Planning application tool—a risk assessment tool for non-specialists

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Abstract

This paper presents means by which risk assessment can be made available as a tool to people who are not specialists in risk analysis but who, in such roles as assessing and approving planning applications in the neighbourhood of hazardous installations, need the information available from a risk assessment in order to make balanced decisions. The method assumes that a risk assessment of the area has already been carried out for the existing situation and that the data from this analysis are available to the user. A comparison is made between 'manual' and computerised approaches. The methodology described has particular relevance to the situation in the Netherlands, but is capable of more general application. © 1998 Published by Elsevier Science B.V. All rights reserved.

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1. Introduction

In a legislative environment which has risk based land use criteria, those involved in land use planning need to be able to use the results of a risk analysis but generally they are not, and should not need to be, trained risk analysts.

Of all the factors to take into account in relation to land use planning decisions, quantified risk analysis is one of the most technologically complex. Items to consider include the risk that a new development will be exposed to neighbouring hazardous installations or transport routes and also the effect the existence of the development will have on the risk profile of the area as a whole. The skills required to calculate this information include elements of chemical engineering and reliability engineering as well as risk analysis techniques. For a non-specialist to derive this information unaided would be an impossible task.

However, if there is already a risk analysis of the existing area, all that is required is an update to the analysis to take account of the new development and, in particular the

additional population, coupled with some means of comparing the risk profile for the proposed situation with legislative criteria.

This paper addresses ways in which such an analysis can be carried out and, in particular, the data required and the part which maps can play.

2. Risk measures and acceptability criteria

One useful means of measuring the risk profile of an area is the '*FN* curve'. [1] This provides the best assessment of the relationship between the frequency and the severity of the range of incidents associated with a hazardous site. It is assumed that some kind of acceptability criterion exists—otherwise risk is irrelevant to the planning process. The normal way to represent such a criterion is as a line on the *FN* plot, with the implication that the curve should not penetrate above the line. The methodology being presented here assumes that an *FN* curve has already been generated for the region under consideration—and that the existing situation meets the criterion.

Adding more people to the population distribution around a hazardous installation will generally have the effect of raising the *FN* curve in some way. This may be because more people will now be killed by a particular accident (a greater N for a given F) or that accidents which previously killed nobody will now have the potential to kill groups of people of certain sizes (additional Fs for some values of N) or, more likely, some combination of the two effects. The information the planning officer needs is whether or not the proposed new population will push the *FN* curve into the unacceptable area.

One final risk consideration is that, in many legislative environments, new developments are not allowed in areas where the risk to the *individual* exceeds some set value. Individual risk is usually presented in the form of 'Risk Contours' [2] and a system which displays these contours on a map will show immediately those areas where new development may take place and where it is prohibited. The existence of risk contours is not essential for the methodology from the point of view of *FN* curve compliance, but if there is an individual risk criterion, it cannot be taken into account without some kind of risk contour plot.

3. Methodology

From the foregoing, it will be seen that a user needs to generate an *FN* curve based on the proposed development in order to compare it with the criterion. He may also wish to compare it with the *FN* curve for the existing situation as a 'reasonableness' check on the increase.

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[1] An *FN* curve is a plot of frequency vs. number of people killed, where, for a given point on the curve, the frequency is the frequency of an accident killing *N or more* people, i.e. it is a cumulative frequency curve. It is normally plotted on a log–log scale.

[2] A Risk Contour plot is a plot on a map showing lines of equal individual risk.

In order to generate an *FN* curve, the data required must include:
· the population distribution in the area,
· the location and strength of any ignition sources if any of the substances under consideration are flammable,
· frequency data by direction for the local meteorological conditions,
· sets of effect zones, such as cloud footprints or distances to a given heat radiation or blast level, for each accident scenario being considered—one set for each characteristic weather condition,
· the location of each accident scenario being considered, and
· the frequency of each accident scenario being considered.

In simple terms, each contribution to the *FN* curve is generated by overlaying an effect zone on the population distribution and determining the number of people killed. The frequency, *F*, is derived from:
· the frequency of the accident,
· the probability of occurrence of the particular weather condition and wind direction and,
· for flammable substances, the probability that the particular cloud will ignite.

The number killed, *N*, depends on: (a) for toxic materials, the probability that the concentration/time profile of the cloud will give rise to a fatal dose, expressed as the proportion of exposed population affected, and (b) for flammable materials, the probability that the thermal radiation or explosive effects will cause fatality, once again expressed as the proportion of exposed population affected.

Whilst each of these quantities is clearly defined and in many cases can be calculated directly, to carry out the huge number of calculations in a typical risk analysis without a computerised tool is clearly impractical.

The situation is not greatly improved if a risk analysis of the area already exists, because any effect zone impinging on the new development area will give rise to the need to recalculate that risk contribution. Furthermore, for most risk studies, the results are not presented in such a way that parts of them can be re-calculated and the revised contributions be included.

One approach to providing the planning officer with a means of assessing the new risk picture without excessive re-calculation has been derived by Ale et al. [1,2]. This method makes assumptions about the population density and the spacing of the risk contours and uses an empirical relationship between the group risk and individual risk results. Whilst it is a useful approach where local conditions meet the assumptions made reasonably well, it is inherently (and deliberately) conservative so that the resulting land use is likely to be sub-optimal. There will also be situations where the local conditions do not meet the assumptions particularly well and where the results will be correspondingly less accurate.

A more robust approach is to provide the planning officer with a computerised tool which is comparable in its technology to the tool used to generate the original study. This implies that the original study's results can be regenerated easily and, more importantly, new results reflecting the revised population can be produced equally easily. The user only needs access to the population distribution and need not concern himself with any other parts of the data.

The Planning Application Tool (PAT) has been produced to demonstrate just this concept. The user starts by supplying the data from the pre-existing studies to the Tool. If these studies have been carried out using the SAFETI package [3], the resulting data files can be imported directly. However, if other approaches have been used, the data can still be used because the formats of the required data are specified and the user can generate appropriate computer files directly using a text editor or a spreadsheet.

The data required by PAT are:

· *either* the set of release cases to be considered, *or* the corresponding sets of effect zones,
· the day time (working) and night time (residential) population distribution around the site (optional),
· day time and night time ignition source information (optional).

3.1. Release cases and effect zones

If the users has a set of already calculated effect zones, these can be used directly as long as they are put into the correct file format. If the user only has the physical characteristic of the releases themselves, such as the rates and durations of the discharges, these can be used and PAT will calculate the appropriate effects zones, using its own in-built consequence models.

If the user has a suitable file of effect zones then using these will ensure better comparability with previous results than recalculating them. However, effect zone data are typically fairly voluminous, and if the file is not already in the correct format, converting it may be an unreasonably time consuming task. The amount of data required to specify a release case requires, by contrast, just a few numbers and setting up a new file should be quite possible.

3.2. Meteorological data

As currently configured, PAT contains a database of meteorological data collected from weather stations around the Netherlands. Any Dutch site should, therefore, be able to use a suitable set of data. For more general use, a database of data from other parts of the world could easily be generated or PAT could be modified to accept a file of data as used by the pre-existing study.

3.3. Population data

Population data is clearly a key input to the kind of study being addressed and it would be normal for the pre-existing study to have some kind of file containing the population distribution for the area in question. However, if this should not be the case, PAT includes a database of the Dutch residential population, which can be used to set up the initial data before adding the proposed new development.

In broad terms the population will have two characteristic distributions, one for the working day and another representing the population being largely at home, i.e., at night. There are, of course, other variations, such as that representing the weekend, as

well as seasonal variations, but as currently configured, PAT expects just two distributions which will be combined to give the overall picture of the risk profile.

3.4. Ignition data

The presence and strength of ignition sources is clearly of importance when assessing the risks from an installation containing flammable material. If the pre-existing study has a file of such data, this can be supplied to PAT, but this is optional. However, unlike for population, there is no database of ignition sources supplied with PAT, so if the user does not supply such a file, no ignition sources will be included in the study. This shortcoming is offset, to some extent, by the fact that PAT regards areas of population as ignition sources.

3.5. Maps

Both population and ignition data are essentially geographical information and should be seen in relation to a suitable map of the area. PAT allows the user to specify a map, typically a 'bit map', from some suitable supplier of computerised maps. Once the scale and location of the map is specified, the population and ignition data will be displayed on top of it.

4. Calculations

Once the basic data has been established, PAT can be used to calculate the individual risk in the area under consideration. This is necessary if the individual risk criterion is to be taken into account. As currently configured, PAT will calculate the risk contour for a risk of fatality of 10^{-6} per year and display this on the map. The *FN* curve is also calculated as part of this process and can be viewed. It should be the same as the curve produced for the pre-existing study and a comparison with this will serve to check the integrity of the source data.

Now the user can start to modify the population distributions (both 'day' and 'night') by displaying the existing population and the risk contour on the display of the map and then drawing in the new areas and specifying the population densities within them. At any time a new *FN* curve can be generated and compared with the criterion line. The user can therefore try various configurations of new population and continue this process until he is satisfied that he has adequate information on the risk aspects of the new development.

5. Validity of results

This approach ensures that the results generated will have a rigorous basis which is comparable to the original study because the assumptions of the original study are preserved in the basic data and because the calculations are performed in full each time

without the need for simplifying assumptions. This in turn will ensure the validity of comparisons with acceptability criteria and with previous results.

6. Conclusions

This methodology demonstrates a flexible and rigorous means whereby the benefits of Quantified Risk Analysis can be made available to non-risk analysts in a way that is useful and meaningful. It allows informed and consistent decisions to be made in the area of land use planning so that optimal use of the land available can be made while keeping the risks to which the local population are exposed to an acceptable level.

Acknowledgements

References

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