OPTIMISATION AND ROBUSTNESS OF INTERVENTION STRATEGIES IN EMERGENCY EXPOSURE SITUATIONS

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Abstract
According to the International Commission on Radiological Protection (ICRP), the intervention strategy in emergency exposure situations is based on the principles of justification and optimisation. The first means that intervention measures must be justified, in other words "do more good than harm". With regard to optimisation, a reference level - "level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration" – is set.
As part of the intervention preparation phase, the intervention is divided up into phases and zones to facilitate application of the protection measures.
For each intervention measure selected, a trigger for the measure is established in the form of an intervention level (IL), a level that is usually set based on the effective dose received by members of the public. To facilitate its practical application in stressful situations, an operational intervention level (OIL) is also set, which is based on an easily measurable quantity.
This paper takes an accident at a nuclear reactor as an example of an emergency exposure situation.

Optimisation during the acute phase
During the acute phase, in other words before the radioactivity has been released into the environment, the basis for decision-making is provisional. At this point, we do not know whether it will be released, on what scale and what the immediate weather conditions will be. The measures to be taken, which cover both the risk of external and internal exposure, would be sheltering or evacuation, and simultaneously taking iodine tablets. The intervention level concerns the effective dose received by members of the public during the release phase, while the operational intervention level is a parameter that measures the probability and potential scale of the discharge, for example the temperature of the reactor core and the containment activity.
This situation is marked by the uncertainty regarding what will happen next and the relatively significant consequences of the release. Also, let us not forget that this is a very rare situation, which also has repercussions on the strategy. Consequently, this is no time for procrastination, but for implementing "generous" protection measures. This means that, given the uncertainty, it is sensible to incorporate a safety margin in decisions. This could be described as "*optimisation under robustness constraints*".

Optimisation during the intermediate phase
Just after the release, decisions are based on the measurements on the ground to estimate the deposition and its dosimetric impact. By this time, maps would

be available, although still rough, showing the ambient dose rate and depositions. The protection measures would be linked to exposure pathways. The protection measure against external exposure would therefore be to limit the stay outside or to evacuate the site, while to protect against internal exposure, a harvest and grazing ban would be issued in the affected territories, and foodstuffs would be controlled. The operational intervention level concerns the ambient dose rate in the first case and the activity deposits on the ground in the second. This situation is characterised by an approximate knowledge of the exposure, a potentially high risk to the public and a need to take action quickly. The intervention should be conducted in a calm and composed manner and the response should be calibrated. This means the measures should no longer be "generous", but instead adapted as effectively as possible to the situation. This could be described as "*optimisation under efficiency and speed constraints*".

Optimisation in the transition phase
During this phase, decisions are based on an examination of the practical situations encountered by inhabitants in their living environments. External exposure would therefore influence whether inhabitants can stay in their homes and the potential associated constraints, while the measures to reduce or avoid internal exposure would mainly involve checks on food contamination and agricultural processes. It should be noted at this point that efforts would no longer be based on the operational intervention levels set during the preparation phase, but on the analyses carried out on the basis of specific situations encountered.
During this phase, the action taken previously would be adapted to changes and local conditions. There is time to reflect and to plan protection measures. The public and stakeholders should participate in decision-making so their needs and requirements are incorporated as effectively as possible. This could be described as "*optimisation under social acceptance constraints*".

Conclusions
The methods for optimisation in emergency exposure situations evolve over the course of the different phases of the intervention, from a focus on robustness, through to efficiency and speed and finally social acceptance.
Throughout the intervention, the models and arguments used must be simple and transparent, partly because those in charge of applying them are not usually the same people who developed them during the preparation phase, so they need to be able to assimilate them quickly and often in stressful situations; and partly in order to be able to communicate effectively with the public, as this communication is key to the implemented protection measures gaining acceptance. Finally, it should be emphasised that decision-makers have an important and delicate task and that they should refrain at all costs from covering their backs by adapting their strategy to potential backlashes.