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Road to more uniform and more transparent results for the QRA in Flanders

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The government of Flanders (Belgium) observed that results of quantitative risk analyses (QRA) that are performed in the context of environmental safety reporting are insufficiently uniform. To improve the process and make the results more transparent and uniform, an exploratory exercise was conducted. This study included (1) defining options; (2) establishing an evaluation framework; (3) comparing options; and (4) formulating recommendations. The recommendations focus on (1) joint knowledge building, (2) improved quality control, and (3) leveraging the ADAM software developed by the JRC (Joint Research Centre).

The government of Flanders believes that this is the road to more uniform and more transparent results for the QRA in Flanders, and therefore intends to implement these recommendations. A big advantage of this renewed way of working is the opportunity for more international cooperation and knowledge sharing on the entire QRA process, specifically for investigating which steps of the calculations cause the greatest differences in results.

* 1. Introduction

The government of Flanders noted inconsistencies in QRA results performed in the context of environmental safety reporting. These are due to the use of different software packages and the interpretations by the certified experts, who perform the QRA. Initial steps towards unification included (1) a feasibility study (Smit C., 2010) indicating the need of more guidelines and (2) drafting a Risk Calculation Manual with specific guidelines (Department of Environment, 2019), but not mandating a specific software package. The government of Flanders now wants to take a next step with the exploratory exercise. An important question is whether it is possible to use one specific QRA-software to obtain more transparent and uniform results.

This article summarizes the recent exercise aimed at exploring different options to achieve more uniform and transparent QRA results (Gommers A. et al, 2024).

* 1. Methodology

The study was conducted as a desk-top study, in interaction with the internal and external stakeholders involved in the QRA process (including from the Netherlands). Focus group discussions were held to explore different options that can contribute to more uniform and more transparent QRA results.  A steering committee was installed to evaluate intermediate results and take important decisions (on the options to be included, on the criteria in the evaluation framework, ...).  Finally, the certified experts and the employees of the government of Flanders were brought together in a workshop setting to discuss the results of the evaluation and formulate recommendations.

Key steps included:

1. Exploring options for uniformity and transparency: the different options were elaborated; preconditions and advantages and disadvantages were identified.
2. Establishing an evaluation framework to compare the different options objectively: all evaluation criteria were defined from the point of view of the government of Flanders (e.g. costs, capacity, etc.). Advantages and disadvantages from the stakeholders’ point of view were identified separately.
3. Conducting a multi-criteria analysis (MCA): an integrated evaluation and comparison of the options were done for each evaluation criterion separately. The aggregation used the ‘Evamix’ method, which is suited for a combination of quantitative and qualitative data. It treats the quantitative and qualitative scores separately first and then combines them (Janssens R., van Herwijnen M., 2006) (VU, 2023).
4. Formulating recommendations to achieve more uniform and more transparent results for the QRA.
	1. Different options

Different options have been explored and evaluated, each intended to eliminate some of the causes underlying the differences in QRA results: either through encouraging or requiring the use of one software package, or through reducing different interpretations by experts, or through a combination of these two. The options retained in the study are summarized in Table 1.

Five groups of options were distinguished: (1) knowledge sharing between experts to lead to a more uniform approach for similar cases; (2) third-party quality control to increase understanding of how certain cases could be addressed; (3) use of a reference software to make results more uniform and more transparent (without obligation to use this reference software); (4) obligation to use one given software package; (5) all QRA calculations done by one organization, following a standardized way of working. Within each group, several sub-options were distinguished and described, resulting in twelve options compared to each other and the current situation.

Table 1: Options to be evaluated

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| --- | --- | --- | --- |
| Group  | Short description | Sub-option and changes with respect to current situation |  |
| 0 | Current situation |  |  |  |
| 1 | Knowledge sharing  | 1a | Advanced initiatives on knowledge sharing and modeling for specific cases |  |
|  | 1b | Obligation for a company to alternate between certified experts in consecutive permit applications |  |
| 2 | Third-party quality control  | 2a | Challenging input and results of the QRA through discussion with other certified experts |  |
|  | 2b | Obliged recalculation of the whole QRA by a third party with own software to discuss the differences and decide on the most likely conclusions |  |
| 3 | Reference software  | 3a | Encouragement to use a specific ‘reference’ software to perform the QRA. When experts choose to use their own software, they must prove that the software gives “equal” results as with the reference software |  |
|  |  | 3b | Quality control by the government of Flanders using a reference software |  |
| 4 | Obligation software package  | 4a | Obligation of the use of the open-source software ADAM developed by JRC  |  |
|  | 4b | Obligation of the use of a specific software chosen by the government of Flanders |  |
|  | 4c | Obligation of the use of a specific software chosen by the government of Flanders, in which as many parameters as possible take on fixed values |  |
|  | 4d | Obligation of the use of a specific (new) software developed by the government of Flanders |  |
| 5 | QRA calculations by 1 organization | 5a | Mandatory appointment of 1 organisation that is chosen by the government of Flanders and that drafts the whole safety report with the QRA, with consequent use of software. |  |
|  | 5b | Mandatory appointment of 1 organisation that is chosen by the government of Flanders and that performs the QRA, with consequent use of software. The certified experts get the results of the modeling work, perform the evaluation based on these results and draft the safety report. |  |

Note with option 4a: ADAM (Accident Damage Analysis Module) (European Commission, 2023) is a software tool developed by the Joint Research Centre (JRC) of the European Commission (EC) to assess physical effects and associated damages of an industrial accident resulting from an unintended release of a hazardous substance. It is now available for free for EU competent authorities. The software is in a process of being converted to open-source software, allowing the software to be used and further developed by everyone.

Note with options of group 2 and group 5, implying (additional) costs for quality control or for having the QRA performed by experts of one dedicated organisation: two variants were included in the evaluation, one in which these (additional) costs are borne by the industry (variant “) and one in which these (additional) costs are borne by the government (variant ‘).

* 1. Evaluation framework

Each option was evaluated according to three main aspects, namely (1) the extent to which the option contributes to more uniform and more transparent results, (2) the feasibility and (3) advantages and disadvantages. Within each of these main aspects, different evaluation criteria were defined from the point of view of the government of Flanders. This resulted in the evaluation criteria summarized in Table 2.

Table 2: Evaluation criteria

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| Main aspect  | Evaluation criteria |
| 1. Extent to which the option contributes to more uniform and more transparent results
 | * Extent to which more uniform results will be obtained after implementation of the option
* Extent to which the results of the QRA will become more transparent for all stakeholders
* Time needed to evolve to a situation with more uniform and transparent results after implementation of the option (immediately after implementation of the solution vs. in the longer term)
 |
| 1. Feasibility
 | * Financial cost of implementing the option (government side)
* Capacity needed to implement the option (government side)
* Extent to which the required knowledge is present or can be easily obtained
 |
| 1. Advantages and disadvantages
 | * Extent to which joint knowledge building is achieved in the community of persons dealing with QRA calculations
* Extent to which the safety reporting process becomes more complex
* Risk of vendor lock-in (making switching suppliers practically impossible because of the high thresholds involved (financial costs or other))
* Market distortion because of the choice for a specific option
* Required switching time for the experts or the industry
 |

Financial feasibility and feasibility in terms of capacity were assessed quantitatively (€ and (extra) staff), while other criteria were assessed qualitatively, i.e. using a ranking within the list of options from the option(s) scoring best on this criterion to the option(s) scoring worst on this criterion. The scoring was performed in interaction with employees from the government of Flanders. Each of the scores awarded was motivated.

Before aggregation of the scores in the MCA, the relative importance of each of the evaluation criteria within each of the main aspects was defined through weights. Sum of the weights within one main aspect equalled 1.

* 1. Aggregated evaluation

By means of a multi-criteria analysis, the scores of the options across the different evaluation criteria were aggregated into a final score per main aspect in the evaluation, considering the relative importance of the evaluation criteria (weights). An aggregation of the intermediate results for each of the main aspects was purposely not carried out, as this makes the underlying reasons for the final score unclear.

The result of the integral evaluation is shown in Figure 1, with the position on the x-axis representing the extent to which the option contributes to more uniform and more transparent results, the position on the y-axis representing the feasibility of implementing the option, and the radius of the spheres representing the extent to which the option has advantages or disadvantages.

An ideal option would be located at the top right in the figure and have a large radius (few or no disadvantages and some advantages). The evaluation revealed that no single option is ideal (or that the ideal option was not explored). Options involving one organization performing all QRA calculations (group 5) offer the greatest unification but have significant disadvantages (i.e. risk of vendor lock-in, market distortion, etc.). The feasibility for the government is also high if the costs for the QRA in this option are borne by industry (as is currently the case) (options 5a” or 5b”). On the other hand, knowledge sharing options (group 1) are feasible and have few disadvantages, but they have limited impact on uniformity and transparency. Options in groups 2, 3 and 4 take intermediate positions on the graph.


Figure 1: Aggregated evaluation of the different options according to the three main criteria (diameter of the spheres: extent to which advantages outweigh disadvantages - the larger the more positive)
Note: The option's number label points to the centre of the corresponding sphere. Options 2a" and 2b" score identically for each of the evaluation criteria and so the spheres overlap completely.

* 1. Stakeholder evaluation

The evaluation as represented in Figure 1, was carried out from the point of view of the government of Flanders. When making a policy decision, it is also important to consider the views of the main stakeholders. After all, they will have to cope with the decision on the option(s) and ensure efficient operation. The pros and cons suggested by stakeholders were collected and can be summarized as follows.

* For industry, it is important that the costs for companies are not driven up, that the lead time for obtaining a permit is not extended significantly, and that they have the freedom to contract a certified expert of their choice to carry out the QRA.
* For the certified experts themselves, it is important that their expertise continues to be used and valued. An option in which QRA consists of running a model, without experts having to or being able to think about the inputs, the possible mitigating measures, and so on, is an option that represents for them an impoverishment of the whole QRA process.
* Knowledge exchange was highlighted as crucial by all stakeholders.
	1. Recommendations

Recommendations include (1) committing to joint knowledge building, (2) improved quality control by the government using reference software, and (3) leveraging the ADAM software when it becomes open source. The recommendations are summarized in Table 3.

Of course, it is always useful to check at regular intervals whether the situation is evolving towards the desired situation (i.e. more uniform and more transparent results).

Table 3: Recommendations

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| Main aspect  | Description |
| Joint knowledge building | The study proposes to implement option 1a for this purpose, in which, by means of studies, insights are obtained on how complex (new) cases are best modeled in QRA, what the causes are of the differences resulting from the use of different software or from the execution of the QRA by different experts, and how the cases are best handled. Implementing this option can be started immediately. A budget for the studies and additional staff is needed to implement this option. |
| Improved quality control  | The study puts forward option 3b, in which the government of Flanders performs recalculations using a ‘reference’ software of their choice. The aim of these recalculations is to have a basis for discussing with the experts on how the modeling was handled (hypotheses, input, justification, etc.). This improves the quality of the environmental safety reporting, improves transparency and (in time) will also bring the QRA results closer together. Implementing this option requires extra staff and resources at the side of the government of Flanders. |
| Leveraging ADAM software | If ADAM becomes an open-source software (at the earliest in autumn 2025), ADAM could be used as reference software by the government of Flanders. However, a further development step of the ADAM software will still be needed first. In its current form, ADAM calculates only the consequences, but does not aggregate them into fully-fledged QRA. Flanders could choose (possibly together with other interested member states) to initiate and finance this further development step. Implementing this option is the costliest. Additional staff will be needed (1) for the further development and (2) to permanently monitor the developments. |

Other options were not recommended due to various disadvantages.

* Option 1b: the industry no longer has freedom of choice in appointing experts.
* Options 2a and 2b: the third-party quality control must be carried out by certified experts. Although there is a quality-enhancing aspect when peers critically review each other's results, there is probably insufficient capacity for this within the group of certified experts. In this option, they must all be able to free up time to participate from time to time. In addition, in this option, a 'referee' will be needed if the experts cannot agree on the interpretation and working method for a specific case.
* Option 3a: setting up a homologation process that can demonstrate whether a software package is 'equivalent' to the selected reference software package will not be easy. During the workshop with experts and employees of the government of Flanders, it was indicated that it can be assumed that all software packages currently in use are ‘equivalent’, but that there is an inherent uncertainty in the calculations.
* Options 4a, 4b, 4c and 4d: making a specific software package mandatory, without setting the parameters, addresses one of the causes of the non-uniform results. Important causes for non-uniform results remain, namely different interpretations of a specific permit application. When updating the software, results obtained with the updated software, will also differ from previously obtained results. Complete uniformity cannot be achieved with these options (and is only possible if a specific software is made mandatory and ‘frozen’ so that no future changes are possible). This is also not what the government of Flanders prefers. They are in favour of incorporating new scientific insights into the software used to perform the QRA.
* Options 5a and 5b: working with 1 organisation for the drafting of the safety report or the performing of the QRA has quite a few disadvantages: little common knowledge building, high risk of vendor lock-in, market disruptive effect and switchover time will be long. Also, the industry no longer has any freedom of choice in appointing experts. The stakeholders clearly indicated that they do not prefer one of these options.
	1. Points of interest

In addition to the recommendations for future practices to move towards more uniform and more transparent results, several interesting points emerged during the study, which are included in the report as points of attention.

* Documentation of the version of the software used is useful and necessary. This increases the transparency of the results for the future.
* Nowadays, sharp limits for the external safety risks are used in the evaluation of the external safety of an installation in Flanders: going above or below a limit means obtaining or not obtaining a permit for a company. The stakeholders argue to adopt a more nuanced approach.
* The Risk Calculation Manual remains important in the recommendations as formulated above. From the joint knowledge building that is realised, good practices must be formulated for the cases dealt with and included in the manual.
* The principle of engaging external safety experts that are certified for their expertise remains valid in the recommendations. For the industry, it is important to be able to rely on the experience and expertise of certified experts as a sign of quality they can deliver.
	1. Future developments

The government of Flanders believes that the recommendations made in the study are indeed the road to more uniform and more transparent results for the QRA in Flanders, and therefore wants to implement the recommendations about (1) intensified knowledge sharing by conducting more scientific studies and specific case studies and about (2) improved quality control by the government of Flanders by using a reference software.

The use and further development of the ADAM software is considered optional and will be evaluated when it becomes available as open-source software.

A significant advantage of this renewed way of working is the opportunity for more international cooperation and knowledge sharing on the entire QRA process, specifically for investigating which steps of the calculations cause the greatest differences in results.

* 1. Conclusions

The study concludes that a combination of options is necessary to achieve the desired uniformity and transparency in QRA results. After all, the options that highly contribute to more uniform and transparent results and are reasonably feasible include other large disadvantages. On the other hand, feasible options without large disadvantages do not seem to contribute enough to more uniform and transparent results. However, the choice that must be made between the options should not be an or/or-choice, but can also be an and/and-choice: a combination of options or a sequence of options over time. Therefore, the recommendations are a combination of (1) joint knowledge building, (2) improved quality control, and (3) leveraging the ADAM software developed by the JRC. The government of Flanders shares the vision developed in the study and intends to implement the recommendations.

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