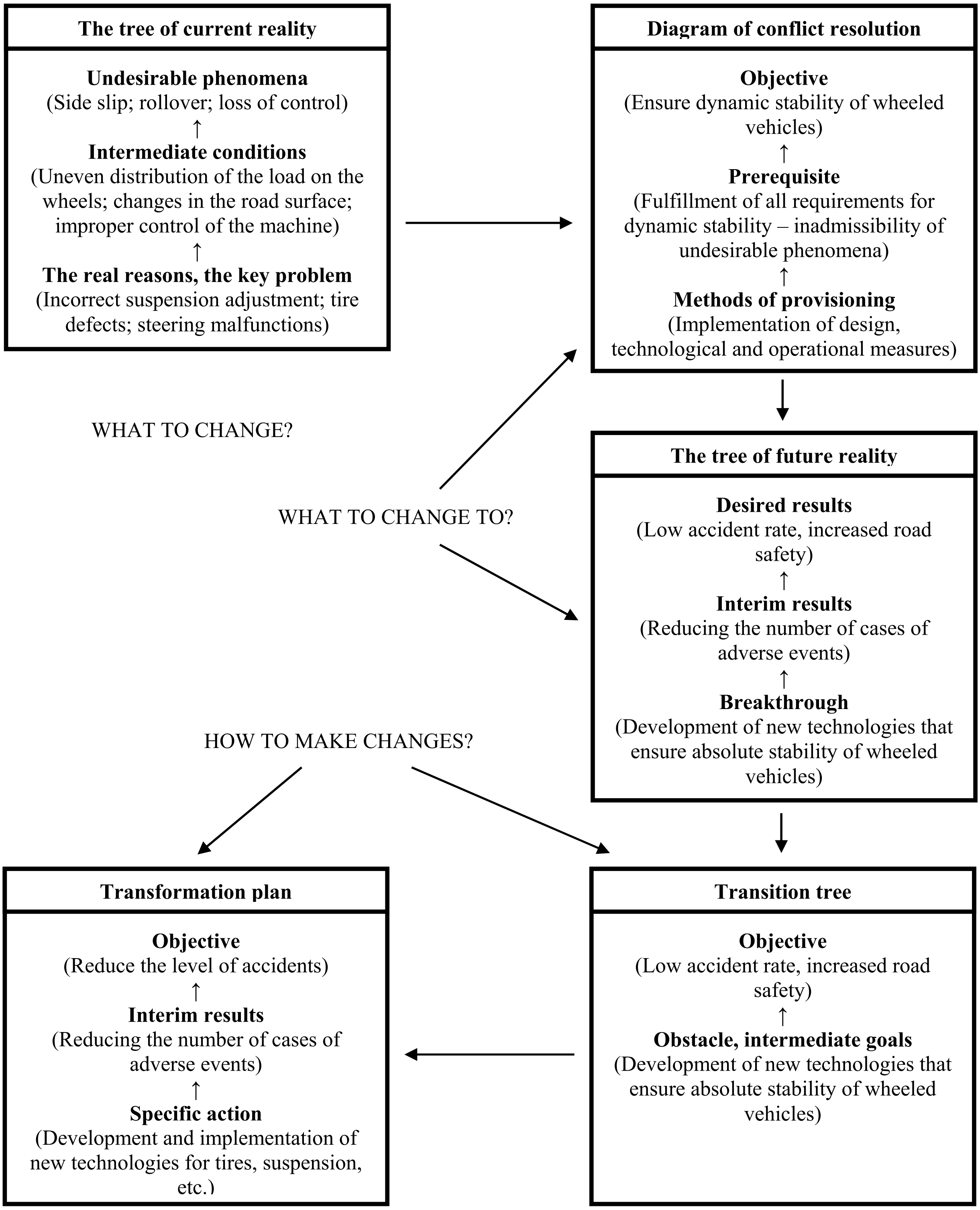

Figure 2 – Five logical tools as a single process of logical thinking

Source: developed by the authors

2. Modeling parameter variation, using an approach that will allow for parameter diversity and uncertainty in the study. Instead of fixing parameters to specific values, models allow them to vary within acceptable limits. This can be especially important in cases where parameters may change due to variations in production, different operating conditions, or other factors. This will allow for more realistic modeling of operating conditions, taking into account parameter variations that may occur in real-world conditions.

3. Development of a limited testing system, which, in combination with the use of the theory of constraints, involves the creation of a test method that takes into account the actual operating conditions of the vehicle and the limitations that may arise during its operation. This will allow for effective testing of vehicles conditions as close as possible to actual operation, ensuring compliance with restrictions and safety standards.

4. The use of innovative technologies, in particular the use of simulation and virtual testing in the field of vehicle stability research, which can greatly facilitate and improve the testing process. These are powerful tools for researching and improving the dynamic stability of vehicles.

5. Generalization of research results using the theory of constraints, which is important in order to draw conclusions that will be as characteristic as possible for real-world vehicle operating conditions. This approach will make the study more comprehensive and versatile, which in turn improves the quality of the results obtained and their application in real-world operating conditions.

Conclusions.

1. It is determined that the theory of constraints is an effective tool for improving the dynamic stability of wheeled vehicles. The methodology allows identifying system limitations, developing recommendations for their elimination or mitigation, and implementing these recommendations. Various measures can be used to improve the dynamic stability of wheeled vehicles, including: installation of directional stability systems, optimization of suspension stiffness, increasing track width, optimization of vehicle weight distribution, use of new materials and manufacturing technologies, and development of new vehicle dynamics control systems.

2. The application of the theory of constraints in the context of dynamic stability testing of wheeled vehicles can lead to such advantages as: improved test quality, increased test efficiency, and reduced test costs.

3. To improve the tests for dynamic stability of wheeled vehicles using the theory of constraints, the following measures can be used: using the search for optimal research parameters, modeling parameter variation, developing a limited testing system, using innovative technologies, and generalizing research results. Thus, the application of the theory of constraints can be an effective tool for improving the dynamic stability of wheeled vehicles, both in the design and production process and in the testing process.

List of references

1. Neave H. R. The Deming Dimension. SPC PRESS (Statistical Process Control); 1st Paperback Edition, 1990. 440 p. ISBN 978-0-945320-36-4.
2. Goldratt E. M., Cox J. The Goal: A Process of Ongoing Improvement. North River Press; 2nd Rev edition, 1992. 274 p. ISBN 0-88427-061-0.
3. Goldratt E. M. It's Not Luck. North River Press, 1994. 288 p. ISBN 0-88427-115-3.
4. Zosym M. Теорія обмежень. URL: https://www.maxzosim.com/tieoriia-obmiezhien/.
5. TOC (Theory of Constraints). *DTU*. URL: http://wiki.doing-projects.org/index.php/TOC_(Theory_of_Constraints).
6. Колодізєва Т. О. Використання принципів теорії обмежень при проектуванні логістичних систем. *Конкурентоспроможність та інновації: проблеми науки та практики:* матеріали Міжнародної науково-практичної конференції, 16 листоп. 2017 р. Харків: ФОП Лібуркіна Л.М., 2017. С. 145–148.
7. Thinking Processes as a Tool for Improving the Administrative Process / García-Vidal G. et al. *International Journal of Management Science and Business Administration*. 2016. Vol. 2, No. 7. P. 25–41.

URL: https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.27.1003.
8. Total Quality Management: Meaning, Concept, Process, Elements & Tools. *Economics Discussion*. URL: https://www.economicsdiscussion.net/quality-management/total-quality-management/32329.
9. Dettmer W. H. Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement. Asq Pr; Later Printing edition, 1997. 378 p.
10. Примостка О. Розумові процеси теорії обмежень Голдратта: системна методологія. *Науковий журнал «Економічний вісник Запорізької державної інженерної академії»*. 2017. № 5 (11). С. 31–36.
11. Мороз Л. В. Нормативно-методичне забезпечення статистичного контролю виробничих процесів та якості продукції : автореф. дис. на здобуття наук. ступеня канд. техн. наук : 05.01.02. Львів, 2016. 22 с.
12. Діаграма конфлікту «Грозова хмара». *Громадська організація «Координаційно-правозахисна група «Zaslon».* URL: https://zaslon.at.ua/index/diagrama-konfliktu-grozova-khmara/0-62.
13. Problem-Solving With a Future Reality Tree. *Lucidspark*. URL: https://lucidspark.com/blog/future-reality.
14. Theory of Constraints Concepts and Details. *Quality Assurance Solutions, Spreading the QA Word*. URL: https://www.quality-assurance-solutions.com/Theory-of-Constraints.html.

References

1. Neave, H. R. (1990). The Deming Dimension. SPC PRESS (Statistical Process Control); 1st Paperback Edition, 440 p. ISBN 978-0-945320-36-4 [in English].
2. Goldratt, E. M. & Cox J. (1992). The Goal: A Process of Ongoing Improvement. North River Press; 2nd Rev edition, 274 p. ISBN 0-88427-061-0 [in English].
3. Goldratt, E. M. (1994). It's Not Luck. North River Press, 288 p. ISBN 0-88427-115-3 [in English].
4. Zosym, M. (2023). Teoriia obmezhen' [Theory of constraints]. Retrieved from: https://www.maxzosim.com/tieoriia-obmiezhien/ [in Ukrainian].
5. TOC (Theory of Constraints). *DTU.* Retrieved from: http://wiki.doing-projects.org/index.php/TOC_(Theory_of_Constraints) [in English].
6. Kolodizieva, T. O. (2017). Vykorystannia pryntsypiv teorii obmezhen' pry proektuvanni lohistychnykh system [Using the principles of the theory of constraints in the design of logistics systems]. Competitiveness and innovation: problems of science and practice: *materialy Mizhnarodnoi naukovo-praktychnoi konferentsii (16 lystopada 2017 roku) – materials of the International Scientific and Practical Conference.* (p.p. 145-148). Kharkiv: FOP Liburkina L.M. [in Ukrainian].
7. García-Vidal, G. et al. (2016). Thinking Processes as a Tool for Improving the Administrative Process. *International Journal of Management Science and Business Administratio, Vol. 2, No. 7,* P. 25-41. URL: https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.27.1003 [in English].
8. Total Quality Management: Meaning, Concept, Process, Elements & Tools. *Economics Discussion*. Retrieved from URL: https://www.economicsdiscussion.net/quality-management/total-quality-management/32329 [in English].
9. Dettmer, W. H. (1997). Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement. Asq Pr; Later Printing edition, 378 p. [in English].
10. Prymostka, O. (2017). Rozumovi protsesy teorii obmezhen' Holdratta: systemna metodolohiia [Mental processes of Goldratt's theory of constraints: a systematic methodology]. *Naukovyi zhurnal «Ekonomichnyi visnyk Zaporizkoi derzhavnoi inzhenernoi akademii» – Scientific journal "Economic Bulletin of Zaporizhzhya State Engineering Academy" , 5 (11),* 31–36 [in Ukrainian].
11. Moroz, L. V. (2016). Normatyvno-metodychne zabezpechennia statystychnoho kontroliu vyrobnychykh protsesiv ta iakosti produktsii [Normative and methodical provision of statistical control of production processes and product quality]. *Candidate's thesis.* Lviv [in Ukrainian].
12. Diahrama konfliktu «Hrozova khmara» [Storm Cloud Conflict Diagram]. *Hromadska orhanizatsiia «Koordynatsiino-pravozakhysna hrupa «Zaslon» – Public organization "Coordinating and Human Rights Protection Group "Zaslon".* Retrieved from URL: https://zaslon.at.ua/index/diagrama-konfliktu-grozova-khmara/0-62 [in Ukrainian].
13. Problem-Solving With a Future Reality Tree. *Lucidspark*. Retrieved from URL: https://lucidspark.com/blog/future-reality [in English].
14. Theory of Constraints Concepts and Details. *Quality Assurance Solutions, Spreading the QA Word*. Retrieved from URL: https://www.quality-assurance-solutions.com/Theory-of-Constraints.html [in English].

О.С. Полянський, проф., д-р техн. наук, **Є.О. Дубінін,** проф., д-р техн. наук, **А.І. Коробко,** доц., д-р техн. наук, **В.Ю. Байдала,** асист.
Харківський національний автомобільно-дорожній університет, м. Харків, Україна

Підвищення якості оцінювання стійкості колісних машин використанням теорії обмежень

У статті розглянуто проблему оцінки стійкості колісних машин, яка є важливою характеристикою, що впливає на безпеку руху, а також на економічні показники експлуатації колісних машин. Проаналізовано існуючі алгоритми прийняття рішень за допомогою теорії обмежень при оцінці стійкості колісних машин, розглядаючи п’ять видів логічних дерев та встановлюючи правила їх застосування для аналізу динамічної стійкості транспортних засобів. Виявлено, що ці алгоритми мають обмежену точність, що пов’язано з відсутністю врахування усіх факторів, які впливають на стійкість колісних машин, або не можуть враховувати ці фактори з достатньою точністю. На основі цього розроблено правила застосування логічних дерев для більш точного дослідження стійкості колісних машин, що дозволяють враховувати більше факторів, які впливають на стійкість колісних машин, з більшою точністю.

Використовуючи отримані в роботі рішення, можна значно розширити обсяг вимірювань, дозволяючи здійснювати більш об’єктивний аналіз параметрів транспортних засобів у різних умовах експлуатації. Проведено дослідження для оцінки точності розроблених правил з використанням різних наборів даних, які включали інформацію про параметри колісних машин і результати випробувань на динамічну стійкість. Результати досліджень показали, що розроблені правила дозволяють істотно підвищити точність оцінки стійкості колісних машин.

Розроблено рекомендації для вдосконалення якості випробувань на динамічну стійкість колісних машин, які стосуються вибору параметрів випробувань і методів обробки даних. Підкреслено, що використання теорії обмежень може значно покращити якість випробувань на динамічну стійкість колісних транспортних засобів, надаючи відповідні підходи та методології для вдосконалення цього процесу.

Результати дослідження, представлені в статті, мають важливе значення для підвищення безпеки руху й економічної ефективності експлуатації колісних машин.

колісна машина, теорія обмежень, вдосконалення випробувань

Одержано (Received) 25.10.2023 *Прорецензовано (Reviewed) 05.12.2023*
Прийнято до друку (Approved) 27.12.2023

УДК 629.332 DOI: https://doi.org/10.32515/2664-262X.2023.8(39).2.169-175

Д.В. Абрамов, проф. д-р техн. наук
Харківський національний автомобільно-дорожній університет, м. Харків, Україна
В.О. Тесля, канд. техн. наук, **А.Б. Гупка,** доц., канд. техн. наук, **М.Д. Сіправська**, асист.
Тернопільський національний університет імені Івана Пулюя, м. Тернопіль, Україна
e-mail: volodymyr_teslya@ukr.net

Вплив показників якості палива та технічний стан автомобіля під час руху

Досліджено вплив параметрів якості палива та технічного стану автомобіля в умовах експлуатації на стан двигуна та трансмісії. Виявлено, що ці фактори мають критичне значення під час маневру обгону, де недостатня потужність може вплинути на безпечність виконання даного процесу. Для боротьби з цими проблемами пропонується використовувати інтегральний коефіцієнт урахування технічного стану автомобіля та якості палива, який враховує різницю між новим, справним та автомобілем у поточному технічному стані. Запропонований коефіцієнт дасть можливість підвищити точність прогнозування потенційного прискорення автомобіля бортовою системою.

автомобіль, технічний стан, якість палива, інтегральний коефіцієнт врахування технічного стану, експлуатація, безпека руху