

AN IMPROVED APPROACH TO OFFSHORE QRA

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QRA is now an established method used worldwide for the evaluation of risks on offshore installations. The technique is increasingly used as a tool throughout the planning phase and more closely integrated with the design processes. The scope of QRAs may also now be extended to cover other types of loss such as asset and environmental damage. However, there are many issues in the use of QRA which may challenge the value which such studies provide. These include;

- integration with the design process
- appropriate involvement of the operators and decision makers
- lack of consistency
- complexity of the overall model structure
- uncertainties
- lack of functionality
- likelihood of errors
- knowledge of analysts
- ability to update existing studies, and
- incorporation of new data and methodologies

Each of these issues present challenges to an efficient and effective approach. Some models may have been used for a long time and users may have become complacent - no longer striving to improve the model's accuracy or functionality. This paper looks at these issues and suggests steps which can be taken to achieve an improved approach.

KEYWORDS: Offshore, QRA, Safety Case

INTRODUCTION

Risk analyses have been actively used by the offshore industry in the North Sea for more than 25 years and are now established tools which are used worldwide. However, the requirements for Quantitative Risk Assessment (QRA) differ between different geographical areas and they may also have been modified with time as the technique has matured and legislative requirements have changed.

QRA has developed from primarily being a verification activity to being a tool which can be used throughout the planning and design process, although the extent to which this latter function is applied may vary between operators and within different parts of the world.

While the main focus of QRA historically has been to evaluate personnel risk, other outcomes such as environmental damage, asset damage and loss of production have lately been calculated/estimated.

This paper outlines the issues and shows what steps can be taken to revitalise the QRA method and move to a more effective approach. The development of offshore risk models has been used as an example but many of the issues are equally applicable to onshore studies.

CURRENT CHALLENGES IN OFFSHORE QRA

There are many challenges in the continual development of QRA models as a decision support tool. Issues include;

- consistency in models
- handling of uncertainties
- implementing improvements in model functionality
- knowledge of analysts
- effective presentation of results
- ability to update existing studies

Some of these issues have been described in detail [Gadd et al, 2003] and [Bain, 2003] but are summarised below.

DIVERSIFICATION OF APPROACHES

The seeds of problems in the current QRA modelling in the UK were possibly sewn in the early 1990's with the need to rapidly develop models to support Safety Case submissions. There was a conflict between the need to produce assessments quickly and the need for adequate accuracy and consistency. This speed of development made it difficult for the offshore oil and gas industry to evolve standard ways of tackling the various technical problems. Inevitably, different operators and different consultants adopted different approaches to each of these aspects. This has led to a multitude of model types.

Although the basis of QRA is straightforward, its implementation in a model with the capability of providing results to support decision making in the design process is complex. It involves many aspects of physical modelling each of which can have large uncertainties and there might be little consensus on the most appropriate methodology and computational tools to use. There are many different aspects to consider, each of which has a number of different approaches which could be followed. It is little wonder, therefore, that models created independently of each other have evolved in very different ways.

There were some views that QRAs should be created or customised to deal with specific installations or the specific requirements of a client. While there is some merit in this, the number and variety of solutions offered went beyond the need to meet these requirements and similar situations have been dealt with in entirely different ways. For example, assessment of fire hazards can be addressed by a variety of phenomenological models, empirically derived equations or simple rule sets. The same can be said of ignition modelling, release modelling and the structure of event tree risk calculations.

Even where there is consensus on an approach or set of data to use there may still be differences in how this is implemented. In the UK and most other counties, the UK HSE's hydrocarbon release database (HCRD) [HSE, 2007] is acknowledged by most practitioners as the best source of data on process release frequencies. However, different QRA providers will still interpret the result in different ways leading to different calculated risk levels.

MODEL COMPLEXITY

In many parts of the world, the impression has formed that QRA studies are simple commodity services which any competent practitioner can undertake with a high level of accuracy. In fact, the process of providing a QRA which produces meaningful answers is quite involved. There is an expectation that a simple QRA with a reduced set of input parameters can identify the difference in risk associated with different design or operational options but this often isn't the case. Ignition control is an example of a key safety systems and it is therefore often important to evaluate the effect of different measures and configurations as part of a QRA. In order to do so, it is necessary to simulate their effect in the model itself. Adopting a simplified model with generic ignition probabilities will not be able to differentiate between alternative strategies. In many parts of the world clients may express a desire for a simplified approach and while this is well motivated and has some benefits there are also some obvious disadvantages. In this market there is little incentive for a QRA service provider to invest in developing the tools they use in their analysis. The model is likely to be less accurate and less capable of being inspected to understand the drivers which lead to a particular risk level for a given hazardous event.

In Norway the trend is going in a slightly different direction with a stronger focus on detailed and complex models and where the customer often is very active in the risk analysis process.

INVOLVEMENT OF OPERATOR IN THE PROCESS

Few operators carry out QRA studies using their own safety departments. Typically they are contracted to an external consultancy. On occasions they may be further removed from the detail through other intermediaries, e.g. where the operator employs an engineering consultancy who contract a consultant to prepare a safety case who in turn rely on a separate group of providers to perform the QRA. This distancing makes it harder, both to reflect the operational aspects of the installation in the analysis and for the persons who are in a position to implement improvements to benefit from information and insights uncovered in the model. Typically, analysts carry out the work in an office and base their assumptions on the information provided by the client in the form of drawings, tables, information in the existing Safety Case and other documentation. Some of this information may be out of date but this may not be apparent. An analyst is not always afforded the opportunity to visit the platform and assess at first hand the effect a given hazard might have.

USE OF RESULTS

In the UK the main purpose of QRA has been to demonstrate compliance with tolerable risk criteria in the Safety Case legislation [HMSO, 2005]. Consequently, there was a focus on demonstrating that the criteria for Temporary Refuge Impairment Frequency (TRIF) and Individual Risk per Annum (IRPA) were met. A typical approach was to initially carry out the analysis using conservative assumptions and progressively refine the model as necessary to meet the acceptance criteria. When compliance with these criteria had been reached, the incentive to develop the analysis further declined.

There is still a requirement to demonstrate ALARP (As Low As Reasonably Practicable) and this puts further requirements on the QRA model. Simple models and approaches as described above are less likely to be able to support such processes in a satisfactorily manner.

The approach in Norway has been different; here QRAs have been more integrated with the design process and there has been more of a drive towards accuracy through the use of CFD modelling, and probabilistic tools, particularly for explosion analysis [NORSOK, 2001]. In the past, risk analyses were often carried out in isolation from the main design process and the overall planning. The findings of the QRA were not always effectively implemented because the best solutions were often identified late in the design process resulting in costly variations and compromises which could have been achieved more simply if these issues had been identified earlier. Experience in the use of the technique, changes in legislation, and some very costly incidents such as Alexander Kielland, Piper Alpha and the P36 disasters have influenced the use of QRA. Today it is a tool that is actively used throughout a project’s planning and design phase. It is used for decision support as well as to explore the safety implications of the choices being made. The QRA activities are closely integrated with the design processes and are in many respects considered as routine.

UPDATING OF EXISTING STUDIES

QRAs are normally intended to be “living” studies which can be updated to reflect changes in configuration and operation of the installation. Unless there are major changes in design or operation, there will normally be an expectation that risk levels will be within the tolerable criteria and therefore the motivation to carry out the work to a high degree of rigour and to develop more accurate approaches is lessened. The time available to update a QRA will normally be far less than for the original analysis and so the opportunity to modify it to include improved data and methodologies will be compromised.

Very often the analyst updating the study is different from the one who carried out the original work. The process of building up a detailed knowledge of the model may take days or even weeks. In such circumstances it may be necessary to accept that a complete understanding won’t be achieved. This will diminish the ability of the analyst to fully understand the interaction of the various parameters and hence the ability to identify the key safety critical parameters and remedial measures which could provide risk reductions.

Changes to the model may be made in a way which addresses the aims of the present study but they may be done in a less than robust manner which will be difficult to understand by others at a later date. It also increases the risk of inadvertently introducing errors into the model.

It is also likely that there will be a different person commissioning the study on behalf of the operator. It is therefore important that risk assessment reports are written in a way which clearly describes the status of the installation and the assumptions made. This will assist in identifying changes that have taken place in the intervening years.

Updates to QRAs are normally driven by technical or operational changes. Changes in analytical models and our knowledge of physical phenomena may, however, also necessitate modifications. In such cases it is important to analyse the effect of improved modelling and the effect related to changes in configuration and operation in separate stages. This allows the actual risk change to be evaluated as opposed to changes in calculated values which are purely the result of different methodologies. For example, in 1998 fire and explosion experiments performed by the Steel Construction Institute gave new knowledge to the industry regarding potential explosion risk. This resulted in the re-analysis of most platforms in the North Sea and changed the design parameters for many installations.

It is easy to see why a "vicious circle" might be set up whereby the value the client places on the model and the lessening ability of the QRA provider to maintain their understanding and make improvements leads to a decline in the overall quality of the model and further reduction in its value to the client - quite the opposite of what should be aimed for.

UNCERTAINTY IN RISK ANALYSIS

It is well known that uncertainties in risk and consequence assessments can be considerable. Furthermore, the accuracy of such studies will vary extensively with detailed analyses providing more accurate estimates than coarse assessments. A systematic way of managing uncertainties in risk estimates is particularly important when the accuracy of the results is critical, e.g. if probabilistic explosion results are to be used as the basis of the design of a blast wall, or if the results are close to an acceptance criterion. In structural engineering it is normal practice to reflect uncertainties through safety factors. Use of safety factors has not been normal practice in the area of risk assessments; instead a "best estimate" approach is the norm, while the nature and effect of uncertainties may be discussed but not quantified. It has become apparent that, because of the uncertainties in the analysis and the wide variety of approaches which can be taken, the results obtained by different QRA providers will differ significantly.

A risk analysis may, for example, be compared to a weather forecast. Based upon models and available data, one tries to say something about what can be expected. The accuracy of the weather forecast is dependant on analytical skills, available tools, quality of data and the degree of detail required. The uncertainty of a quantitative risk analysis will be related to aspects such as relevance and degree of detail of:

- Analytical models.
- Failure data (scarce or no data on equipment representing new technology).
- Engineering judgement (response assessment, human reliability etc.).

The uncertainties in even the most detailed risk assessment may be significant and the user of the results needs to be aware of this in making decisions based on them.

In general, all evaluations of risk in the analysis are sought to be "best estimates", i.e. no systematic conservatism (or optimism) is included in the evaluation. However, the assessment of issues where the uncertainty is significant tends to be on the conservative side in order to account for the uncertainty. In addition, sensitivity analysis is often performed to investigate which input parameters influence the results to the greatest extent. Here, the effect of a small change in an input parameter on the result is quantified. The results from these sensitivity analyses can then be used to focus more attention on evaluating the key parameters which influence risk.

AN IMPROVED APPROACH

A risk analysis by itself is of no value unless it is used as input to real decisions. The risk analysis must therefore focus on issues where it can identify practical improvements in design or operation. The analysis must be suitable for its purpose and this will impose several requirements on the analysis itself and how it is integrated in the decision process. In order to get more benefit from QRAs and hence an improved ability to identify cost effective safety improvements, a number of steps are suggested. These are discussed in turn.

INTEGRATION OF ANALYSIS IN THE DESIGN PROCESS AND CLIENT INVOLVEMENT

In order to achieve the goal, the risk analysis must be initiated earlier and be more integrated in the design process;

- Effective communication between the risk analysts and the design team is essential.
- The risk analysis process should be synchronised with the engineering activity.
- Finally, the QRA results need to be "translated" into engineering terms.

Many QRAs suffer from lack of client involvement. As a result, the quality of data based on subjective judgements will not be as high as it should be. The client's staff may be in the best place to provide both the factual data and judgements on the likely consequences of initial and escalated events. Similarly, the results of the analysis need to be fully understood by the client in order to correctly interpret them as an input to decision making.

The active use of QRA for decision support for the planning and design phases of a platform lifecycle poses several challenges to the risk analysts, the engineering team and the decision makers. QRA models are very abstract representations of the actual scenarios being modelled. Effective communication is essential, both to ensure a proper understanding of the design problems so that these can be effectively addressed in the QRA, and also to ensure that the QRA results are understood by the design team and decision makers.

Another important communication aspect is that the risk analysis process is synchronised with the engineering activity. It needs to provide the right information at the right time. As the design progresses, the level of detail in the design increases and the uncertainties reduce. The risk analysis needs to reflect this in order to address the key required decisions as the design progresses. It is therefore necessary to aim for a living QRA, i.e. a risk model of the platform that is updated and refined as required. Assumptions being made at an early stage to compensate for missing information need to be followed up and eventually replaced by factual information when available.

Finally, the QRA results need to be translated into engineering terms. Risk is measured in terms dictated by the risk acceptance criteria; PLL (Potential Loss of Life), FAR (Fatal Accident rate), etc. and risk reduction will typically be measured in terms of these. This is not relevant information for the engineering team. The requirements must be specified in terms of, for example, design capacities for explosion barriers or location of critical equipment. The risk analysis needs to be sufficiently detailed to address the effects of safety critical elements so that alternatives can be assessed. Consequently, the risk analysis needs to be closely integrated with detailed engineering studies.

A graphical representation of how the QRA views the platform layout and the hydrocarbon equipment may aid client involvement by providing a more convenient means of presenting data and results.

STANDARDISATION

The single most important aspect which places a barrier in the way of improvements in QRA is the lack of standardisation. With numerous variations of model to maintain, possibly a different one for each installation analysed, there is unlikely to be the opportunity to appreciably enhance a given model's capability within a given project budget.

There is a desire for consolidation but this conflicts with a desire to minimise the spend on a given study. Some improvements can be made as the model moves towards compatibility with a perceived best practice approach but this is a long and inefficient process which will take many iterations.

Some operators have come to recognise this problem and how it impairs their ability to compare risk levels between different installations. Some have decided to contract the provision of QRA services, at least within a geographical region, to a single provider who has been tasked with developing a consistent approach. Other operators are documenting their requirements for a standard approach which they require their QRA providers to follow. The Dutch government have, for example, specified one particular tool to be used for onshore QRA's One major operator is developing a standard tool for high level QRA to be applied to its installations worldwide. However, they will still rely on different providers for detailed QRA. These approaches have some clear benefit but is likely to still leave room for interpretation leading to different results from two analysts complying with the same requirements.

Some countries have sought to introduce standards to improve consistency but most have put the onus on operators to apply suitable techniques and engineering practices.

Standardisation of approach is almost essential for the long term development of QRAs. It will have the following advantages.

- More efficient development because cost can be spread over a number of projects.
- Greater accuracy because the model will be scrutinised by more analysts who can feedback information on errors and possible enhancements.
- Consistency of results between installations.
- Easier to justify the writing of user manuals and training material.

STRUCTURE

It is clear that appropriate data and methodologies are important in creating a successful QRA model. Less obvious is the need for an appropriate structure and its importance is generally underestimated. The clarity of how the model is operated and how the component parts interact with each other is essential for developing a good understanding of it. A complex intertwined model with little or no documentation will be difficult to understand. It will take a new user longer to understand than would otherwise be the case and is more likely to contain errors. It also makes updating the model harder and errors are more likely to be introduced when making changes to it. The more complex a structure becomes the more effort is required to change it into a simpler one which is easier to follow. The temptation to make changes using a “quick fix” is greater but this makes the model structure more difficult to follow for future users.

The size and complexity of a QRA model can vary considerably. At one end of the spectrum there are highly integrated models with automatic transfer of data between the component parts. At the other end, the study may consist of independent pieces of analysis where the part referred to as the QRA model itself consists only of the analytical structure for combining the results of the separate frequency and consequence analyses. Some elements of the overall QRA may be external programmes or calculations whereas the part regarded as the model itself will have a greater degree of connectivity. This is illustrated in figure 1. The greater the proportion of elements within the QRA boundary, the faster it is likely to be to process changes in data through to final results.

Models which require the manual transfer of data between one component and another are time consuming to operate. When a change to an item of data is made and the model has to be re-run the user may be faced with the time consuming task of re-running large parts of the model and having the tedious task of carrying out data transfer operations. Data transfer operation can include;

- Viewing data in the output from one model and typing it to the input of another.
- Cutting and pasting operations between spreadsheets.

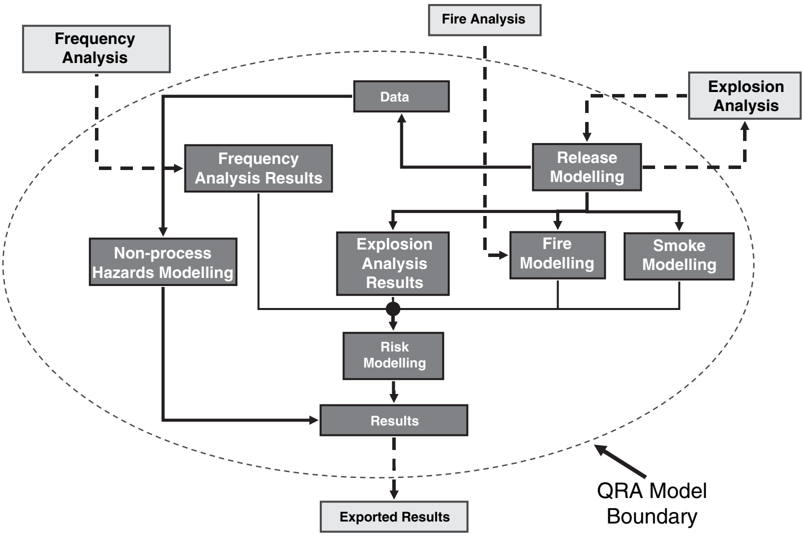

Figure 1. Internal and external components of a QRA model

- Linking of spreadsheet cells.
- Use of programming embedded in spreadsheets, e.g. visual basic macros, to manage the transfer between parts of the model.
- Automated transfer between models in toolkit type models.

One further type might be termed "operated adjusted data transfers" in which the analyst considers the output from one or more models and makes a judgement on the value to be entered into the next part. This might include situations where, for example, the size of a fire and the layout of the platform are considered together in order to make a subjective judgement on fatality rates in different areas. This has detrimental effects on the speed and consistency with which models can be run but this may be offset by allowing the analyst to take a fuller account of all the parameters which affect the results rather than being bound by prescriptive rule sets which may not always be appropriate. Figure 2 shows an example of a data transfer tool.

EVENT TREES

At the heart of the analysis of a given hazard in a QRA is some form of event tree. This may be represented in the classical format, in some variation presented graphically or as a series of calculations presented in tabular form. Generally, some form of diagrammatic form is preferable since it is easier to follow the logic when it is split into manageable steps

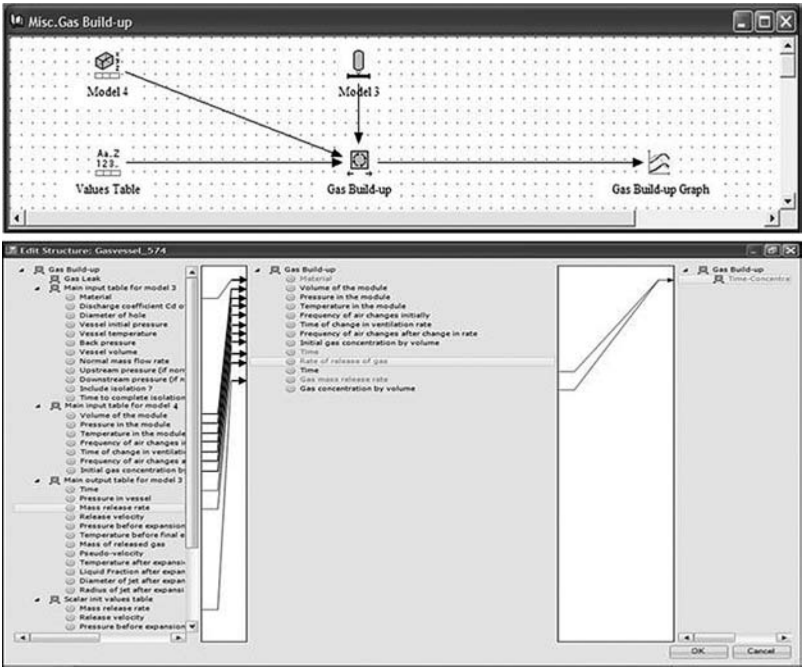

Figure 2. Example of data transfer tool in risk analysis software

rather than a complex equation which is difficult to understand. The complexity to which an event tree should be developed is a matter of opinion. The more parameters considered the more accurate and detailed the solution should be. This may be important in improving resolution for F-N curves, or in order to reflect the impact of different safety systems. However, the number of parameters which could be considered can be large leading to a very great number of end outcomes which have to be handled. However there are some techniques which can be employed to increase the number of parameters while still maintaining a relatively simple diagrammatic form.

One method is to combine branches at an intermediate point in the event tree where the remaining branch structures are the same. For example, consider the segment of an event tree shown in Figure 3.

A more advanced technique is the use of linked event trees where the end branch probabilities of the first become the top events for a second event tree which is then run iteratively to produce sets of end outcomes as illustrated in Figure 4. This approach reduces the overall event tree structure to a number of segments which are relatively easy to

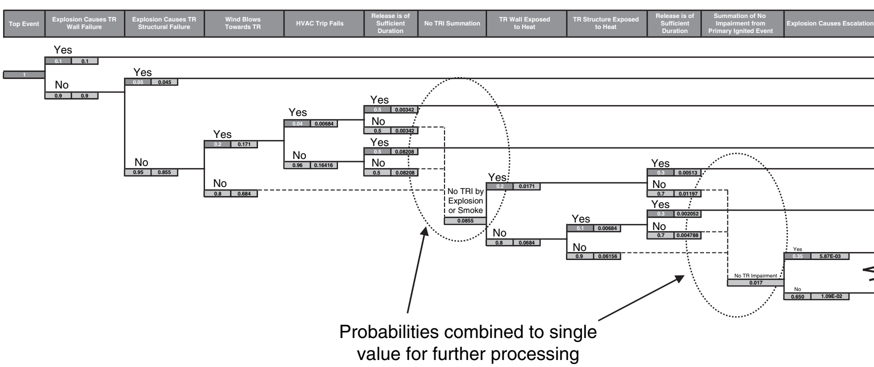

Figure 3. Combining of branches to reduce overall size of event tree

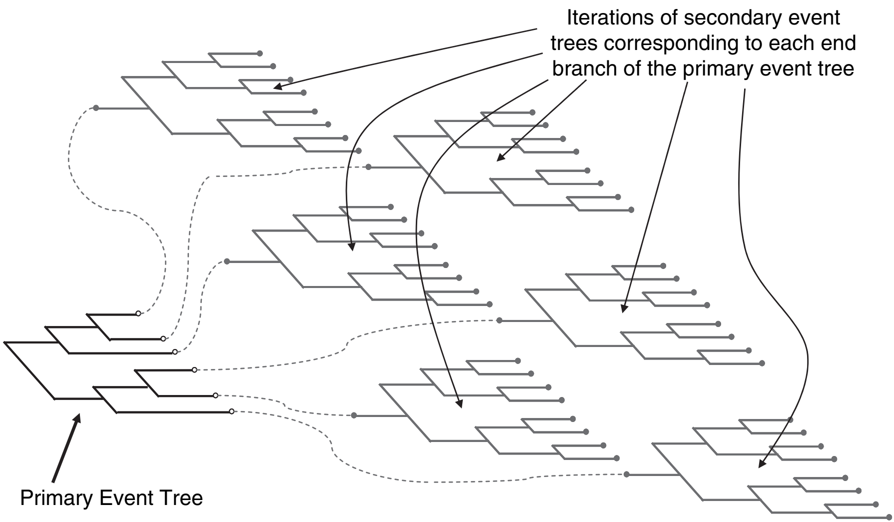

Figure 4. Linked primary and secondary event trees

understand but which combine to produce a very detailed structure addressing a large number of safety critical parameters.

LOCATION OF DATA

In a typical QRA, data is distributed throughout the structure and mixed with the analytical elements and results. Figure 5 shows this situation diagrammatically. This may not appear to be a problem but it creates difficulties when trying to continually develop a standardised approach.

In this situation it becomes almost impossible to maintain the consistency of the various models. Either the same methodology change has to be applied to all of the models or one model has to be upgraded, copied to provide a series of templates for the others and then data replaced.

The alternative approach which resolves this issue is to separate out the data from the analytical parts of the model. This situation is shown in Figure 6. This configuration allows for the same model to be used to analyse any number of data sets each representing a different platform or different variations of the same installation. It is now possible to modify the single model structure and in effect update all the QRA studies simultaneously. The user will still have to update the data as the configuration of the platform changes but this is a relatively simple task. Only if the methodology change requires the structure of the data file itself to be modified do the individual data files need to change and this will normally be a relatively short task.

METHODOLOGY

The use of an appropriate methodology is self evident, but what constitutes "appropriate" in this context may be a matter of opinion. "Appropriate" may not necessarily mean most accurate since this may involve the use of techniques which are expensive and time

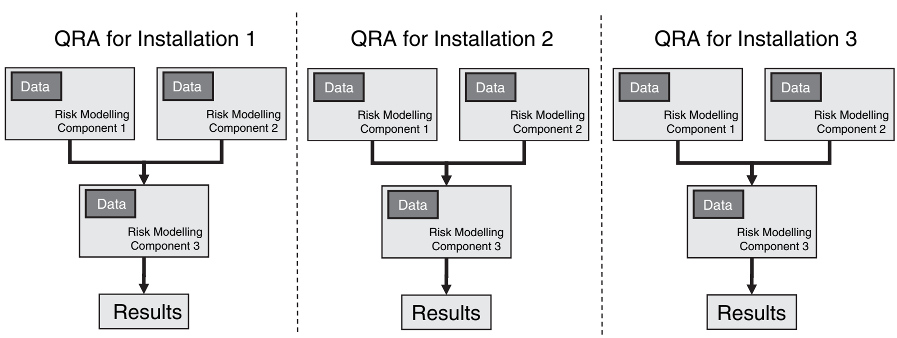

Figure 5. QRA models with embedded data in each component

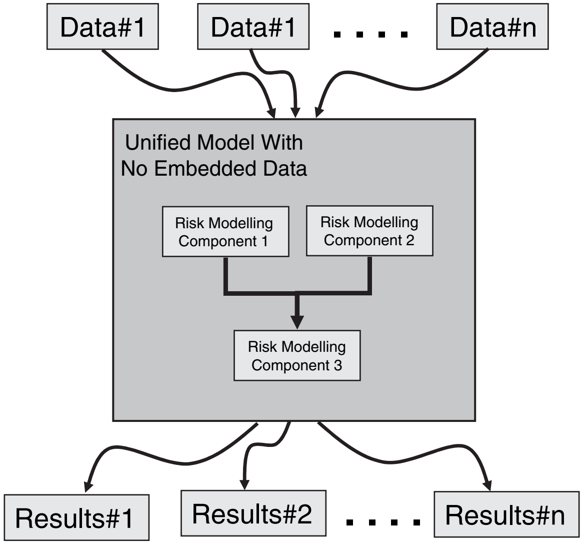

Figure 6. Installation specific data sets processed through a common model

consuming. Furthermore, the most detailed forms of dispersion, explosion and fire consequence analyses look in depth at a set of very specific scenarios relating to the location, rate, direction and composition of a hydrocarbon release, whereas a QRA has to consider the overall effects of all the possible combinations of these parameters. Detailed analyses will normally require specialised software outside the QRA model itself and so there will be issues of transferring the results in an appropriate manner into the overall analysis so that it can be combined with the frequency data in order to calculate risks. This is both time consuming and a potential source of errors. The main issue is however that the model must be suitable for its purpose meaning that the complexity of the model must reflect the level of detail required for supporting the related decision.

One possible way of getting the benefit of sophisticated software in QRA is to generate a set of results from it covering a wide range of typical scenarios and use this to construct a data set which can be accessed by the QRA. The data set would be part of the model and so could be readily accessed when required, as shown in Figure 7.

One simple example of this is the use of the lookup correlations for the "UKOOA" ignition model [Energy Institute, 2006]. These are a series of curves relating ignition probability to release rate for a number of typical scenarios. These curves were derived from a spreadsheet model which implemented the full methodology as described in the same report and which covers the development of the method. Whereas, the use of the full analysis requires the user to obtain and enter a significant amount of data relating to the

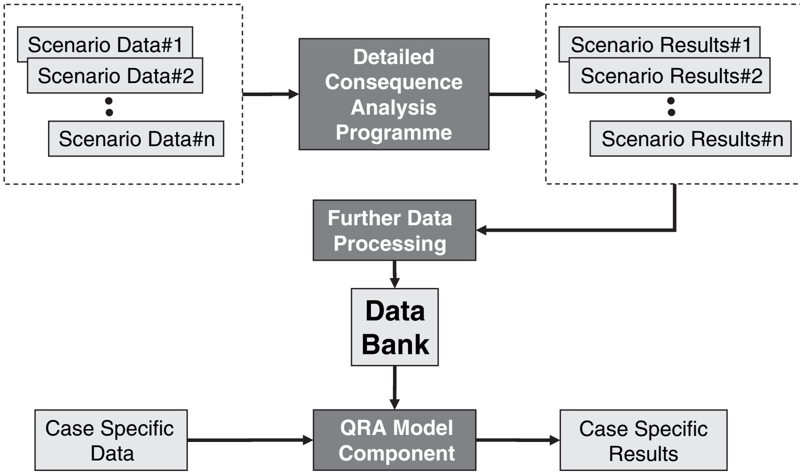

Figure 7. Use of detailed analysis to create data bank for subsequence input to QRA

installations configuration and ignition sources, the look-up version requires only the selection of the appropriate curve and the release rate, as shown in Figure 8 for typical examples.

A more complex application of this approach has been used by DNV Energy to make the detailed information available from the Computation Fluid Dynamic (CFD) modelling available in a simplified form within spreadsheet based QRA models.

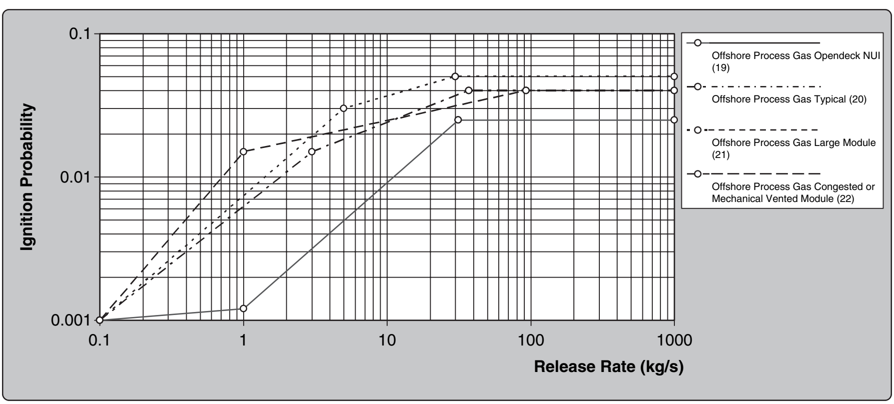

Figure 8. Look-up correlation curves from the UKOOA ignition model

METHODOLOGY OPTIONS

Generally the more complex the applied methodology the greater the amount of data it requires and the more time consuming it is to implement. In the early stages of an installation's design, much of this data may not be available and the analysts may have to rely to a greater extent on more approximate methods. For this reason it is convenient to provide a number of options for some of the key parts of the consequence analysis such as release, dispersion, explosion, fire, escalation and smoke ingress. In the early stages of the design the simpler less data intensive options can be chosen. In the later stages these are replaced with more detailed alternatives. The key here is to ensure that the outputs from the various alternatives are in the same form so that it can be passed on to the next stage of the analysis as indicated in Figure 9.

NSPECTABILITY

A typical QRA has to process a multitude of combinations in arriving at overall risk values. As a necessity the results have to be summarised for reporting purposes. However, this tends to hide the detail of the analysis and with it the information which describes the

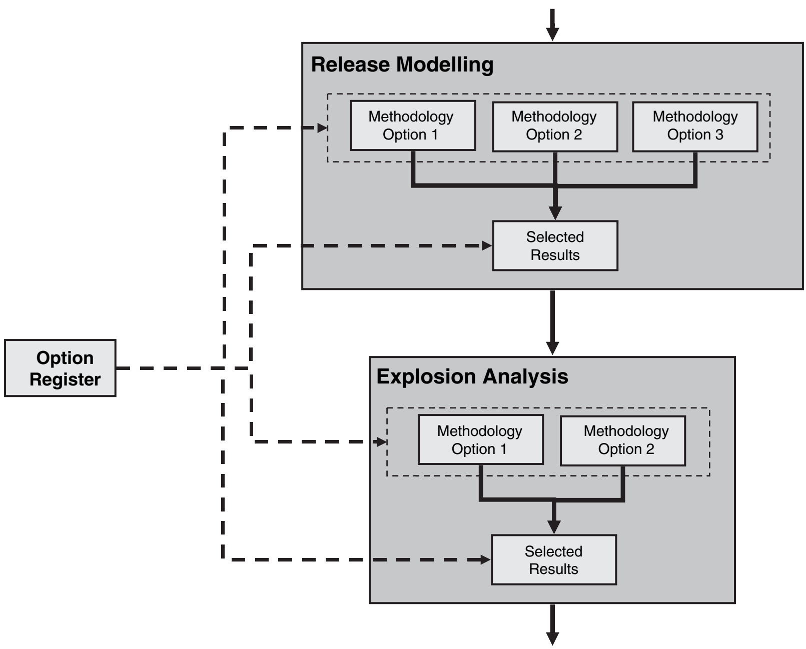

Figure 9. Consequence analysis with processing options

reasons for the contributions of the individual components. Without the ability to gain an understanding of these issues the QRA process loses much of its value since it is this detailed understanding of the safety critical parameters that may lead to the identification of risk reduction measures.

A good QRA will allow the analyst to access the detailed information in a convenient manner. One approach is to save all the intermediate data so that it can be referred to later. This, however, may lead to the model itself being excessively large. A more convenient approach is to arrange for the model to conduct the analysis in iterative loops in which only the results needed for later parts of the analysis are stored. When an event of interest is identified the user can cause the model to recalculate that particular scenario for inspection.

In one model used by DNV Energy the user is able to access a detailed event tree relating to the risks for a worker in;

- a given area when the release starts
- a given manning configuration
- a given isolation/blowdown failure combination
- a given ignition condition, and
- a given release size of
- a given hydrocarbon release scenario

This allows the analyst to view the progress of the calculation in detail. This may enable them to identify that some items of input data are inappropriate, and hence can be corrected, or to identify the significant safety critical parameters for the installation.

RESOLUTION/DEGREE OF DETAIL

The resolution to which a QRA model is constructed is important. In this context "resolution", sometimes referred to as "granularity", is the degree to which the various possible scenarios are treated independently. It is common, for example, to average the effect of release direction when determining the consequences for structures and workers in the various areas of a platform. One approach is to consider six broad directions (up, down, north, south, east and west), assign a failure probability or fatality rate for each direction but then to average these before moving on to the next stage in the analysis. The model does not calculate the number of fatalities which would be expected for a release in each of the directions but only the average. This does not affect the calculation of risk for the platform workers but it does make it more difficult to examine the model to gain an understanding of the impact of the hazard. Identifying why the fatality rate might be a certain value for a certain release direction may be apparent to the analyst but the origins of the average may be more obscure. Typically many more parameters such as manning density, explosion strength, HVAC (Heating, Ventilation, Air Conditioning) shutdown and the effect of weather conditions on evacuation fatality rates are all averaged. This means that when inspecting the flow of data through an event tree the analyst is looking at an average effect of many different parameters rather than a specific scenario which would be easier to evaluate.

Resolution is particularly important if the model is required to produce F-N curves. This is because while intermediate parameters can be averaged without making a difference to the overall risk measured by traditional parameters such as IRPA, FAR and PLL the distribution of f-N pairs is affected by the averaging process.

A fatality rate of 0.1 applied to an exposed population of 20 will result in an average of 2 fatalities. This might mean;

- that on each occasion 2 persons will be killed
- that on 90% of occasions everyone will survive but that everyone will be killed in the remaining 10%, or
- that 50% of the time 2 persons will be killed, 25% of the time 4 persons will be killed and 25% of the time that all will survive.

There is actually a spectrum of possibilities all covered by the same fatality rate. Each of these will result in the same contribution to personal risk but the f-N pairs generated are different and so the shape of the F-N curve will be changed. This means that the relatively few incidents which result in large numbers of fatalities can become diluted by the more numerous incidents where the number of fatalities are small or zero. This situation is illustrated in figure 10 which shows two curves from a hypothetical QRA. Both curves portray the risk distribution from a set of hazardous scenarios and have the same PLL. The difference is that some parameters have been averaged when arriving at the result depicted by the "Low Resolution" curve. This may make the difference between passing and failing an acceptance criterion especially if a risk aversion factor greater than unity is used.

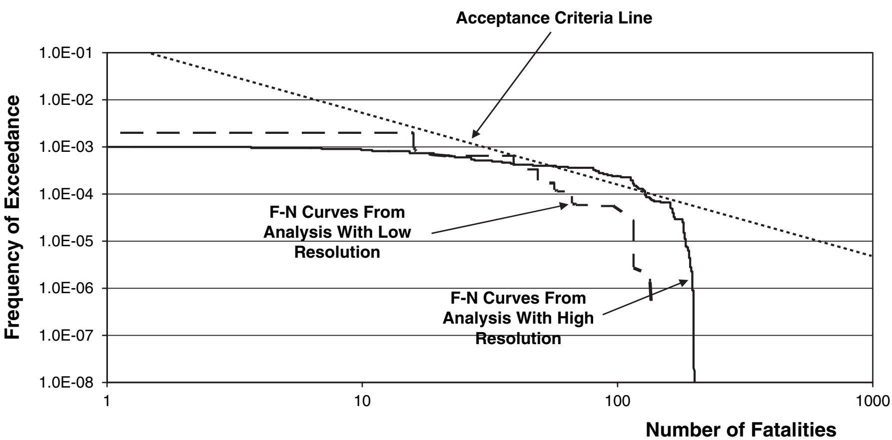

Figure 10. Variation in F-N curve output with resolution

Conversely, there is also a danger of making the QRA so complex that the user loses an overview of the situation. The complexity must be balanced with respect to the state of knowledge, availability of data etc. It may also be inappropriate to have detailed methodologies employed in one part of the model while other parts employ relatively simple techniques.

More complexity can be added but it then becomes increasingly important to implement it in a clear logical structure.

One way of dealing with this issue is to use a set of acceptance criteria measuring the risk for different groups of people in different ways. Achievement of a combination of criteria for maximum individual risk together with average risk for a group of people and F-N curves will give a better presentation of the risk than measuring only one of the criteria.

COMPETENCE

The above aspects focus on the structure and methodology of the model itself, but how it is used is also important. It may be possible to construct a model and make its operation so automatic that the role of the analyst is reduced to entering data, and initiating the run and transferring the results to a report. In these situations it can become easy to accept the results without spending the time to check that the model is adequately representing the frequency and consequences of the various risks or in deriving an understanding of the key drivers in the analysis.

The range of consequence analysis, techniques and mathematical operation in a QRA may be quite extensive and cover topics which the analyst will not have met in their education. In order to get the best value from a QRA the analysts have to be adequately trained in the various aspects of consequence analysis and the operation of the model being used. Although some university programmes on risk assessment exist, most analysts come from a more general engineering background so the obligation will tend to fall on QRA providers to educate their junior analysts through structured training and on the job experience combined with appropriate supervision.

ADDED VALUE

In most parts of the world, QRAs focus on the threat to human lives. While this should remain the primary focus it should be noted that many of the results can also form the basis of an analysis of other forms of loss, particularly environmental damage, asset damage and loss of production. Rather than studying these types of loss separately they can be combined into a single analysis which can evaluate the total risks resulting from the hazards present.

The QRA can provide results such as expected number of days of production loss per year and how this is distributed (many small stops or fewer larger ones) together with the expected amount and distribution of accidental oil spills. Results can be portrayed as an annual average or as frequency-cost curves. This can again be used as input to specific economic and environmental studies and to emergency planning.

CONCLUSIONS

Risk Analysis has been successfully used to support decisions relating to the safety of offshore installations. However, the benefits of using the technique may not always have utilised its full potential. This is partly because the creation and use of QRA models is a complex process which requires a great deal of effort to implement effectively and also because the diversity of methods has led to inconsistencies in output. Steps are therefore being taken to address these issues which should result in the technique delivering greater value as an input to engineering decision support with consequent benefits to cost effective safety, environmental and business risk management.

The key factors in creating an effective approach can be summarised as follows;

- Active involvement of the customer in the process and better synchronising between the analysis and the decision process.
- Standardisation of approach and methodologies
- Use of a clear structure which the analyst can understand
- Provision of a mechanism in the model to allow analysts to inspect the various scenarios to gain understanding of the key factors affecting risk.
- Provision of alternative methodologies appropriate to the stage in the design and the availability of data.
- Using appropriate higher degrees of resolution in the QRA.
- Striving to continually improve levels of competence among practitioners.

When implemented, the quality and consistency of results obtained should provide a better basis for decision making. The same approach should also deliver benefits in the field of onshore risk analysis.

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