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An Overview of Leading Software Tools for QRA

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ABSTRACT

This paper presents the findings of a comprehensive survey of software currently available for undertaking quantitative risk assessment (QRA) for onshore and offshore oil and gas facilities. The key requirement was that the software had to be available to users under licence, with full user support. From an initial list of over 80 tools, only a handful of software products were found that could undertake full QRA.

The paper sets out the criteria used to compare the software and lists the leading products. The paper also provides guidance to users on selecting an appropriate tool and discusses other options available to organisations, such as developing bespoke spreadsheet or software models.

KEYWORDS

Quantitative risk assessment (QRA)

Consequence modelling

Frequency analysis

Software products

1 INTRODUCTION

As part of a larger research project for a client, Risktec recently completed a comprehensive survey of software currently available for undertaking frequency, consequence and quantitative risk assessment (QRA) modelling for onshore and offshore oil and gas facilities. This paper presents the results of the survey, albeit generalised to remove any client-specific issues.

It is not the purpose of this paper to recommend specific software tools, but rather to set out what is currently available and provide some practical guidance to QRA practitioners on selecting an appropriate tool.

2 USE OF QRA

A QRA approach is justified for a project, facility or operation where there is a major HSE hazard potential, significant economic implications, and a variety of risk trade-off decisions that need to be made. The objectives of QRA studies are usually different for the various phases of a project life-cycle, but in all cases the main objective should be to reduce risk. QRA is only one of several inputs to the decision-making process, and must be balanced against other approaches such as engineering judgement and company values. Consequence modelling and frequency assessment can also each be used effectively on their own, without a full QRA study, to guide engineering solutions, safety system design and emergency planning arrangements.

Most experienced organisations consider the best use of QRA to be in support of decision-making, in particular comparing options during the design phase, and in the demonstration of ALARP. It should not be used solely for the estimation of absolute risk levels for comparison with quantitative criteria due to possible manipulation of data, methods and assumptions.

So the key question is: what software tools are available to help organisations conduct QRA?

3 SCOPE OF RESEARCH

The key requirement of the research project was that the software had to be available to users under licence, with full user support. This immediately removed from the search any 'in-house' tools developed by companies and consultants.

The tools were categorised as:

- QRA
- Physical effects (consequence) modelling
- Frequency analysis

Excluded from the scope were tools specifically designed for:

- Project risk analysis (e.g. Active Risk Manager)
- Maintainability analysis (e.g. RCM Toolkit)
- Structural response analysis (e.g. ANSYS, DYNA-3D, USFOS)
- Evacuation models (e.g. EXODUS, EGRESS)
- Human factors analysis (e.g. HEART)

4 RESEARCH METHOD

An initial list of over 80 software tools was identified by searching the internet and visiting the websites of the software providers. Information was documented for each tool on three key aspects: scope (i.e. scientific content), validation status of the model and user-related aspects.

From this list, a subset of 'leading' software providers was selected based on criteria including: user base, validation of the software model, ease of use and resources required, quality of product support, and continuous improvement. A total of 18 consequence, 16 frequency and 6 QRA leading tools were selected for further scrutiny.

An initial desktop assessment was then made of each of these leading tools to determine whether the tool is able to conduct the range of calculations required for a full QRA without the need for other, separate, 'off-line' calculations. Over 80 calculation requirements were reviewed, covering:

- Risk measures
- Risk presentation
- Physical effects modelling
- Impact, vulnerability, escalation modelling
- Frequency modelling
- Cost-benefit analysis
- Sensitivity and uncertainty analysis
- Hydrocarbon and non-hydrocarbon hazards

This initial assessment was made based on information readily and publicly available from the software websites, supplemented in some cases by previous experience of using the tools.

The initial assessment was then issued to the providers to correct any errors or misunderstandings and provide more specific details on any limitations of the tool. A brief questionnaire was also issued to give the providers the opportunity to fully represent their software; 60% of providers responded.

Face-to-face demonstrations of leading QRA models (NEPTUNE, SAFETI and SHEPHERD DESKTOP) were provided by the software suppliers to confirm details of their functionality. These included their consequence models PHAST and FRED.

5 LEADING SOFTWARE TOOLS

The leading consequence, frequency and QRA tools are shown in Figure 1. The list does not claim to be exhaustive, but is considered to be representative of the most commonly used tools.

Figure 1 – Leading Software Tools

SOFTWARE		PROVIDER
AERMOD/ISC PRO	C	TRINITY
AUTOREAGAS	C	Century Dynamics
BLOWFAM	F	Scandpower
CAFTA	F	SAIC
CANARY	C	QUEST
CAPTREE	F	CAB
CARA	F	Sydvest
CEBAM	C	ACE
CIRRUS	C	BP
COLLIDE	F	CorrOcean
CRASH	F	DNV
DAMAGE	C	TNO
DDMT	F	RMRI
EFFECTS	C	TNO
FAULT TREE AND EVENT TREE	F	RELEX
FAULT TREE+	F	ISOGRAPH
FAULTREASE	F	ICF
FIREX	C	Scandpower
FLACS	C	GEXCON
FRED	C	Shell Global Solutions
FT PROFESSIONAL	F	RELCON
HAZ FIRE/EXPLOSION	C	TRINITY
HAZ PROFESSIONAL	C	TRINITY
KAMELEON FIREX	C	CIT
LEAK	F	DNV
LOGAN F&ETA	F	RM Consultants
NEPTUNE	Q	DNV
OILMAP	C	ASA
OSIS	C	ASA
PHAST	C	DNV
PLATO	Q	ERM
PSA PROFESSIONAL	F	RELCON
RISKCURVES	Q	TNO
RISKMAN	F	PLG
RISKPLOT GRAPHIC	Q	ERM
RISKSPECTRUM	F	RELCON
SAFETI	Q	DNV
SAPHIRE	F	BBWI
SCOPE	C	Shell Global Solutions
SHEPHERD	F	Shell Global Solutions
TRACE	C	Safer Systems

C = Consequence modelling
F = Frequency assessment
Q = Quantitative risk assessment

6 KEY FINDINGS – CONSEQUENCE MODELLING

There is no single "best" tool that solves all problems. What is important is the selection of the appropriate tool for the specific situation being modelled, i.e. the tool should be proportionate to the magnitude of the hazard, as illustrated in Figure 2.

Figure 2 – Leading Consequence Tools

Increasing level of accuracy and time, cost & resource →

EMPIRICAL MODELS	PHENOMENO-LOGICAL MODELS	CFD MODELS
FRED PHAST TRACE CIRRUS EFFECTS CANARY HAZ PROF	SCOPE	KAMELEON/ KAMELEON FIREX FLACS AUTOREAGAS CEBAM EXSIM**
Release, fire, explosion and gas dispersion	Confined/vented explosions	KAMELEON models dispersion/fire, others model explosion
Fairly simple, robust, used as screening tools to provide rapid indication of physical effects	**Greater accuracy than empirical models but less than CFD**	**Appropriate for design decisions for offshore & congested onshore explosion modelling**

There is no single "best" tool that solves all problems

There are several well used, accepted and generally similar empirical/physically based computational suites for dispersion, fire and explosion modelling. Referred to as "screening tools", they often use exactly the same equations, e.g. Chamberlain jet fire, TNO explosion, etc.

For offshore explosion modelling, in general, as it is the near field that is of interest, results are strongly influenced by obstacles or confinement, and so sophisticated CFD tools are often more appropriate.

Onshore it is the far field that is generally of most interest, so scaling/correlation models can be fit for purpose, e.g. TNT, TNO, CAM, Baker, etc. which are included in the screening tools. CFD may be required for very congested plant areas.

The SCOPE phenomenological tool provides a greater degree of accuracy than scaling models but less than that provided by CFD (with less time and cost).

Whichever tool is selected it needs to be applied with plausible, yet appropriately conservative assumptions for method and input data.

Where ambiguity exists for particularly problematic or highly sensitive issues, the more effective approach may be to compare results from, for example, the two main alternative methods. This would provide a view of the relative extent to which the two alternatives may over- or under-predict the possible actual consequences.

While scale models, e.g. wind tunnel testing, were not within the scope of the study, they should not be forgotten. Although they can be slow to set up, they can be cost-effective, for example to provide detailed information on the global flow, dispersion and fluctuations of smoke and gas around an entire offshore structure, to determine the impact on the TR habitability.

7 KEY FINDINGS – FREQUENCY ANALYSIS

Frequency assessment tools may be sub-divided into those which provide either fault tree or event tree modelling or those which carry out both. The leading frequency analysis tools are illustrated in Figure 3.

Figure 3 – Leading Frequency Tools

FAULT TREE ONLY	EVENT TREE ONLY	FAULT & EVENT TREE
FT PROFESSIONAL CABTREE FAULTREASE	RISKMAN DDMT	CARA FAULT TREE+ PSA PROF RISKSPECTRUM FAULT TREE & EVENT TREE LOGAN F&ETA SAPHIRE CAFTA

The powerful fault tree and event tree tools were created for analysing complex safeguard systems, for example, nuclear power plant where multiple redundancy and diversity exists. Oil and gas industry applications tend to be less demanding and often use simpler tools or spreadsheets, though occasionally these powerful tools are used.

Use of the tools tends to be in line with their country of origin, e.g. UK, Norway and USA.

None of the tools are integrated with consequence tools.

There are some predictive database models for blowouts, process leaks and ship collisions, but none for personnel transportation, as illustrated in Figure 4.

Figure 4 – Hazardous Event Frequency Tools

BLOWOUT FREQUENCY MODELLING	LEAK FREQUENCY MODELLING	SHIP COLLISION MODELLING
BLOWFAM	LEAK	COLLIDE CRASH

8 KEY FINDINGS – QRA

What is clear is that there is no single "best" tool designed for both offshore and onshore QRA. However, a handful of products stand out as technical leaders, see Figure 5.

Figure 5 – Leading QRA Tools

OFFSHORE QRA	ONSHORE QRA – "INTEGRATED" note 5	ONSHORE QRA – "NON-INTEGRATED"
NEPTUNE note 1 PLATO note 2	SAFETI note 3 SHEPHERD note 4	RISKCURVES + EFFECTS + DAMAGE RISKPLOT

Notes

1) 'Computational workbench' linking modules to MS Excel/ VBA

2) Concentrates on escalation of fire and explosion events taking account of geometry

3) Incorporates PHAST physical effects tool

4) FRED physical effects tool is part of suite but user is not constrained to using it

5) "Integrated" means that most calculations are done "on-line" within software rather than "off-line" by other tools. SAFETI is arguably more integrated than SHEPHERD

All of the QRA tools tend to concentrate on determining risks for sites/installations. There are no commercially available tools for "coarse" QRA of offshore facilities to compare different options at the concept selection stage, though some consultants have developed in-house models.

Offshore and onshore QRA tools tend to be packaged separately, reflecting the different characteristics that need to be modelled, e.g. offshore evacuation, or onshore far field impact on the public.

Onshore is better served and software products are generally well used and accepted, arguably because onshore risks are simpler to model. Non-hydrocarbon or chemical risks (e.g. transport) still need to be quantified "off-line", though they tend to be less critical onshore than offshore.

There is no single fully "integrated" offshore tool, where the term "integrated" is used to mean that all necessary calculations are done "on-line" within the software model rather than having to be done by other external tools. In practice, most companies develop bespoke, installation-specific, linked spreadsheet models.

In practice, most companies develop bespoke, installation-specific spreadsheet models for their offshore facilities

9 SOFTWARE QRA TOOL OR SPREADSHEET?

The advantages and disadvantages of integrated software tools for QRA compared to spreadsheet approaches are outlined in Figure 6.

Figure 6 – Integrated QRA Models versus Spreadsheet Models

INTEGRATED QRA MODELS

Advantages	Disadvantages
• Inclusion of many models in a common computing environment • Models validated against experiment • Software quality assured by supplier • Technical support from software supplier • Available "off-the-shelf" enabling early start of work • Recognised and generally accepted within the industry	• Difficulty of use and understanding – onerous user training and familiarity requirements (but decent results require complex modelling) • Lack of control and flexibility – user unable to modify software (can be an advantage) • Lack of transparency – hidden assumptions and calculation methods, "black box" (requires high quality technical user manual) • High initial and ongoing costs (licences)

SPREADSHEET MODELS

Advantages	Disadvantages
• Relatively easy to understand • Lower user training requirements and easier user familiarisation • Good spreadsheet models provide transparent calculations and assumptions • Better control – user able to develop spreadsheet model to level of detail required (flexibility of calculation and presentation) • Lower external cost (but man-hour time can be expensive)	• Prone to errors by the analyst • Can be personal to analyst and difficult to update by others without errors (requires careful QA) • Macro programming can be difficult to check • More time consuming to demonstrate validation • Perception – less sophisticated (when reverse is often true)

10 SOFTWARE QRA TOOL OR BESPOKE SOFTWARE DEVELOPMENT?

Larger organisations with multiple facilities who want a flexible but more robust approach than one-off spreadsheets, have an alternative cost-effective option: to develop their own bespoke model making use of Microsoft.NET and/or ActiveX technology.

The upfront development cost is likely to be no greater than a perpetual multi-user licence and, if the organisation has a clear view of the technical and user requirements for the tool, this option will provide far greater flexibility in modelling the risk issues specific to the organisation.

11 KEY SELECTION CRITERIA

Key factors to consider when selecting QRA software include:

Scope – what exactly do you want to model and in how much detail? Can the software meet your requirements or will you be overwhelmed by the functionality?

Repeatability and transparency – are the methods, rule sets and data visible and traceable?

Cost – how much will licences, training, in-house time and external consultants cost over the long-run?

Integration – how easy will it be to integrate the processes for managing the software and assessments into your company's management system?

Remember; don't be fooled by good looks. Users want flexibility and transparency in methods, rule sets and data.

12 CONCLUSION

Physical effects modelling is quite well served, as is frequency analysis, but users need to consider very carefully their requirements before selecting specific software for QRA. The choice is limited and there is plenty of scope for improvement in the software currently on the market.

For onshore facilities, often using one of the available QRA products is the best way to proceed. But the complexities of modelling offshore risks mean that most organisations develop their own spreadsheet models to utilise the methods, assumptions and data they understand to an appropriate level of detail.

Organisations with multiple facilities who want a flexible but more robust approach than spreadsheets, have an alternative cost-effective option: to develop their own bespoke model making use of Microsoft.NET and/or ActiveX technology.