INFORMATIZATION OF MULTI-CRITERIA ANALYSIS OUTRANKING: A SOFTWARE TO IMPROVE DECISION-MAKING IN RADIOLOGICAL PROTECTION OPTIMIZATION PROGRAMS

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ABSTRACT

This project aims the informatization of the decision technique known as Multi-Criteria Analysis Outranking, used in radiological protection optimization programs. This technique could prove more helpful than an aggregative technique whenever options can not be placed in ascending or descending order when related to each factor. In order to assist the decision maker to identify the optimal analytical solution, this system was developed mostly according to the criteria and methodology established by the ICRP-55. It comprises several distinct stages and it provides user spreadsheet calculation which can be saved or printed in order to be given to stakeholders and competent authorities. This software is full compatible with all major internet browsers and can be accessed from any computer with a conventional internet connection.

Key words: radiological protection; decision-making technique; multi-criteria analysis outranking

Introduction

This paper intends to present a computer analysis to select the "optimum" radiological protection option using the quantitative decision-aiding technique known as "multi-criteria outranking analysis".

This technique was selected instead of the "extended cost-benefit analysis" and "multi-attribute utility analysis", since the first one loads excessively the alpha value and the second one may present some difficulties when the factors to be considered are particularly heterogeneous or when they can only be evaluated in a qualitative manner, for instance, in the public acceptability on impact on staff relations. Alternatively, whenever protection options are too disparate, it may be judged that the related options which associates minimum protection cost and maximum detriment cost is not really comparable to those leading to maximum protection cost and minimum detriment cost, even though the sum of the overall cost might be the same in both cases. In such circumstances, as suggested by Roy and Vincke (1981), the use of a multi-criteria outranking technique could prove more helpful than an aggregative technique.

Even though ICRP would prefer the "Multi-attribute Utility analysis", in many cases ministered by us, the participants always chose the "Multi-criteria outranking analysis" technique. When they were questioned about their choices, the answer was unanimous: when comparing each option to others, we can clearly realize how the optimum option was selected. In the case of the "Multi-Attribute Utility Analysis" the data is simply given, without further explanation. Due to this fact, we decided to start with the Multi-Criteria Outranking Analysis technique.

2. Short description of this Decision-Making Technique

The outranking technique initially compares each option *i* to every other option *m*, in order to evaluate whether option *i* outranks (or is preferred to) option *m*. This comparison by pairs is generally based on two indicators.

(i) An "advantage index" that expresses the amount by which option *i* is preferred to option *m* by the assessor conducting the study. The index, $Ad_{i, m}$, is equal to 1 when *i* is preferred or equivalent to *m* for all *j* factors; it is equal to 0 when *i* is never preferred or equivalent to *m* and it varies in the range from 0 to 1 when *i* is preferred or equivalent to *m* for some factors

(ii) An "exclusion criterion" that expresses the degree to which the disadvantages of option *i* as compared whit option *m* are significant for the factors where *i* is not preferred or equal to *m*. In the simplified version presented here this index, $Ec_{i, m}$, is equal to 1 when the drawbacks associate whit the choice of *i* rather than *m* are very substantial and equal to 0 otherwise.

If $Ad_{i, m}$ is high enough and $Ec_{i, m}$ low enough, in this simple treatment zero, option *i* "outranks" option *m*.

In calculating the advantage index it is possible to incorporate criteria for the importance attached to the factors k_j. This is carried out in the simplest case using scaling constants, which for convenience of comparison are defined to be the same as those in the multi-attribute utility analysis, so that the advantage index is given by

$$Ad_{\iota, m} = \sum k_j a_j$$

Where a_j is the advantage index for the factor j; this is equal to 1 if option $_I$ is better than or equal to option *m* for this factor, otherwise it is equal to 0.

3. Software description

This technique is useful whenever options can not be placed in ascending or descending order when related to each factor. In order to assist the decision maker to identify the optimal analytical solution, this system[1] was developed mostly according to the criteria and methodology established by the ICRP-55, and it comprises several distinct stages.

In the first stage the decision maker defines factors, criteria and radiological protection options to be adopted, as well as build-up factors. First of all user chooses up to ten quantitative or qualitative factors. In this first stage, user should choose up to ten options and fill out the values, which should be entered with numeric data. Whether a factor expresses qualitative values, it is necessary to establish their relative importance in numbers. Yet, at this stage, there should be given the exclusion criterion and advantage index, as well as more discriminatory elimination criteria when options outrank others but are not themselves outranked.

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[1] The development of this software is part of the master thesis developed at IPEN, entitled "Contribution to the Informatization of Radiation Protection Programs for Nuclear Facilities other than Nuclear Fuel Cycle".

The second step comprises a Cost-Benefit Analysis, considering costs and doses of all options and pointing the cost effective solutions. Yet, the system suggests non-cost-effective options to be eliminated. Nevertheless, the system does not eliminate options itself. We understand that at this point human judgment is essential, as the software is not sensitive to some aspects that should be considered. As instance, decision maker may choose not to eliminate a noncost-effective option, whether it offers a qualitative achievement such as better ventilation in workplace, or it improves public opinion. Therefore, after presentation of cost- effectiveness analysis graphic, it is up to the user to confirm the options to be compared.

In the third stage, differently from ICRP method, the system calculates the “exclusion criteria” ($Ec_{i,m}$), leaving the “advantage index” ($Ad_{i,m}$) for a third stage. Therefore the system calculates all exclusion indexes, presenting data tables according to the results. This inversion decreases considerably the calculations, limiting the “advantage index” to the options that have obtained the zero value.

The forth step includes the advantage index calculated according to the results obtained in the previous step. Then the system compares and evaluates the outranking relations. In the fourth stage outranking options are checked and more discriminatory elimination criteria are applied whenever it is necessary. Besides the optimal analytical solution, the program provides spreadsheet calculation which can be saved or printed in order to be given to stakeholders and competent authorities.

This software was developed in HTML and PHP (Web based languages) with aid of MySQL relational Database and jQuery Library (javascript). This system is full compatible with all major internet browsers and can be accessed from any computer with a conventional internet connection.

5. Discussion and Comments

While developing this technique, our team followed ICRP recommendations for the decision technique known as Multi-Criteria Analysis Outranking for the optimization. The only change was the decision to calculate at first “exclusion criteria” and then the “advantage index”. This inversion decreases considerably the amount of options to be compared, which limits the “advantage index” only to those options that have obtained the zero value.

The software proved to be helpful, as it allows a great amount of options and factors to be chosen. Once the software is fed with appropriate data, the software shows great performance and all values can be calculated in just few seconds. The system allows users to go back to any previous stage in order to review the data entered and change values, calculating and recalculating results as many times as it is necessary.

Nevertheless, despite the agility provided by the system, the software does not replace human judgment that can be sensitive to some aspects that would not be considered by the system, such as unreasonable costs or decision maker's aversion to high doses. Still there are some qualitative factors that depend on decision maker´s judgment, as mentioned in the description of the cost-efficacy analysis in the second step of this system.

References

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