Translation of the emergency planning zone to an intervention zone: a multidisciplinary approach improving common understanding and implementation of protective actions

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Abstract:
Nuclear emergency plans prepare the response to a nuclear or radiological accidents and threats around NPP's and other nuclear installations. Predefined emergency planning zones are designed as circles of appropriate radius around nuclear installations; their dimension depends on the potential source term specific for each installation and the intervention guideline adopted for a specific protective action (evacuation, sheltering, thyroid blocking …). When an accident occurs, its consequences are evaluated on the base of the actual source term and weather conditions and remedial actions are decided for implementation within a given area, generally a sector under the wind.
The feedback from nuclear emergency exercises clearly demonstrates that the transposition of a geometric sector (angle up to a certain distance) into an operational area is not straightforward.

A working group has developed an approach to facilitate the process based on general rules. The concept was applied to the 10 km planning zone around the Tihange NPP and is presently implemented at all nuclear sites considered in the Belgian emergency plans, including the French Chooz NPP.

1 INTRODUCTION

In nuclear emergency response, the zone were protective actions are needed (the intervention zone) is primarily determined by the wind direction and its variation during the (expected) release. Depending on the fluctuation of the wind direction the angle of the intervention zone can be more or less open. The extent of the sector from the source point is influenced by the source term (in amount and quality), the weather conditions (presence of rain, atmospheric stability …), the land relief and the intervention guideline adopted for a specific protective action (evacuation, sheltering, thyroid blocking …) (Fig. 1).
Once the localisation and extent of the intervention zone at risk have been estimated by a group of experts (the evaluation cell), it is to the decision makers (the federal authority in Belgium) to decide where protective action should actually be implemented. During nuclear emergency exercises, it is often noticed that the deciders extend the area proposed for consideration by the evaluators to better fit administrative divisions of the territory and to make sure that no part of the affected area is forgotten and that every person is duly protected. The contours of the resulting intervention zone then are communicated for implementation to the local authorities (provinces and communes) and to the first responders. At the local level, where the best knowledge of the terrain is found, the zone decided by the federal level is revisited to meet field constraints and other operational issues.

Lack of common understanding among this process and steps (evaluation/assessment – decision – implementation) could also explain the noticed extensions of the intervention zone.
By the end of day, the size of the intervention area, increased at each step, could be not justified anymore by the risk.

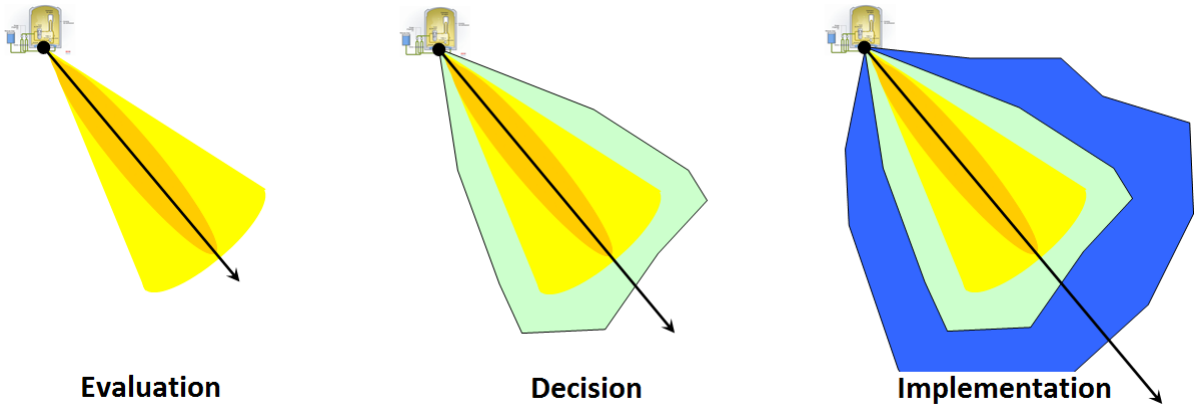


Fig. 1: Intervention zones grow through the process "evaluation (left) – decision (centre) – implementation (right)".

During emergency exercises, difficulties are also recurrently encountered that delay the process. The reasons are: (i) the transposition of a geometric sectors at risk as defined by the evaluation experts into geographic zones where actions are decided and into operational areas where they need to be implemented increasing conservatism at each step, as described above, (ii) the fact that circular planning zones of predefined radius are considered in emergency response plans which do not necessarily coincide with the sector identified for protective actions, (iii) the necessity to translate an area on a map into words for spoken messages when addressing the public and the first responders.

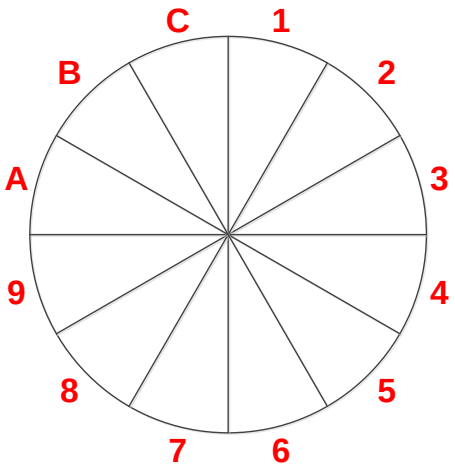
At the formal request by the governor of the Province of Liège, on the territory of which the Tihange NPP is located, a working group was set up with representatives of federal and local bodies and intervention teams. The terms of reference of this working group were to propose mechanisms which would speed up and improve the communication process and common understanding, to apply and fine-tune the selected solution in a case study (the planning zone around the Tihange NPP) before it could be generalized around the other Belgian nuclear sites and formally incorporated into the particular emergency and intervention plans specific for each of these sites.

2 THE THEORETICAL CONCEPT

To improve the process of defining the area for intervention, the best solution is that the same concept is used at the three levels of evaluation, decision and implementation: if everyone could "speak the same language", i.e. use the same approach built together and shared between all actors, evaluators could already incorporate this knowledge into the assessment process and propose intervention zones that could be directly transposed on the field and fit the reality of the terrain. Moreover, the description of the areas of concern could already be prepared and communicated to the public and the first responders with only minor adaptation in real emergency situation.
The solution proposed and developed by the working group is to divide the emergency planning zone (EPZ) into blocks of reasonable dimensions, not too large but also not to small, in order to allow enough flexibility when defining the area where protective actions are needed. To make sure that this cutting up could be applied in a similar way around all Belgian nuclear sites, driving rules have been stated.

2.1 Rule 1: Make use of 30°sectors

The cutting up will be based on sectors around the source point, starting from the North (0°). The angle of these sectors has been set at 30° because already used in most emergency plans in Belgium. The twelve sectors will be numbers using one single digit, from 1 to 9 and A to C.

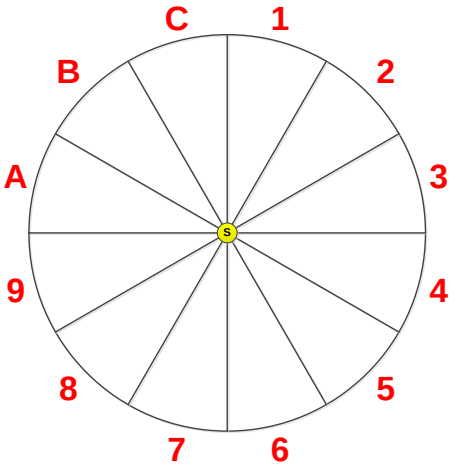


Using this pattern nuclear emergency sectors are in line with the cutting up and the numbering used by the Civil Protection for the selective activation of the 'SEVESO' sirens.

2.2 Rule 2: The 'keyhole' concept

Protective actions decide in one or more sector(s) will systematically be implemented in a keyhole shaped area i.e. also within a 'circular' zone centred on the release point.
This approach is also applied in other countries such as France, Germany or USA. However there are apparently no international guidance (IAEA, EC …) for the dimensioning of the keyhole.

The round part should mainly cope with the diffusion uncertainties due to local eddies created by the presence of buildings and enhanced diffusion at low-speed winds. The radius of this circular area has been set at 500 m around each source point (i.e. each stack). It was also decided to consider one single 'circular' zone for each nuclear site even where multiple source points are present. The result is that the 'circular' part, is not a circle anymore and that its largest dimension can easily extend to 1 km (Fig. 2). Moreover the final shape needs to be adapted to the local peculiarities as described later in this paper (see §3).



It is noteworthy that for operational reasons (accessibility to rescue and intervention vehicles) the nuclear emergency plan developed by the province of Antwerp for the Doel NPP systematically considers a circular area of 1 km. In France this area extent to 2 km and corresponds to the 'reflex' zone around the EDF NPP's. In Germany the dimension of the circular part of the keyhole is also 2 km without being associated with a 'reflex' zone.

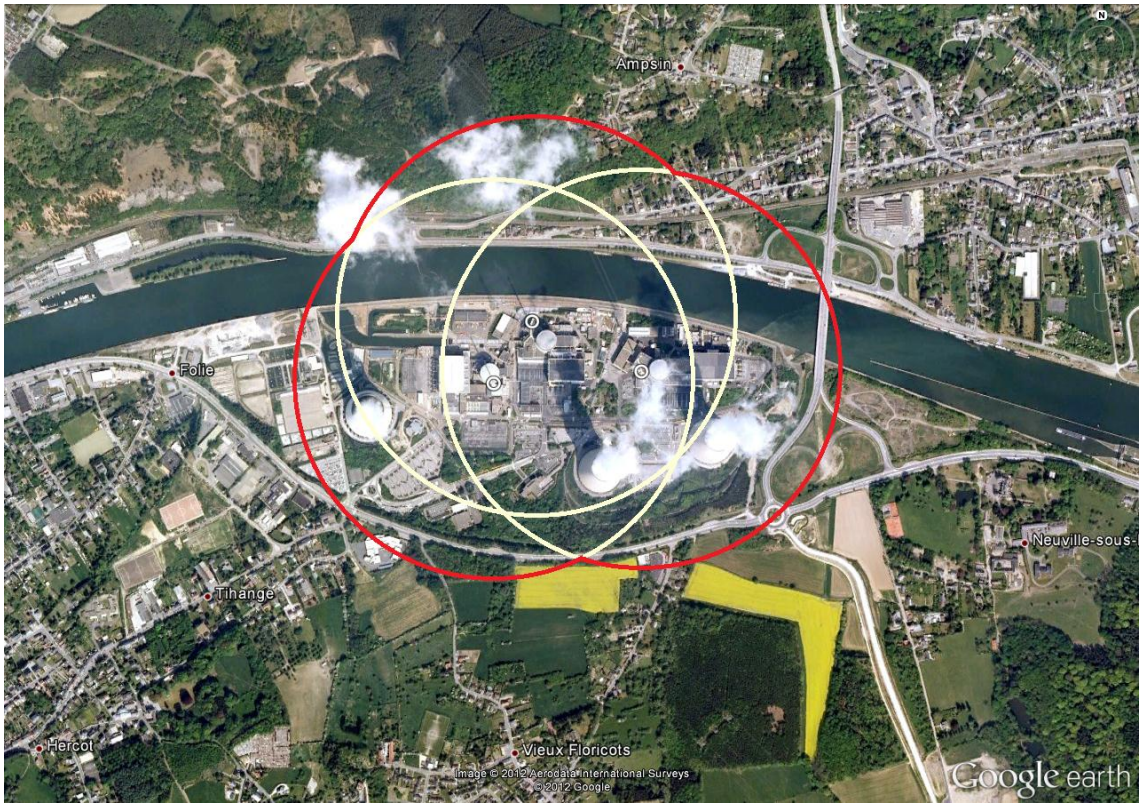
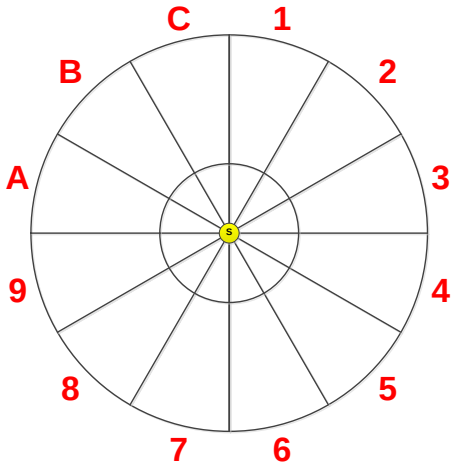


Fig. 2: The theoretical 'circular' part of the keyhole around the Tihange NPP.

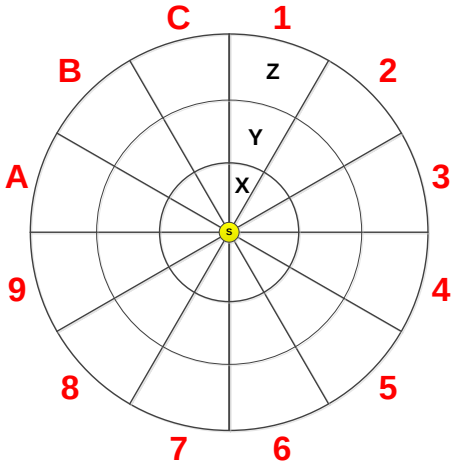
2.3 Rule 3: Make use of the 'reflex' zone as the first crown.

Accidents could evolve quickly without leaving enough time for the mobilization of the experts and decision makers and for a thorough evaluation of the expected consequences. In the meantime the population nearby the affected site could already be at risk and request precautionary actions.
To avoid this temporary lack of leadership the Belgian nuclear emergency plan has foreseen a so-called 'reflex' phase during which the local authority (the governor of the province hosting the nuclear site) is endorsed of informing the population, recommending them to shelter and to listen to the media.
These precautionary protective actions must be implemented within a circular area (the 'reflex' zone) up to a distance that has been calculated considering the source terms associated with selected quick kinetic scenarios. Around NPP's, the 'reflex' zone has been set to 3.5 km from each source point (i.e. the stack) and combined to consider one single 'reflex' perimeter for NPP. The final perimeter had also to be adapted to the local peculiarities of the terrain and urban tissue. The 'reflex' zone defined for rapid implementation of protective action in the case of accident leading to rapid and significant releases of radioactivity into the atmosphere does already exist will be used as the first crown of blocks closed to the nuclear site.



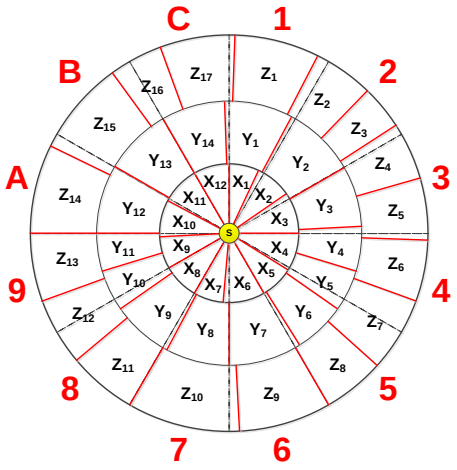
2.4 Rule 4: Intermediate crown(s)

The EPZ for sheltering and evacuation is 10 km around Belgian NPP's [Ref.1]. However, according to the evaluated risk, the intervention zone could less or extent beyond 10 km.
In order to be more flexible, but reasonable, an intermediate limit was decided, half way between the 'reflex' perimeter and the 10 km limit of the EPZ for sheltering and evacuation.
Beyond the limits of the EPZ, it was decided that entire administrative entities (i.e. communes) will be considered.



2.5 Rule 5: Numbering of the blocks

A numbering pattern is suggested to ensure coherency of denomination for all nuclear sites and to improve accordingly the common understanding among involved bodies and authorities.
Beyond the circular part of the keyhole, the planning zone is divided into several crowns. The circular part of the keyhole is coded 'S'; other crowns are coded from the most external one 'Z', 'Y', 'X' and further downwards if needed.
In each crown, blocks are identified by the letter of the crown and a sequential figure starting from '1' from the North (i.e. from sector 1). Depending on peculiarities there might be a different number of blocks than sectors; especially the outermost crowns will often have more blocks than sectors.



3 THE APPLICATION CONCEPT

The driving rules having been stated, they have to be applied to the geographical and sociological specificities of the terrain around the nuclear site. In other words, the cutting up of the "jigsaw puzzle" must consider among other items the soil use (namely the distribution of the habitat, industry, agriculture and forests), the administrative structure (limits of communes, province's …) and other landscape characteristics such as the presence of rivers. It is also essential that blocks are contiguous (no overlap) and that they stick as much as possible to the limits of the 12 sectors and crowns drawing a regular and continuous area were remedial actions will be taken.
In an iterative process, the concept was applied to the 10 km EPZ around the Tihange NPP leading to the final results presented in Fig. 3, agreed by and known to all stakeholders.

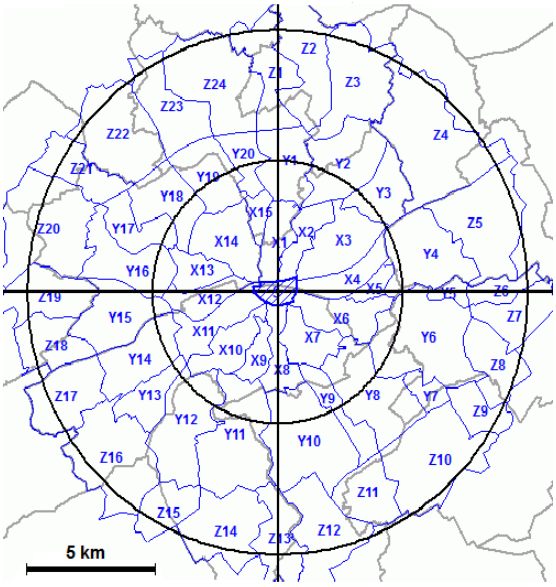


Fig. 3: Cutting up of the 10 km planning zone around the Tihange NPP.

4 THE SELECTION OF THE BLOCKS

Depending on the trace of the (potential) plume, the expected time integrated concentration in air (governing the doses and deposits) and according to the guidelines specific for a given protective action, the evaluation experts will determine the area 'at risk'. The evaluation cell generally ends up with a geometric area: an angle on both side of the average wind direction up to a certain distance from the source. The sizes of the angle and distance are defined in an ALARA process (justification and optimisation) to cope with the many uncertainties, especially in threatening situations, about the source term, the time and time length of the release (if any), the meteorological prognoses and the accuracy of the dispersion model used.
In a second step, using the cutting up of the planning zone, the evaluation experts will translate the sector for a given protective action into a list of blocks where actions are strongly recommended and blocks at the edges for the decision makers to decide whether they will include them or not (Fig.4).

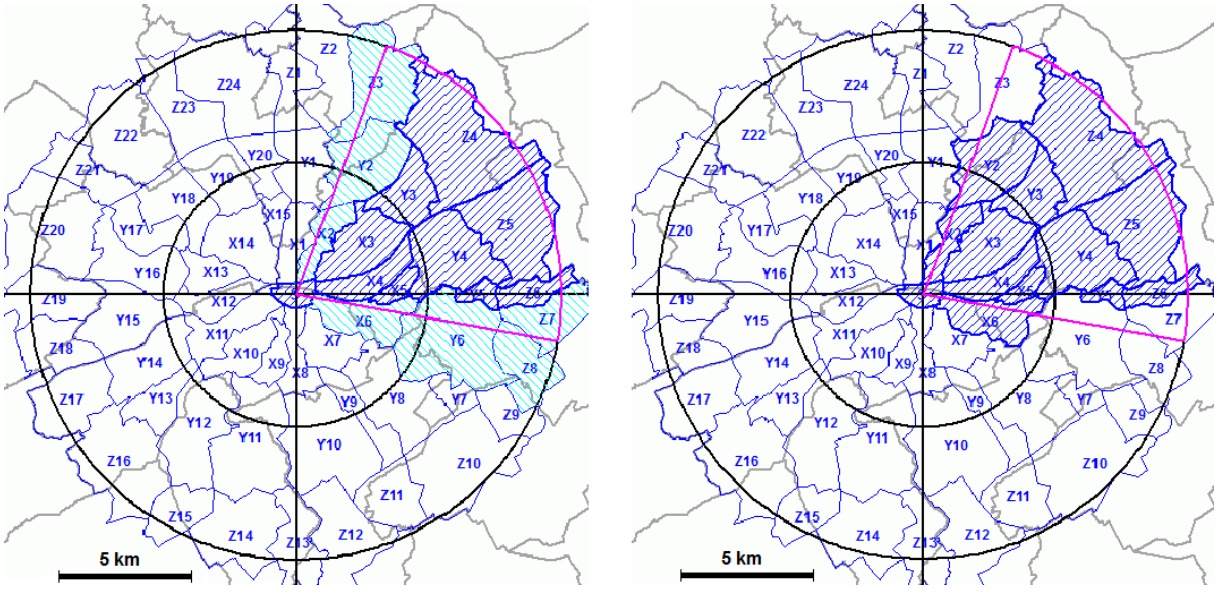


Fig. 4: Example of intervention area (left) proposed by experts and (right) decided by the decision makers.

Once the protective action areas are stated, the decision is conveyed to the local authorities and first responders for implementation. The decided areas are also communicated to the public and media.

5 TESTING THE CONCEPT IN EXERCISE

The yearly nuclear exercise conducted in 2011 with the Tihange NPP had as main objective the test of the cutting up concept. From the debriefing with the federal and local stakeholders the experience was very positive: the overall process of evaluation, recommendation, decision and communication to all interested groups was much more straightforward (less time consuming and less ambiguous) than it was in the past.

6 THE WAY FORWARD

The driving rules having been defined and applied in a case study to the planning zone around the Tihange NPP (Province of Liège), the concept has been presented to other provinces dealing with other nuclear site (East-Flanders and Antwerp for the Doel NPP, Antwerp for nuclear installations in Mol-Dessel, Hainaut for IRE and Namur for the Chooz NPP in France) for application to their own situation. Lessons learned at each step and for each nuclear site have been integrated step by step into the implementation process, recognizing the specificities of each site (urban around Tihange, industrial around Doel, forest and agricultural around Chooz …).
This on-going process is expected to be finalized in the beginning of next year for all Belgian nuclear sites.

7 REFERENCES

1. Royal Decree relative to the Nuclear and Radiological Emergency Plan for the Belgian Territory (dated 17 octobre 2003), Belgian Official Journal 20/11/2003.