National
University of Public Service
Doctoral Committee

Máté Solymosi

New methods to assess and enhance nuclear safety and security culture

Official assessment and authorial review

Budapest
2018

NATIONAL UNIVERSITY OF PUBLIC SERVICE
DOCTORAL SCHOOL OF MILITARY ENGINEERING

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BUDAPEST
2018

EXPOSITION OF THE SCIENTIFIC CHALLENGE

The research and development of the processes and tools of enhancing nuclear safety have been improved rapidly in the previous few decades. The number of nuclear facilities and the use of radioactive sources are constantly expanding all over the world and the need for complying with the requirements for their safe and secure application is also increasing. For decades, safety and security have been the nuclear industry's top priorities, particularly in relation to providing protection against the harmful effects of ionizing radiation. They share the same fundamental goal to protect people from the harmful effects of the ionizing radiation.

The exposition of my scientific challenge is to examine and research the topic of nuclear safety and security especially their human element, namely the culture.

During the review of the scientific literature, I have presented four serious nuclear safety accidents and several incidents of the application of nuclear energy that occurred in the past few decades.

All these accidents and incidents, including the demonstrative event in Tennessee (2012) prove the necessity of the management and the culture.

"The thickness of a wall is less important than the will to defend it" as Thucydides, 5th Century B.C. historian stated.

The scientific publication of S. L. Morrow, G. K. Koves, and Valerie E. Barnes about the analysis of several previous incidents demonstrated that the deficiencies of (safety) culture were the root causes of the previously introduced incidents and accidents.

In the case of the Chernobyl accident, as we have seen, the design defects and the deliberate violation of the safety procedures by the order of the management in the organization drew the attention on the deficiencies of the security culture. The cultural issues usually related to the deficiencies of both nuclear safety and nuclear security cultures.

On the other hand, the domestic and international system of legislative and guidance provisions is not unified related to nuclear safety and security culture and contains several problems. Among others, there is difficult to conduct a comparative analysis of the assessments made according to differing guidance, or the comparative analysis of the previous results with the new ones in the case of the implementation a new assessment methodology.

In addition, the guidelines do not mention the possibility to conduct an integrated nuclear safety and security culture assessment. In my dissertation I am looking for the solution for an integrated assessment method, and analyse its advantages and limitations.

Although, such assessment is not required to be performed by “small” facilities, the human factor is also a priority for them. A nuclear safety or security culture assessment performed according to the domestic or international guidelines would be too comprehensive and complicated for them, there is a need for the methodological summary of the assessment at the “small” licensees. To carry out a large-scale assessment would be quite difficult and expensive for them, in many cases would be impracticable and usually would end without any useful results or conclusions.

Based on my statements and conclusions at the exposition of the scientific challenge, my scientific research is aimed to develop such new methodologies, which are effectively and efficiently applicable in practice.

GOAL OF THE SCIENTIFIC RESEARCH

1. The main goal of my research is to prove that the assessment of nuclear safety and security culture can be performed not only simultaneously, but moreover as a harmonized and integrated process, taking into consideration all the instructions and recommendations of the domestic and international provisions. Additionally, I intend to determine the advantages and disadvantages of the integration of the assessment.
2. Taking account of the limitations of the domestic and international literature, my goal is to determine all the special considerations, which are required for an efficient, reliable, fast and successful assessment of the culture of nuclear safety and security.
3. Another goal of my work is to establish such a method, which is applicable in practice and allows for transforming and comparing the results of surveys made on the basis of different guidelines.
4. In the domestic and international guidelines of the assessment of nuclear safety and security culture a fast, easy and reliable way is missing to compare the survey results. My goal is to develop such a new methodology to compare the results of the surveys.

HYPOTHESES

1. I assume that the assessment of nuclear safety and security culture can be conducted more efficiently in an integrated and harmonized process. Due to my hypotheses, the greatest advantage of the method would be the savings of human resources and a more efficient evaluation of the results. However, in addition to efficiency, some other considerations have to be taken in place.

2. Based on my assumption, if the necessary methodological conversation, innovations, and compromises are made, then the assessment of the "small" facilities is efficiently and reliably achievable.

3. I assume that with the reorganisation of the assertion of the survey (characteristics of nuclear safety and security culture) made according to different guides, the conversation and the comparative analysis of the results between these guidelines would be achievable.

4. I assume that the established method for the comparative analysis will ease and accelerate the comparative analysis of the survey results. The method uses not only the averages but the ranks of the averages. According to my hypothesis the method will reduce the effects of the distortion based on the difference between two organisations or assessments and make the comparative analysis easily applicable.

METHODS OF THE SCIENTIFIC RESEARCH

During my work, I have used such up to date research methods as analysis, synthesis, on-site pilot surveys and comparative autopsies.

I have studied and analysed the domestic and international environment of the literature, the legislation and the guidance of nuclear safety and security culture. I have fully processed the legislative background during the study of the domestic and international literature and continued the literature research with the thorough critical analysis of the publications.

With the methodology of deduction, I have determined the partially different elements and connections of the two cultures.

During my research, at 2015 I have conducted an integrated nuclear safety and security culture assessment at the Gamma Technical Corporation and at the Hungarian Public Limited Company for Radioactive Waste Management (PURAM) for the first time in the history of the organisations. I have received an inside view of the results of the nuclear safety and security culture self-assessment (2015) of the MVM Paks Nuclear Power Plant (Paks NPP). In addition, in 2016 I was invited and spent 2 weeks as an expert on nuclear security culture involved to the nuclear safety and security culture self-assessment conducted at the Bruce Power NPP, Canada, Toronto.

In the third chapter, I have conducted the comparative analysis of the self-assessment made at the Paks NPP and at the PURAM, and analysed and evaluated the results with an inductive method.

With the publication of my research results, I have challenged them with the wide academic audience. The advice of the experienced colleagues and especially the critical remarks and words of acknowledgment on the domestic and international conferences have supported me a lot, and every time designated the appropriate direction for my research.

As an extremely honourable acknowledgment, my publications were accepted by several conferences of the National University of Public Services, such as:

- the “In service of the Nation - 2014” and
- the „Transatlantic Policy Consortium - 2015”;

and by the conferences of the International Atomic Energy Agency (IAEA):

- „International Conference on Human and Organizational Aspects of Assuring Nuclear Safety – Exploring 30 Years of Safety Culture - 2016”;
- „International Conference on Nuclear Security: Commitment and Actions – 2016”;
- „International Conference on Physical Protection of Nuclear Material and Nuclear Facilities - 2017” and
- „International Conference on Security of Radioactive Material: The Way Forward for Prevention and Detection - 2018” and

In addition, I attended, as an invited lecturer, on the following workshops and technical meetings:

- I participated in a nuclear security culture workshop in January 2018. in Yogyakarta, Indonesia and in March 2018 in Rabat, Morocco as a lecturer of the School of Public and International Affairs of the University of Georgia (USA, Athens);
- As a delegated expert of the Hungarian Atomic Energy Authority I participated three times in a consultancy meeting on the topic of the nuclear security culture in Vienna between 2016 and 2018;
- As an expert of the IAEA, I participated in several workshops on the topic of nuclear security culture, in 2017 in Malaysia, and in 2018 in Mexico, Ghana, and Pakistan.
- In addition, as the only invited Hungarian participant I attended and will attend on the consultancy meetings on the topic of the development and finalizations of the IAEA’s training materials of the nuclear security culture in Vienna in June (and November) 2018.

THE BRIEF DESCRIPTION OF THE SCIENTIFIC RESEARCH

In the introduction of my dissertation I have presented the summary of the relevant literature, the goals of the scientific research, hypotheses, and methods of the scientific research.

In the first chapter, I present the analytical evaluation of the domestic and international recommendations and requirements of nuclear safety and security culture.

In the second chapter, I present the process and methods of the nuclear safety and security culture assessments that I have conducted, have been involved or received an insight into the result:

- The process and methods of the self-assessment at the Bruce Power NPP and the limitations and the advantages of those based on my personal experiences;
- The process and methods of the self-assessment at the Paks NPP, which was conducted in 2015;
- The methods and the conditions of the nuclear security culture assessment, which I have conducted at the Gamma Technical Corporation in 2015;
- The process and methods of the combined nuclear safety and security culture (survey) assessment, which I have conducted in 2015 at the PURAM.

In the third chapter, I compare the nuclear safety and security culture survey assessment results with the method developed by me.

At the end of each chapter I summarize my personal conclusions and at the end, as a summarized conclusion, every achievement of my scientific research is presented.

I have developed my new scientific achievements in separate thesis points.

Finally, I provided recommendations related to the practical feasibility and applicability and to the further research possibilities.

SUMMARIZED CONCLUSIONS

In the first chapter, I have reviewed the elements, the legislation and the theoretical background of the nuclear safety and security culture, including the methodology and the process of assessment, and the responsibilities related to the assessment and enhancement.

The review of the literature verified that there are many overlaps between the elements and the processes of the assessments of the cultures. On the other hand, the system of legislation and guidelines has limited view on their connection and the possibility of the combination of the individual assessments.

I have developed my conclusions on the relation of the elements, the connection of the assessment processes of the two cultures, the coherent of the analysis of the results and on the concept of a new methodology for the more efficient comparative analysis of the survey results.

I have uncovered that there is no requirement for the assessment of the culture of “small” facilities and the processes described by the guidelines would need for too significant expenditure from them.

In the second chapter, I have introduced the process, and the background of the methodology of the nuclear safety and security culture self-assessment, whihc were conducted at the Bruce Power NPP and at the MVM Paks NPP.

At the PURAM I have justified in practice, that an integrated nuclear safety and security culture assessment could be conducted as a single process in compliance with all the national and international guidelines.

I have summarized my experiences such as an integrated assessment is more cost-effective, reliable and applicable than a separated one. On the other hand, due to the challenges in coordination between the departments of the organisation, the lack of an integrated model of nuclear safety and security culture and of the necessary experience and competence, an integrated assessment could exceed the possibilities of the licensees and the expenses could be higher than advantages.

During the assessment at the PURAM and Gamma Technical Corporation, I have demonstrated that the nuclear safety and security assessment of “small” facilities can be achieved if the necessary significant methodological changes, innovations and compromises are developed and applied.

Based on the international literature and during experiences of the assessments, I have developed my personal conclusions related to the methods and to the process of the assessment of “small” facilities. During the assessment of the “small” facilities, the violation of the anonymity have to be taken into consideration, but on the other hand, the answers of the respondents are more reliable and deliberate.

The licensees always have to make a compromise between the reliability and the validity, but in the case of the "small" facilities validity is more important than reliability because of the size of the organisation. In addition, it is favourable to integrate the process of the assessment and the enhancement.

In the third chapter, the results of the assessments made at the MVM Paks NPP and at PURAM are compared.

I have developed a methodology to compare the results of the surveys that were conducted according to safety and security guidelines independently. The method makes it possible to evaluate (even after the assessment process) the result of different guidelines so that potentially ease the process of the transfer and apply the methodologies described in different guidelines. The comparative analysis of the PURAM and MVM Paks Zrt. was made according to four different guidelines.

In addition, it has been proved that the methodology for the (comparative) analysis of the survey based on the averages of the results hides the strong or potentially developing characteristics if the results are too close to each other or if a significant difference is between two assessments.

The methodology that I have developed is based on the ranking of the averages in each sample. The method for the reduction of the effect of the distortion reveals the strengths and potential rooms for improvements of each culture and the differences between them, already in the first step of the process. It standardizes the differences between each culture characteristic; therefore during the analysis, the characteristics have an equal interval and distance from each other. Consequently;, the method increases the differences among those results that are too close to each other. In general, I demonstrate that my developed method simplifies the process of the comparative analysis.

NEW SCIENTIFIC ACHIEVEMENTS

1. I have developed a new scientific method to assess nuclear safety and security cultures in a single joint/integrated process. In addition, I have determined the advantages and limitations of the method and justified its applicability in the practice.
2. I have justified in the practice that the assessment of the “small” facilities can be efficiently and effectively accomplished, and I have determined those significant methodological novelties and compromises, which are necessary to be considered and applied.
3. I have proved that the comparative analysis and the conversation of the results of the assessments made according to different guidelines can be achieved with the rearrangement of the elements of nuclear safety and security cultures.
4. I have proved that my new methodology (serving for the comparative analysis of the survey assessments of nuclear safety and security cultures), which is based on the ranking of the averages within the sample significantly simplifies the comparative analysis and makes it more efficient.

RECOMMENDATION

The dissertation fills a gap because such comprehensive domestic study was not made on the topic before. It makes the basic knowledge of the issue much more organised, hereby establishes the necessary basis for the further research by the professionals of the topic.

I recommend using my new scientific results, especially for the "small" domestic facilities.

In the dissertation, I have only conducted the comparative analysis of two facilities that operate in a very similar environment. Thus, I recommend using my methodology for the comparative analysis of two similar international or domestic facilities or two facilities in a different environment, in different countries or even different operational cycles of the facilities.

Such applications of the method have not been assessed due to the restrictions of the accessible materials, however, I consider these research directions the most promising for future research.

PRACTICAL APPLICATION OF THE RESEARCH RESULTS

I would recommend using the considerations, conclusions and my research results in practice as follows:

1. The developed new scientific method is applicable to any kind of facility to assess the nuclear safety and security culture in a single joint/integrated process.
2. The application of my achievements in the case of "small" organisations establishes the opportunity to conduct an effective and efficient nuclear safety and security culture assessment.
3. In addition, I advise the application of the methodological recommendation to nuclear regulators at the development of the systems of the legislation and guidelines of the assessment of "small" facilities.
4. I advise to use the methodology for the comparative analysis and the conversation of the results of the assessment of nuclear safety and security culture made according to different guidelines with the rearrangement of the elements. Consequently, the method is applicable in case of experienced or even new licensees related to nuclear safety or security culture assessment.
5. The new methodology developed by me for the comparative analysis of the survey assessment of the nuclear safety and security significantly simplifies, makes more efficient and also eases the process of comparative analysis in the practice.

My study, after re-editing, can be applicable as an educational material at the BA and Master degree of Public Service Institute of Disaster Management and at the Doctoral School of Military Science of the National University of Public Service.

LIST OF PUBLICATIONS OF THE AUTHOR RELEVANT TO THE TOPIC

Papers in authoritative domestic journals

1. Solymosi Máté: Tehetséggondozás a Katonai Műszaki Tudományokban, (100%) Bolyai Szemle XXIII., 2014/2., pp. 98-104, https://www.uni-nke.hu/document/uni-nke-hu/bolyai-szemle-2014_-ev-2_-szam.original.pdf (Date of access: 2018.08.01.)
2. Solymosi József; Solymosi Máté: Gondolatok „Az atomreaktorok biztonsága" című könyvről: Hadmérnök, IX. – 01.2014., pp. 124-129, http://hadmernok.hu/141_12_solymosij.pdf (Date of access: 01.08.2018.)
3. Solymosi József; Solymosi Máté: Előzetes megfontolások az iparbiztonsági szakértők kötelező minősítéséről I. Védelem Online: tűz- és katasztrófavédelmi szakkönyvtár, 481 study, 20.02.2014., http://www.vedelem.hu/letoltes/anyagok/481-elozetes-megfontolasok-az-iparbiztonsagi-szakertok-kotelezo-minositeserol-i.pdf (Date of access: 01.08.2018.)
4. Kátai-Urbán Lajos; Solymosi Máté: Katasztrófavédelmi díj létrehozása és tapasztalatai Védelem Online: tűz- és katasztrófavédelmi szakkönyvtár, 483 study, 10.02.2014., http://www.vedelem.hu/letoltes/anyagok/483-katasztrofavedelmi-dij-letrehozasa-es-tapasztalatai.pdf (Date of access: 01.08.2018.)
5. Solymosi Máté: A hazai nukleáris biztonság jogszabályi hátterének rövid áttekintése, Társadalom és honvédelem, XIX.,2., 2015., p. 161-173., http://193.224.76.2/downloads/konyvtar/digitgy/tartalomjegyz/tarsadalom_es_honvedelem_2015_2.pdf (Date of access: 01.08.2018.)
6. Solymosi Máté; Horváth Kristóf; Petrányi János: Nukleáris védettségi kultúra önértékelés egy radioaktív anyagokat alkalmazó szervezetnél, (80%) Hadmérnök, X., 2.– 06.2015., pp. 179-189., http://www.hadmernok.hu/152_16_solymosim_hk_pj.pdf (Date of access: 01.08.2018.)
7. Csurgai József; Solymosi Máté: Levegőszűrők hatékonyságának mérése I. rész: Az aeroszol szűrés alapjai, a por- és részecskeszűrők minősítésének rendszere, (10%), Hadmérnök, X., 1., 03.2015., pp. 62-78., http://hadmernok.hu/151_06_csurgaij_sm.pdf (Date of access: 01.08.2018.)

8. Solymosi Máté: Új eljárás a nukleáris biztonsági és védettségi kultúra felmérésére és értékelésére (100%), Katonai Műszaki Közlöny, XXVII., 02.2017., pp. 113-123., http://hhk.archiv.uni-nke.hu/downloads/kiadvanyok/mkk.uni-nke.hu/PDF_2017_2sz/009_SOLYMOSI_MKK%20formazott%20LEKT.pdf (Date of access: 01.08.2018.)
9. Horváth Kristóf; Solymosi Máté; Vincze Árpád; Vass Gyula: Cut the costs and enhance efficiency in nuclear safety and security culture self-assessments: considerations that should be taken to merge nuclear safety and security culture assessments, (70%), Hadmérnök, XII.,1., 03.2017., pp. 115-122., http://hadmernok.hu/171_09_horvath.pdf (Date of access: 01.08.2018.)
10. Solymosi Máté: Kis szervezetek nukleáris biztonsági és védettségi kultúrájával kapcsolatos megfontolások, Hadmérnök, 2017/3, p. 154-165, http://www.hadmernok.hu/173_14_solymosi.pdf (Date of access: 01.08.2018.)

Papers in foreign language journals

11. Csurgai József; Solymosi Máté: Thoughts on the Book Nuclear Reactor Safety (95%) AARMS, Vol. 13, No. 1, 2014., pp. 229–233., http://uni-nke.hu/uploads/media_items/aarms-2014-1-csurgai.original.pdf (Date of access: 01.08.2018.)
12. Csurgai József; Solymosi Máté; Horváth Kristóf Csaba; Vass Gyula: Nuclear Security Culture in a Radioactive Material Associated Facility (70%), AARMS, Volume 14 Issue 3 2015, pp. 265-272, http://uni-nke.hu/uploads/media_items/aarms-vol-14_-issue-3_-2015.original.pdf (Date of access: 01.08.2018.)
13. Solymosi Máté: Assessing and Enhancing Nuclear Safety and Security Culture for Small Facilities that Handle Radioactive Material, International Journal of Nuclear Security, 2017 Volume 3, 1 Issue, 12 Article, Student competition: Award of Excellence, http://trace.tennessee.edu/ijns/vol3/ iss1/12/ (Date of access: 01.08.2018.)

Publications in conference proceedings

14. Solymosi Máté: A hazai nukleáris biztonság jogszabályi hátterének rövid áttekintése, A haza szolgálatában konferencia 2014.10.31., presentation
15. Máté Solymosi: Nuclear Security Culture Self-assessment in a Radioactive Material Associated Facility, 2015 Conference of the Transatlantic Policy Consortium

"Rethinking Public Governance" Budapest, June 10-12, 2015 http://tpc.uni-nke.hu/program/phd-session (Date of access: 01.08.2018.)

16. Horváth Kristóf; Solymosi Máté; Vass Gyula: Fewer can be more: Nuclear safety and security culture self-assessment in the Hungarian Public Ltd. for Radioactive Waste Management /Poster/ (80%) International Conference on Human and Organizational Aspects of Assuring Nuclear Safety: Exploring 30 years of Safety Culture, https://conferences.iaea.org/indico/event/80/session/25/contribution/205/material/poster/0.pdf (Date of access: 2018.08.01.)
17. Horváth Kristóf; Solymosi Máté; Vass Gyula: Fewer can be more: Nuclear safety and security culture self-assessment in the Hungarian public ltd. for radioactive waste management /kézirat cikk/ 80% International Conference on Human and Organizational Aspects of Assuring Nuclear Safety: Exploring 30 years of Safety Culture, https://conferences.iaea.org/indico/event/80/session/25/contribution/205/material/paper/0.docx (Date of access: 01.08.2018.)
18. Solymosi Máté: Hungarian Country report on the Effort for Enhancing NSC előadás, International Workshop on Nuclear Security Culture, Spain, Madrid, 29.02-04.03.2016.
19. Solymosi Máté: Nuclear Security Culture Self-Assessment in Hungary, International Workshop on Nuclear Security Culture presentation, International Workshop on Nuclear Security Culture, Spain, Madrid, 29.02-04.03.2016.
20. Solymosi Máté; Horváth Kristóf; Solymosi József: Combine Nuclear Security and Safety Culture Self-Assessment, Fewer or More? (Poster, 80%), International Conference on Nuclear Security: Commitments and Actions, 5-9.12.2016., https://conferences.iaea.org/indico/event/101/session/37/contribution/50/material/poster/2.pdf (Date of access: 01.08.2018.)
21. Solymosi M., Brissette S.: The Harmonisation of Nuclear Safety and Security Culture and the Responsibilities of the Management, poszter, International Conference on quality, leadership, and management in the nuclear industry, 15th FORATOM-IAEA Management systems workshop, 16-19.07.2018., Ottawa, Canada, https://events.foratom.org/wp-content/uploads/2018/04/2018-07-19_MSTF2018_DraftProgramme_A4_V2.pdf (Date of access: 01.08.2018.)
22. Máté Solymosi, Dr. Kristóf Horváth, Susan Brissette: Combined Nuclear Security and Safety Culture Self-assessments in NPPS Practical experiences of combined nuclear security and safety culture self-assessment in Nuclear Power Plants in Hungary (2015,

Paks) and Canada (2016, Bruce Power, Ontario), International Conference on Physical Protection of Nuclear Material and Nuclear Facilities, 13–17 November 2017, Vienna, Austria https://www.iaea.org/sites/default/files/17/11/cn-254-solymosi-presentation.pdf (Date of access: 01.08.2018.)

AUTHOR'S PROFESSIONAL AND ACADEMIC CURRICULUM VITAE

Name: Máté Solymosi

Place and date of birth: Budapest, November 12, 1984

Studies

After the secondary school in 2003, he received his certificate in Extended Level of Radiation Protection.

He has started his higher studies in 2003 at the Budapest Corvinus University and graduated as an Accountant (BA) in 2007.

In 2009 he graduated on the faculty of Defence Administration (MA) at the Budapest Corvinus University.

In 2011 he graduated as a Sociologist at the Budapest Corvinus University.

In 2014 he received a certificate in Advanced Radiation Protection.

Language skills: Advanced level "C" type language proficiency in German language and intermediate level "C" type language proficiency examination in English language.

Professional career:

His first workplace was Somos Environmental Protection Ltd form 2005 until 2009, where he worked as a project lead. Between 2010-2012 he worked at the Public Limited Company for Radioactive Waste Management, as a public procurement expert. After that he worked as a labour assistant at the Gamma Technical Corporation. In 2013, he continued his carrier to and he still works at the Somos Environmental Protection Ltd. as a project lead and analyst.

Budapest, September 10, 2018.

Máté Solymosi