HABILITATION THESES BOOKLET

Strategic Priority Identification in Safety-Critical Systems

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Strategic Priority Identification in Safety-Critical Systems

INTRODUCTION

This thesis booklet presents the essential features of my scientific work in the field of management and business studies, the scientific results, the significance of the results, and the extent to which my results have contributed to the development of science and practice.

In Chapter 1 of the thesis booklet, the theses are presented, and then in Chapter 2, the most important scientific results leading to the theses are introduced.

In the period since obtaining the PhD degree, the five most important scientific articles selected to form the habilitation theses are organically and closely related to each other in terms of the research topic. Thus, by presenting the scientific and intellectual content arc behind the habilitation theses in plain text, it is also possible to precisely determine the results of the individual scientific articles and their itemized contribution to the habilitation theses. Thus, in Chapter 2, the publications are linked to the individual theses and present the connection of the publications to each other in detail. At least one typical figure is also presented for each article, marking the essence of the article's statement.

Chapter 3 presents the extent of the contribution of the present work to the development of science and practice and presents the summary of the main directions of practical and scientific research in the subject area in the future. Finally, the literature used to compile the thesis booklet is highlighted.

1. PRESENTATION OF THE HABILITATION THESES

This chapter provides the textual formulation of theses, and the conceptual structure and relational system behind them will be presented in detail in the next chapter.

TEXT OF THE HABILITATION THESES

T1: In safety-critical systems, instead of or in addition to the RE (risk exposure) value of the risk matrix or the RPN (risk priority number) value of the FMEA method used in practice, it is reasonable to take the PRISM value of the PRISM method into account when determining strategic priorities, since the PRISM method provides prioritization by estimating hidden risks, one of the greatest dangers of safety-critical systems.

T2: By combining the PRISM method with multi-criteria decision-making methods, it forms a decision support system, and based on the specific characteristics of the decision support system, the strategic prioritization process can be adjusted in the direction of the requirements of the practical problem.

T3: During strategic prioritization in a safety culture environment, integrating the PRISM method with techniques based on pairwise comparisons – especially with the AHP method – is well-founded.

2. DESCRIPTION OF THE SCIENTIFIC ARC LEADING TO HABILITATION THESES

The scientific arc leading to habilitation theses covers a part of developing a methodology within the available framework of the thesis booklet. Regarding the framework, the most significant limitation was the number of technical articles that could be included in theses. Taking this into account, the scientific arc can be drawn along the development of the methodology, from the moment the methodology was born. The division of the current Chapter 2 into further subsections is done according to the interconnected steps of developing the methodology related to strategic prioritization. Just as there is a conscious research intention behind the development of the methodology, the subsections follow one another in a way that follows this development intention.[1]

According to the main motives of the individual steps, it is worth formulating the following milestone-like development steps, which are presented in detail in the following subsections:

- description of the concept of the methodology;
- developing the concept into a formal methodology;
- the steps to further develop the methodology by satisfying the applicability requirements of some cases taken from real business life.

This chapter presents the description of the scientific arc based on the most important technical articles from the point of view of habilitation theses according to the criteria standard to all articles below so that the significance of what is described in the individual technical articles and their contribution to the habilitation theses can be reviewed in a unified framework. Each sub-chapter that divides the thought arc of this chapter is also linked to a technical article. The chapters are presented in the following three-fold breakdown.

(1) The essential characteristics of the described problem and its relationship with the thought process leading to theses are briefly explained, so the methodological development unfolds step by step, from technical to technical articles.
(2) The proposal for solving the problem is presented, and each new stage in developing the methodology and its results is discussed.

[1] Cases where, due to the longer or shorter review or publication process, the description of a development step could only appear publicly later than the description of a subsequent development step, in this thesis I will solve it simply by changing the order of the technical articles.

(3) The contribution of the novelty content of the given sub-chapter (and thus the technical article discussed in it) with the habilitation theses is linked.

2.1. THE BIRTH OF THE PRISM (PARTIAL RISK MAP) CONCEPT

This subsection presents the birth of the concept of strategic prioritization methodology in PRISM. The concept came about when I visited the compliance board of a major bank with my colleague Petra Benedek to support the assessment of compliance risks. This subsection presents the most significant contribution of my work entitled "*A Novel Risk Assessment Methodology – A Case Study of the PRISM Methodology in a Compliance Management Sensitive Sector*"[2] to my habilitation theses. The methodology was born in the world of risk estimation and was prepared for strategic prioritization based on hidden risks.

The essential characteristics of the discussed problem

The background of the discussed problem is that, although the actors of the banking sector are particularly sensitive to the very complex and multifaceted requirements of compliance due to the global intertwining of the banking system, the internationally applied regulatory tools and banking practice paint a rather diverse picture in the direction of banking compliance management and are far from comprehensive.[3]

Banks' compliance risk assessment methodology usually stops at applying the risk matrix (Losiewicz-Dniestrzanska, 2015). In the risk matrix, risks are evaluated according to their frequency of occurrence and the severity of their consequences (Qazi et al., 2021; Wang and Wang, 2020). Thus, if they are used to assess compliance risks, the risks arising from detecting an unwanted phenomenon are not taken into account, or with insufficient importance, which can easily remain in the background and cause a serious system problem later.

Suggested solution to the problem:

The PRISM method also shows the risks in their subsections, highlighting possible hidden risks (hidden risk) or partial risks (partial risk), and prioritizes the evaluated phenomena based on these hidden risks. Thus, it is particularly capable of evaluating safety-critical systems where the realization of unexpected, surprising, hidden risks can result in enormous financial damage.[4]

The essence of the concept is that it combines the advantages of the RE (risk exposure) number of the risk matrix and the traditional RPN (risk priority number) number of the FMEA[5] since:

[2] Bognár, F., Benedek, P. (2021): A Novel Risk Assessment Methodology – A Case Study of the PRISM Methodology in a Compliance Management Sensitive Sector. Acta Polytechnica Hungarica, Vol 18, No. 7., pp. 89-108. https://doi.org/10.12700/APH.18.7.2021.7.5

[3] Just think for a moment about the unfortunate incident in which one of Switzerland's standard, traditional banks recently fell, simply because it had significant investments in a US bank that went bankrupt due to its questionable operations. Not to mention the events of 2008 and the road leading up to it. A widely and carefully operated compliance management system can save the actors of the banking system and the economy in general from many unexpected consequences.

[4] The banking sector can also be considered as such.

[5] The traditional RPN number is a complex assessment tool of the failure mode and effect analysis (FMEA) methodology, which provides decision support in the case of strategic decisions where the goal is to distribute limited resources in order to reduce the risk content perceived in the most risky elements of a system and thus increase the reliability of the system (Liu et al. 2013, Liu et al. 2019, Chen and Deng, 2018).

- the RPN also calculates the frequency of occurrence of the evaluated phenomenon - occurrence (O), the severity of the consequences - severity (S), and the degree of detectability - detection (D) (with the latter, RE does not calculate);
- at the same time, it can perform a two-point evaluation of the risk matrix (RPN cannot do this).

It follows from the combination of the above two advantages that the ability of the PRISM method to identify hidden risks comes from the fact that it is not based on the aggregate value of the three factors of the evaluation (S, O, D)[6], but on the aggregate of the three factors taken in pairs (S-O, S-D, O-D) and takes the highest value of the three as the basis for the resulting assessment.

From the point of view of the interpretation of the habilitation theses, the most expressive diagram of the technical article discussed in this chapter is Figure 1, which shows that the PRISM method essentially spreads out the 3D space that makes up the RPN number like a cube according to its three projections and examines the level of risks separately for each projection. In Figure 1, the darker the color of a cell, the higher the risk classification. The risk can be characterized based on the highest risk occurring in any matrix of the map.

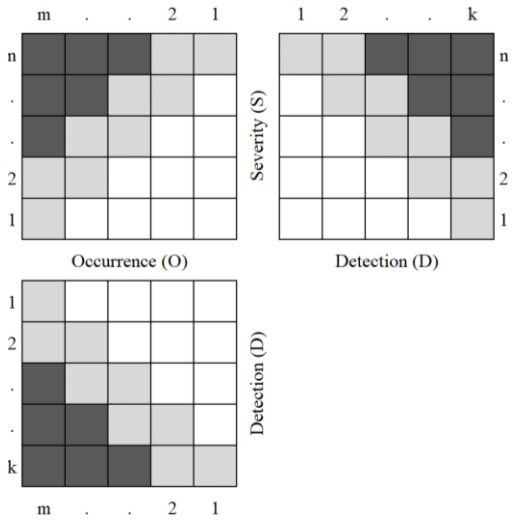

Figure 1: The model of PRISM (Partial Risk Map)[7]

The most significant contribution to the habilitation theses

1. The unique ability of the PRISM methodology to direct decision-supporters' attention to partial or hidden risks, which are not present at the moment, but may even result in an unexpected catastrophic failure in the future if the value of an evaluation criterion deteriorates. **Since the primary purpose of the PRISM method is to draw the attention of analysts and decision-makers to hidden risks in advance, it is justified to use the PRISM methodology instead of or in addition to the RPN methodology in the case of safety-critical systems.**
2. The technical article discussed in the chapter is a basic foundation for the habilitation theses, so **it is organically connected to all three of my habilitation theses, and shows its most important added value in the T1 thesis**.
3. I assign the technical article to the **T1 thesis**.

[6] RPN=S×O×D
[7] Source: Bognár and Benedek (2021), page 11.

Link to the following subsection
With the description of the PRISM concept, the space was opened for developing the PRISM methodology, which will be described in the next chapter.

2.2. FORMAL DESCRIPTION OF THE PRISM METHODOLOGY

In this subsection, I present the development of the PRISM concept into a methodology. The subchapter is basically based on my work entitled "*Analysis and Consequences on Some Aggregation Functions of PRISM (Partial Risk Map) Risk Assessment Method*"[8] although the basic formal descriptions are also included in the works presented in later chapters.

The essential characteristics of the discussed problem
Today, risk assessment methodologies are developed in the industry and the service sector. One typical development direction is to combine different mathematical methods with an existing risk assessment methodology, such as FMEA (Braglia, 2000; Shan et al., 2021), RM (Somi et al., 2021), HAZOP (Marshavilas et al., 2022) or FTA (Zhang et al., 2021). The primary goal of these studies is to develop the risk assessment method, increase the strengths of the method, or reduce its weaknesses by adding new mathematical features. Another vital development direction is combining two risk assessment methodologies (Shafiee et al., 2019; Schafer et al., 2021; Bradley and Guerrero, 2011). The goal is to combine the strengths of risk assessment methods in this case.

Based on the above, a fundamental problem is that the PRISM concept has not yet been formally described using mathematical tools. Completing formal submission and validation tests is necessary to raise the PRISM concept to a methodological level. With this step, the PRISM concept can be developed into an independent methodology, which opens the way to combining PRISM with other mathematical methods.

Suggested solution to the problem:
The first half of the solution is about producing formal mathematical definitions, so I will only list the most important ones because, from the point of view of the habilitation theses, further details are not necessary to describe. At the same time, the description of the "PRISM pattern" and the "PRISM number" are the most essential definitions, which I will present in detail for this reason.

Denote as **m**: (o, s, d) a failure mode or incident that has three characteristics: *o* probability of occurrence (occurrence), *s* severity of consequences (severity), and *d* degree of undetectability (detection). The characteristics have the following values, o [1, 2, , i], s [1, 2, , j] and d [1, 2, , k]. Denote p(**m**) = p(o,s,d) = (o⊗s, o⊗d, d⊗s) the PRISM pattern of an incident. Figure 2 shows this pattern, embedded in the partial risk map.

[8] Bognár, F., Hegedűs, Cs. (2022): Analysis and Consequences on Some Aggregation Functions of PRISM (Partial Risk Map) Risk Assessment Method. Mathematics, Vol. 10, No. 5., 676. https://doi.org/10.3390/math10050676

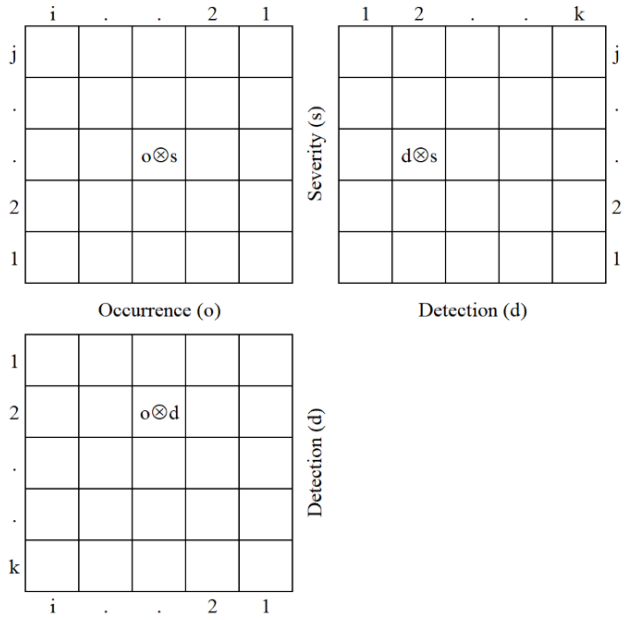

Figure 2: The formally represented PRISM pattern[9]

The PRISM number of incident ***m*** can be given by selecting the maximal value of the three aggregates of p(*m*). Let PRISM(**m**) denote the PRISM number of a specific incident. The calculation of the PRISM number is as follows[10]:

$$PRISM(\boldsymbol{m}) = \max\{o \otimes s, o \otimes d, d \otimes s\} \tag{1}$$

I present the definition of three different evaluation functions for the prioritization that can be formed based on the PRISM number. These are the following[11]:

$$A(\boldsymbol{m}) = \max\{o + s, o + d, d + s\} \tag{2}$$
$$M(\boldsymbol{m}) = \max\{o \cdot s, o \cdot d, d \cdot s\} \tag{3}$$
$$S(\boldsymbol{m}) = \max\{\mathrm{o}^2 + \mathrm{s}^2, \mathrm{o}^2 + \mathrm{d}^2, \mathrm{d}^2 + \mathrm{s}^2\} \tag{4}$$

When evaluating the same PRISM patterns with a different evaluation function, the ranking resulting from the prioritization may change and the target areas of the resource distribution.

<u>The most significant contribution to the habilitation theses</u>

1. **The purpose of the technical article was to transform the PRISM concept into a PRISM methodology** through the definition of key variables of the concept, the specification of evaluation functions based on the defined key variables, and the performance of validation studies, as well as through detailed comparative studies with other methodologies.
2. The results given by the PRISM methodology differ significantly from the results of the RPN method; due to the difference in the interpretation of risks, **the PRISM numbers can be better approximated with a normal distribution than the RPN numbers**.

[9] Source: Bognár and Hegedűs (2022), page 5.
[10] Source: Bognár and Hegedűs (2022), page 6.
[11] Source: Bognár and Hegedűs (2022), page 6.

3. **The PRISM methodology is robust to changes in the scope of standard rating scales used in practice, so the methodology can be used universally in this regard.**
4. The technical article discussed in the chapter is an essential foundation for the habilitation theses, so **it is organically connected to all three of my habilitation theses, and shows its most important added value in the T1 thesis**.
5. I assign the technical article to the **T1 thesis**.

Link to the following subsection
The PRISM methodology only works with discrete scales in its current form, and it is also not suitable for testing the consistency of expert thinking. These extensions will be implemented in the next chapter, thereby expanding the field of applicability of the methodology.

2.3. PRISM ASSESSMENT ON CONTINUOUS SCALES AND CONSISTENCY TESTING

In this subsection, I present the possibility of making the PRISM method suitable for evaluation on a continuous scale, and at the same time, I present a possible way of testing expert consistency. In the subsection, I will present the selected results of my work entitled "*Compliance Risk Assessment in the Banking Sector: Application of a Novel Pairwise Comparison-Based PRISM Method*"[12] elnevezésű munkám kiválasztott eredményeit fogom bemutatni.

The essential characteristics of the discussed problem
In practice, compliance risk management is primarily based on consultations with expert groups, while the reliability of these consultations in the prioritization process and the verification of expert capabilities is rarely validated. The use of pairwise comparison techniques for calculating relative weights is prominent in the literature, so the risk assessment process can be extended in the direction of subjective weightings as opposed to the generally used direct scaling. Another advantage of the combination with paired comparison methods is that the consistency of the experts can be tested (Wang et al., 2021; Djenadic et al., 2022), whereas, in the original PRISM method, this option cannot be used since the risk assessment process here is based on direct scaling. This shortcoming of the PRISM method can be vital in bank compliance risk assessment; therefore, combining the method with paired comparison techniques can be recommended to establish specific strategic level priorities.

Suggested solution to the problem:
Following what was detailed above, what is described in this subsection is intended to be added to the PRISM methodology at two points, expanding its capabilities more in the direction of strategic prioritization:

- enable the method to detect the more detailed differences between the phenomena to be investigated;
- enable the method to test the consistency of experts.

To implement the previously mentioned, the PRISM method can be combined with a version of a paired comparison technique (Guilford, 1928) that identifies preferences without weighting

[12] Bognár, F., Szentes, B., Benedek, P. (2023): Compliance Risk Assessment in the Banking Sector: Application of a Novel Pairwise Comparison-Based PRISM Method. Complexity, Vol. 2023, 9165815. https://doi.org/10.1155/2023/9165815

the importance, which I modified in 2013.[13][14] Figure 3 shows that with the help of the extended PRISM method, fine differences between PRISM patterns can be better represented than with the discrete scale values that exist with the original method.

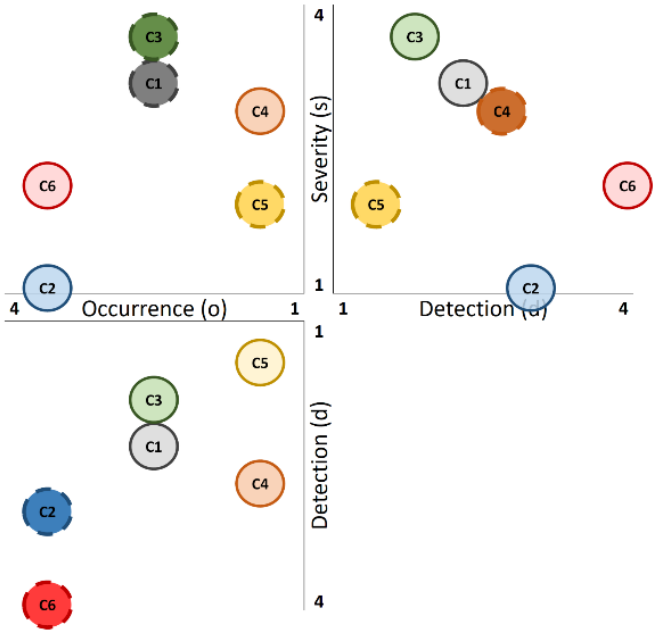

Figure 3: PRISM evaluation visualization in the case of continuous scale values [15,16]

To compare the individual expert evaluations and test the results, I recommend the calculation of the rank correlation coefficient so that the individual expert rankings can be compared with each other and with group rankings and additional reference rankings.

The most significant contribution to the habilitation theses

1. By integrating with a modified version of Guilford's method, **the PRISM method can be extended to examine the consistency of experts**. This is a significant support from the point of view of safety-critical systems, as management decision support for inconsistent opinions cannot be realized.[17]

[13] See: Bognár, F. (2013) A döntésorientált hibamód és hatáselemzés (DOFMEA) módszertani továbbfejlesztése. In: Balogh, Á. (szerk.) Tudomány a karbantartás versenyképességének szolgálatában. Pannon Egyetem, Veszprém, pp. 211-220.

[14] Of course, combining with another method can not only eliminate the problem of the basic method, but also tends to generate new ones. This is also the case in this case, as this paired comparison technique is not capable of comparing a large number of items, so it follows that I recommend using this methodology only when finding answers to the most important questions that are of strategic importance in themselves. I absolutely do not recommend using this method for wide-spectrum, high-element tests.

[15] The figure shows the PRISM patterns and numbers of the six risks included in the evaluation during the banking case study. The PRISM numbers themselves are indicated by circles filled with a dark version of the given color, and the lines delimiting these circles are dashed. The circles marked with a lighter color and continuous line show additional elements of the PRISM pattern of the given risk.

[16] Source: Bognár et al. (2023), page 9.

[17] In addition to professional arguments, the application of the Guilford method also has a self-identifying aspect as a researcher, since the theoretical and practical work with the above-mentioned method also plays a significant role in the works of professors József Kindler, Zoltán Gaál and János Kövesi, mentioning Kindler and Papp (1977), Gaál (2001) and Kövesi et al. (2010) works. Personally, I am proud that I was the first and corresponding author of this technical article, the essence of which is presented in this subsection.

2. **This variant of the PRISM method is recommended to be used for prioritizing phenomena of special strategic importance**[18].
3. T**he technical article discussed in the chapter contributes to my T2 and T3 habilitation theses, contributes to the T1 thesis, and shows its most important added value in the T2 thesis.**
4. I assign the technical article to the **T1 and T2 theses.**

Link to the following subsection
Currently, the PRISM methodology makes expert consistency based on non-weighted pairwise comparisons, so it would only be applicable to a limited extent in safety-critical systems based on safety culture. The following subsection solves this problem.

2.4 APPLICATION OF THE PRISM METHODOLOGY IN THE NUCLEAR INDUSTRY

In this subsection, I present the possibility and result of the integration of the PRISM method and the AHP[19] in the case of safety-critical systems where activities are carried out in the presence of a safety culture. In the subsection, I primarily rely on the results of my work entitled " A Novel AHP-PRISM Risk Assessment Method - An Empirical Case Study in a Nuclear Power Plant "[20].

The essential characteristics of the discussed problem
Since PRISM is a novel risk assessment method, in addition to its advantages, it also has several weaknesses. The aim of the study was to strengthen the safety culture capabilities of the PRISM method. Regarding strengthening these capabilities, the Guilford method could be used, but it would not meet the standard of the safety culture, which is considered fundamental in the nuclear industry, according to which phenomena relevant to the system must be precisely defined. The Guilford method only reports preferences during pairwise comparisons, not their strength[21]. At the same time, another significant limitation of the Guilford method is that it does not support an indifferent expert opinion between the elements to be compared[22].

Suggested solution to the problem:
Compared to the Guilford method, AHP better meets the requirements of the safety culture[23], as it also provides the degree of difference between the elements to be compared and allows for no difference between two compared elements. The proposed AHP-PRISM method was presented and tested in the logistics business processes of the nuclear power plant by assessing the risks of strategic incident groups[24].

[18] Pairwise comparison techniques that compare each item with each item cannot be used effectively to compare large quantities, the reason for this can be traced back to the functioning of the human mind and the limitations of the person as a decision-maker. At the same time, the BWM technique created by Rezaei (2015) is capable of comparing a large number of items, allowing for consistency testing, but I will immediately add that that method does not compare every item with every item, it only evaluates the best and the worst other items.
[19] See: Saaty (1987)
[20] Bognár, F., Benedek, P. (2022): A Novel AHP-PRISM Risk Assessment Method - An Empirical Case Study in a Nuclear Power Plant. Sustainability, Vol. 14. No. 17., 11023. https://doi.org/10.3390/su141711023
[21] We only know that A>B or B<A.
[22] A=B statement is not allowed.
[23] It is no coincidence that this paired comparison technique is widespread in the nuclear industry.
[24] Similar to the problem of supplier selection, the logistics business processes of a nuclear power plant have also critical importance related to system security, since these are one of the key support processes.

In the case study that is the basis of this subsection, the ten strategic event groups defined by the nuclear power plant were presented in detail, the standard professional features of the ten experts who performed the evaluation were presented, and then the analysis process was presented, which also covered the evaluation according to all three PRISM functions. In this way, it becomes possible to examine the extent of the differences inherent in the ranking according to the three functions, and through this, further reliability consequences can be drawn from the results of the analysis. Figure 4 shows the ten strategic event groups' PRISM patterns and numbers.

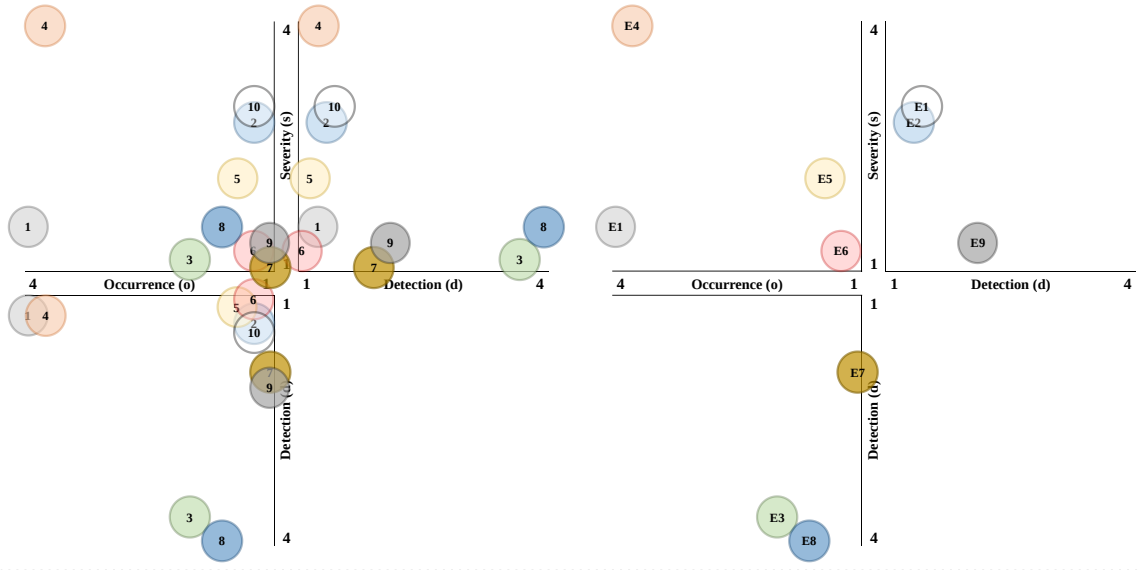

Figure 4: PRISM patterns and PRISM numbers[25] in the partial risk map[26]

The most significant contribution to the habilitation theses

- **This variant of the PRISM method is especially recommended for prioritizing safety-critical phenomena of particular strategic importance when applied in the area of safety culture.**
- **The technical article discussed in the chapter makes an essential contribution to my T2 and T3 habilitation theses, contributes to the T1 thesis, and shows its most important added value in the T3 thesis**.
- I assign the technical article to the **T1 and T3 theses.**

Link to the following subsection

In any state of the PRISM methodology presented so far, it is not able to interpret the dimensions *o*, *s*, and *d* as having different weights during the evaluation. This limitation and the possibility of comparing the results with an ideal result are added to the previous results described in the next subsection.

[25] On the left side of the picture are the PRISM patterns, on the right are the PRISM numbers.
[26] Source: Based on Bognár and Benedek (2022) page 8 and page 9.

2.5 WEIGHTING OF THE DIMENSIONS OF THE PRISM METHOD

In this subsection, I present a possibility of weighting the evaluation dimensions of the PRISM method, highlighting the important usability-enhancing consequences of weighting. In the subsection, I primarily rely on the results of my work entitled " Development of the PRISM Risk Assessment Method Based on a Multiple AHP-TOPSIS Approach "[27].

The essential characteristics of the discussed problem

The peculiarity of each of the methods presented so far was that the *o*, *s*, and *d* values had the same weight. This is an important methodological limitation in case of a possible need to weight the evaluation dimensions. In addition, a key factor during the development is that during the evaluation, the solutions presented so far were not, or only in a limited way, able to relate the risks to be evaluated to an ideal best case. One of the significant positive features of the PRISM method is that it can provide meaningful visual support for drawing conclusions from the evaluation results, but this requires the same *o*, *s*, *d*, dimension weights.[28]. By changing the weights of the three evaluation dimensions, it is necessary to insert a decision support technique into the evaluation process that can present the results in a well-structured way.

Suggested solution to the problem:

In this subchapter, I present the development of an AHP-based PRISM method that enables the creation of different factor weights for the evaluation dimensions and an in-depth analysis of the alternatives by comparing them to the ideal best solutions. In most of the previous known studies, AHP was combined with TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), so the number of AHP-TOPSIS evaluation approaches in the international literature is significant. According to Shih et al. (2007), many significant advantages of the TOPSIS method can be discussed. I present the results of the integration with the TOPSIS method in this subsection. Figure 5 presents the six most important, milestone-like steps of the new evaluation process resulting from the proposed method development.

Step 1	Step 2	Step 3
Assessment Preparation	**Pairwise Comparison of the incidents**	**Pairwise Comparison of the PRISM pattern elements**
Setting the aims, collecting incidents and inviting the members of the committee.	Executed by the PRISM dimensions. Consistency check is performed.	Consistency check is performed.
Step 4	**Step 5**	**Step 6**
Computing the PRISM pattern values of the incidents	**Multiple TOPSIS assessment**	**Comparison of the rankings**
Based on different PRISM functions.	The assessment of the incidents is executed.	Applying statistical analysis of the final incident rankings.

Figure 5: The AHP-TOPSIS based PRISM evaluation flow[29]

[27] Bognár, F., Szentes, B., Benedek, P. (2022): Development of the PRISM Risk Assessment Method Based on a Multiple AHP-TOPSIS Approach. Risks, Vol. 10. No. 11., 213. https://doi.org/10.3390/risks10110213

[28] Otherwise, the interpretation of the drawn PRISM patterns would become difficult and misleading.

[29] Source: Bognár et al. (2022), page 4.

Step 3 of Figure 5 shows the step of weighting the evaluation dimensions. During the solution, the weights of the components of the PRISM pattern are differentiated using AHP, and then the values of the PRISM patterns can be calculated before the TOPSIS-based evaluation takes place. With the inclusion of step 3, the methodology becomes capable of being used in ranking situations where the weighting of evaluation criteria is expected.

The proposed evaluation process was also tested in a nuclear power plant environment, partially based on the data of the process presented in the previous subsection and additional new expert estimates.

Table 1: The results of PRISM prioritization based on AHP-TOPSIS[30]

P(m)	***E1***	***E2***	***E3***	***E4***	***E5***	***E6***	***E7***	***E8***	***E9***	***E10***
$P_A(\boldsymbol{m})$	2	4	6	1	7	9	10	5	8	3
$P_M(\boldsymbol{m})$	2	5	6	1	7	10	9	3	8	4
$P_S(\boldsymbol{m})$	2	4	6	1	7	10	9	5	8	3

Table 2 includes the PRISM methodology and its individual modes and shows the results of the comparison of the individual methods according to aspects relevant to strategic prioritization.

Table 2: Comparison of the properties of different PRISM methods[31]

Method	**Weights of the assessment dimensions**	**Measurement mode**	**Visual support**	**Decision level**	**Number of alternatives**
PRISM	same	deterministic scales	relevant	operative	many
AHP-PRISM	same	pairwise comparison	relevant	strategic	reduced
AHP-TOPSIS-PRISM	different	pairwise comparison	non-relevant	strategic	reduced

<u>The most significant contribution to the habilitation theses</u>

- I interpret the technical article as one of the most significant contributions to habilitation theses, that **it presents a possible method for weighting the evaluation dimensions of the PRISM methodology**.
- Substantial methodological contribution to the development of the PRISM method, that the results can be given relative to the ideal best solution with the help of TOPSIS integration.
- **The PRISM methods are cataloged and compared based on their properties, thus the PRISM method can be configured in advance in terms of solving specific practical prioritization problems.**
- In my opinion, the technical article discussed in the chapter makes **an essential contribution to my T2 and T3 habilitation theses, contributes to the T1 thesis, and shows its most important added value in the T2 thesis**.
- **I assign the technical article to thesis T2 and T3.**

[30] Source: Bognár et al. (2022), page 10.
[31] Source: Bognár et al. (2022), page 10.

3. CONTRIBUTION TO THE SCIENCE AND FUTURE RESEARCH DIRECTIONS

With the birth of the PRISM concept, the field of risk management has been enriched with a new idea, which, through the detection of hidden risks, provides a meaningful and new tool for the risk management of safety-critical systems. Thinking about hidden risks is not in the foreground in the logic of classic risk management techniques. In this regard, the PRISM concept opens a small but new chapter in the toolbox of risk management.

By enabling the methodology to test the consistency of experts in the case of expert estimates, a meaningful step was taken for the disciplines of strategic management and risk management. The importance of this step is given by the importance of strategic prioritization in the case of safety-critical systems. Combining the PRISM method with the AHP method also enriched the field of reliability theory and safety culture. With the step that the degree of importance attached to the evaluation dimensions of the PRISM method could be calibrated, the methodology was significantly expanded in terms of scientific and business use. Thus, the methodological development made a substantial contribution to the enrichment of both strategic decisions and the field of risk management.

An important scientific result is that the basis of a PRISM-based decision support system has also been formulated. The cataloging of the characteristics of the PRISM method supplemented by different extensions has begun, thereby providing assistance to practitioners who wish to carry out strategic prioritization based on PRISM in the future.

The PRISM methodology still has a very long way to go in terms of both business and scientific development and the production of further new results; I will briefly write about the main directions of the planned scientific development paths in the following:

- I consider it an important theoretical study that the PRISM method can be characterized in terms of the extent to which it affects the ranking algorithm compared to the RPN method, if autocorrelation can be discovered in the *o*, *s* and *d* data;
- By integrating with the BWM method (Rezaei, 2015), I would like to develop PRISM into a method capable of checking expert consistency, which can move from the direction of strategic prioritization to tactics and operations;
- I consider the development of the PRISM method to be a fuzzy-based tool as an important scientific priority, since with the help of this, on the one hand, a new way of managing the uncertainty in subjective expert evaluations could be achieved, and on the other hand, the method could be opened in the direction of machine learning.

Ultimately, the above paragraphs all support the transformation of the PRISM method into an increasingly widely applicable, increasingly customizable decision support system and, later, into an expert system.

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