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Moving Beyond Compliance - The role of risk tools in improved operational performance

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ABSTRACT

The management of risks associated with the process industry has traditionally focused on safe operation rather than improved financial performance or increased productivity. With major advances in Information and Communication Technology (ICT) over recent years and the maturing technology used for software tools and related models, the emphasis is now moving beyond straight-forward compliance with safety legislation. In recent years, with greater global competition and much more challenging margins, the business environment has changed. It is now more difficult to justify activities that do not contribute directly to the bottom line, or are perceived as such. ICT advances, along with growth in Internet technology, have brought a highly connected environment where corporations can share information and collaborate globally. Combined with this is a need for corporations to be more transparent in their corporate governance and demonstrate their performance in relation to the environment and society as well as financially.

The combination of ICT advances with the maturity of models used for QRA and related technologies means that the move from compliance based systems to performance based risk management or Risk Based Operations is now possible and desirable. By linking QRA technology with other enterprise applications such as Enterprise Resource Planning (ERP) and Enterprises Asset Management (EAM) systems, company wide risk based performance management systems become possible. This paper reviews the history of QRA software in this context, assesses how much of the technology developed over the last 20 years for safety management can be integrated with mainstream information systems and applied to improving and managing operations. It goes on to look at the state-of-the-art with regard to risk based operational management and to discuss how latest technology in terms of risk modelling, information management software and ICT can be used to improve operational performance.

2 INTRODUCTION

Traditional risk assessment for process plants is most often driven by the needs for compliance with regulations such as the SEVESO II directives in Europe and the EPA Risk Management Plan regulations in the US[1]. Many operators will set their own, more stringent, standards for safety which will impact on the risk assessments but in the main these assessments are done in specialist departments outside of the day-to-day operations management. Formal risk assessments like a Quantitative Risk Assessment (QRA) for regulatory compliance will only be amended when there is a plant modification or a periodic update is required by regulators. Many of the methodologies used today are based on technology developed twenty to thirty years ago. In that same time span the developments in Information and Communication Technology (ICT) have been significant. Processor speeds have advanced massively, PC's have been introduced and are the primary platform for many engineers, network technology has advanced, along with email and many more technologies.

The combination of these ICT advances with the maturity of models for QRA and related technologies means that the move from pure compliance based systems to operational systems utilising risk methodologies or Risk Based Operations is now possible and desirable. When quantifying risks these need not be only those that result in fatalities, as in traditional QRA, but also effects on the environment, downtime or dollars and other potential losses. Also, these technologies can be linked with other enterprise wide applications such as Enterprise Resource Planning (ERP) and Enterprises Asset Management (EAM) systems to provide a company wide risk based performance management system, providing real-time information on the operational and financial impacts of decisions on safety and risk. By quantifying the impact of process hazards on business operations and with the use of real-time information on the status of operations, managers can assess the likely impacts of decisions on safety and business risks and thereby proactively manage the operational risk that the business is exposed to on a day-to-day basis.

3 HISTORICAL EVOLUTION OF QRA TOOLS

QRA in the context of process plant safety provides a methodology for quantifying the risks associated with the activities involved in the production and processing of chemicals and petrochemicals. In order to quantify risks it is necessary to first identify all possible risk situations, quantify them in terms of event consequence and likelihood and compare them with acceptance criteria. The main questions to be answered by a QRA are what can go wrong, what are the potential effects if it does go wrong, how often will it go wrong and is it important. Or, in QRA terms, identify the hazards, analyse the consequence, estimate the likelihood, combine consequence and likelihood to quantify the risks and put measures in place to mitigate and manage those risks. The key objectives of any QRA are to identify the major hazards, quantify the overall risk, optimise the risk reduction measures to be implemented and to help the decision making process with regard to acceptable risk criteria.

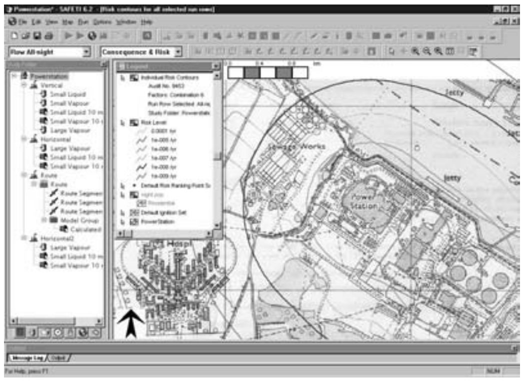

Figure 1 – Typical Individual Risk Contours displayed using SAFETI

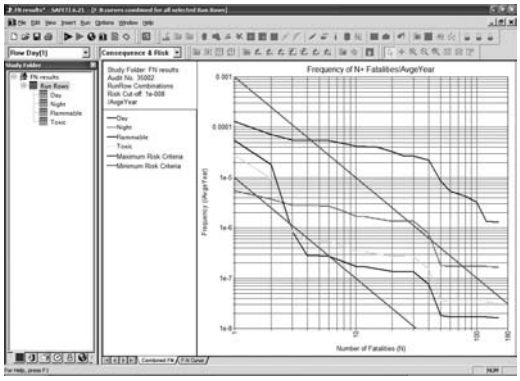

Figure 2 – Typical FN Curves for Societal Risk displayed using SAFETI

Typical outputs of a QRA study are individual risk contours as illustrated in Figure 1 and the FN curve for representation of societal risk as illustrated in Figure 2. Individual risk can be defined as "the frequency at which an individual may be expected to sustain a level of harm from the realisation of specified hazards" and is usually taken to be the risk of death expressed as a risk per year. Societal Risk is defined as "the relationship between the frequency and the number of people suffering a given level of harm from the realisation of specified hazards". It is normally taken to refer to the risk of death expressed as a risk per year and displayed as FN curves.
The first commercially available software tools for Process QRA[2] were developed in the early 1980's. The key drivers at this time were a number of major accidents, like Flixborough and Seveso, and later Bhopal. These resulted in legislation being implemented in a number of countries, particularly the Netherlands, which made QRA obligatory to ensure risks of further major accidents were minimised applying acceptable risk criteria and principles of ALARP[3].
At that time, the techniques and methodologies developed to enable large scale QRA to be performed challenged the computing power available. This limited the possibilities and meant

that the software architecture had to be carefully designed to enable the necessary calculations to be made within the IT limitations of that time.

Since then ICT has developed rapidly and continuously[4] and the last 20 years has seen massive advances in the technology available. However, the methodologies used in performing QRA have generally remained relatively static. Although individual components of the QRA have improved in-terms of both modelling accuracy and speed of operation, the underlying architecture still largely supports the classical risk analysis methodology illustrated in Figure 3. These analyses are usually performed with single-user PC applications, which are not connected to the larger ERP or EAM systems, by an experienced risk analyst, with updates being infrequent and driven by legislation or changes to the plant or process.

These static analyses are extremely valuable to a business and studies built in tools like SAFETI[3] represent significant investment and intellectual capital and knowledge regarding the risks associated with the process plant. But there are limitations to this approach. For example, domino effects or escalation is difficult to account for using the classical approach, which is largely a series of sequential calculations or summations and assumes that hazardous events are independent of each other. However, such a model can be extended to look at other potential losses from process hazards as well as those to people[5,6].

The data collection requirements when performing QRA are extremely labour intensive. Historically data has been collected manually and is often stored in databases which are essentially standalone and non-generic. Although technologies like Computer Aided Design (CAD), Enterprise Asset Management (EAM) and Computerised Maintenance Management Systems (CMMS) contain much of the data required for a QRA study links, where they exist, are rudimentary and largely unintelligent. Because of this, data re-use has been difficult and thus limited. Plant data may have been acquired in a number of separate places for process design, process simulation, maintenance management, inspection planning and QRA. If this were available within a data warehouse, like Intergraph's SmartPlant Foundation[7] for example, providing facilities and procedures for change management could be comparatively straight forward. Much of these data are just as applicable during the operational phase of a plant life-cycle as they are to earlier phases like design and construction.

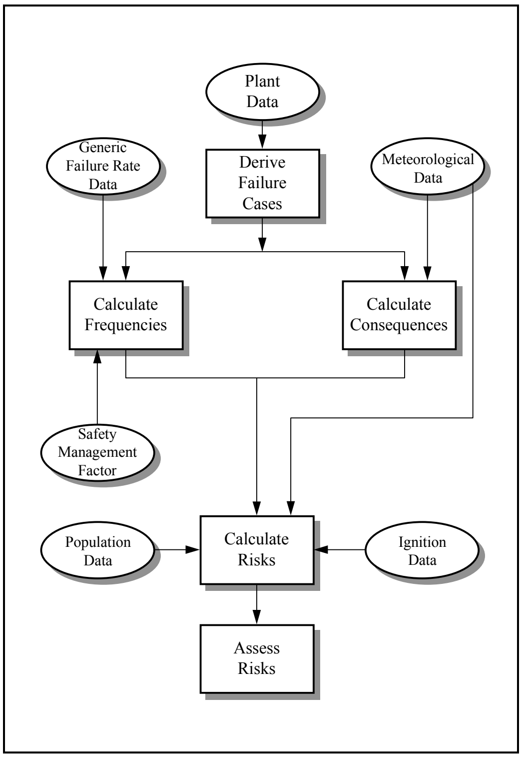

Figure 3 – Classical risk analysis methodology

The advent of the PC and other developments in ICT have revolutionised business work processes. When QRA software was first developed it was typically installed on a central computer connected to a number of workstations or 'dumb' terminals. Now it is most commonly installed and run on local PCs. Calculations that might have taken days to run on a mainframe 20 years ago can now be run quickly on a PC. Software now uses advanced graphical user interfaces enabling input data and results to be manipulated and presented in a far more visual way as illustrated in Figures 1 and 2.

Handling data using ICT has developed substantially over the last 20 years. State-of-the-art approaches to managing data within an organization now involve enterprise-wide systems with integrated financial, personnel and production software applications. They either handle the data within an application from one vendor or, more commonly, make use of a number of applications that are interfaced so that they can share data. These developments have had a dramatic effect on the way data are used and shared. The data have a value to the organisation in proportion to the extent it can be distributed, shared and re-used.

The synergy with advances in network and internet technology makes enterprise-wide data sharing possible, adding enormous value to knowledge based organisations. From the perspective of risk information, these developments make it possible to re-use this in other parts of the organisation and with potential for direct relevance, and benefits, to operational phases of the plant life-cycle.

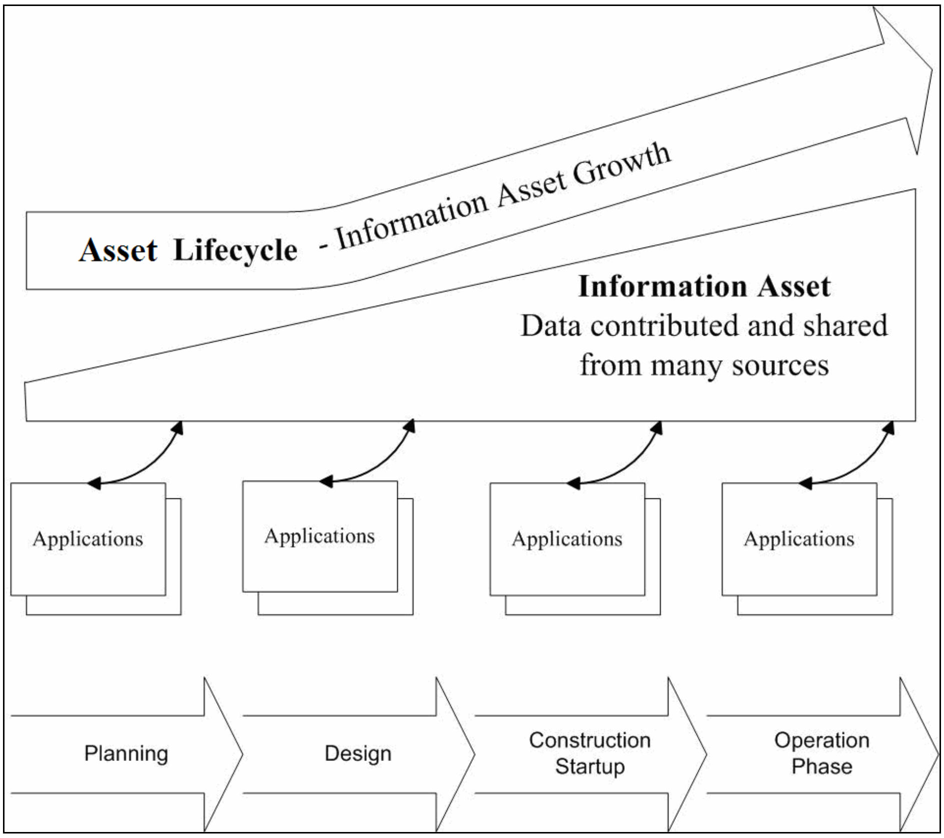

Figure 4 – Information Asset Growth through Asset Lifecycle

The combination of maturity in risk modelling, large quantities of related data and advances in ICT begin to make Risk-Based Operations (RBO)[8] a real possibility.

If it can be shared, re-used and maintained, this wealth of information is of enormous value. The data are a huge knowledge base from which corporate learning can be derived to improve best practice, and should an asset be sold can provide valuable insight to a purchaser as to the value of the asset. The concept of the 'information asset' is illustrated schematically in Figure 4 in the context of the process industry. As a plant (or any other asset in fact) progresses through its lifecycle, the information asset grows as information is added and shared from other processes and applications.

Much of the information required before a classical QRA can be performed will exist in datasets belonging to different departments within an organisation. The software applications used to manage the data may come from different vendors and it is likely to be structured in different ways. This requires a common data modelling system so that the applications can communicate and data can be published to and retrieved from the system. Such systems are now emerging, like Intergraph's SmartPlant Foundation[7], for example, as mentioned earlier.

Even though the data may already exist in other applications within the organisation, the entry and manipulation of these data for QRA remains a largely manual process. One of the first steps to extending the role of risk tools beyond compliance to meet the broader business needs of industry is to take advantage of latest ICT to facilitate the kind of data management described above. As an example, in the latest version of SAFETI we have taken a first step towards enabling data integration with other applications by incorporating Intergraph's GeoMedia GIS system.

4 BUSINESS NEEDS

Today's business environment with global competition and the ever present needs to improve efficiency means that innovations within process plant operations must justify their contribution to the business, more often than not by a contribution to the financial well being of the business. Businesses are also under pressure to be more transparent in their reporting providing not only financial information but also detailing contributions to social and environmental well being or Corporate Social Responsibility (CSR).

At the centre of any risk based approach is the objective to manage risks and enhance safety within operations. Pitblado[8] has shown that although the industry has greatly reduced injuries there seems to be less evidence that there has been a significant reduction in major accidents. Analyses of US and EU data have failed to identify any noticeable downwards trend in major accidents. The one exception to this is within the UK offshore oil sector which is managed by a safety case regime[9] .This has taken recommendations from Lord Cullen's report from the Piper Alpha Inquiry. The focus has been on addressing major accidents through a number of mechanisms, some of which are not present in other regulations.

In assessing performance of the UK legislation the incidence of leaks has been evaluated with the belief that major leaks are a good indicator of the potential for a major accident, although there are insufficient data to identify a correlation between the two. The UK data indicate a significant drop in the number of major leaks reported. Interestingly medium leaks reduced less and minor leaks increased with this approach.

The UK Offshore safety case regime requirements have the following elements

- Safety management system
- Risk Assessment
- Quantitative risk assessment demonstrating meeting a defined risk target
- Identification of safety critical elements (critical barriers)
- Performance standards for all safety critical elements
- Lifecycle programme to maintain critical barriers (written schemes of examination)

The implications of this are that safety is no longer assessed and addressed through a snap-shot assessment made every few years but assessment of the elements controlling risk and thereby safety are monitored and maintained as part of the on-going operational processes.

The industry has made many initiatives in the application of risk based methodologies to the control of safety critical elements. Examples include Risk Based Inspection (RBI), Risk Based Maintenance (RBM) and more lately RBO. These initiatives continue with innovations such as Bow-Tie diagrams and Matrix of Permitted Operations. These innovations will continue to improve safety and drive down the numbers of accidents by pulling safety more into the mainstream operations.

When accidents happen not only can there be loss of life but many other losses can occur that can have a significant impact on the environment and business often costing many millions of dollars. Fewtrell and Hirst[1] examined the costs of accidents post Flixborough and from UK accidents reported quoted losses at the time of the accident up to £100M (1996 values). When looking at accidents internationally the maximum reported loss from a single accident was nearly $1.5 billion when including business interruption costs. Kersten and Mak[10] reported that in the explosion at the Atofina plant in Toulouse in September 2001, 29 people were killed, 2500 injured (30 severely) and material losses were assessed at €2.3 billion.

As well as costing lives these kinds of losses can obviously have a huge impact on a business, the environment, the local population, on surrounding businesses and those that depend on them. There is a clear opportunity for businesses to apply the knowledge and expertise of the safety practitioners to the broader business risk environment. Innovations that have been used to improve safety can be extended to other identifiable types of loss and used to manage a broad range of risks thus minimising many of the potential major losses to a business.

Companies have suffered massive financial losses and entire economies have been disrupted by incidents where asset loss has been minimal and there have been few fatalities. Two well documented examples are the Longford gas explosion in Australia[11] in 1998 and the Seveso Dioxin release[12] in July 1976. In the case of Longford there were only 2 fatalities but the cost to industry was estimated to be in excess of $1.3 billion. So, from the health and safety standpoint both incidents were relatively minor compared to, say, the Toulouse Ammonium Nitrate release in France in 2001 or the Fluxys Natural Gas release at the Ghislengien Industrial Estate in Belgium in 2004.

5 EXTENDING TRADITIONAL QRA TO OTHER LOSSES

This concept of extending the traditional process QRA to look at other losses to the business is one we have termed Process Business Risk. It is not the intention of this paper to discuss this approach in detail as this is covered in another paper[13] and the reader should refer to this for more information. The approach considers potential losses in financial terms and losses covered include:

- Impacts on people in terms of both injuries and fatalities
- Property damage in terms of both capital costs to replace damaged equipment and damage to other property
- Business interruption
- Inventory loss
- Environmental damage including clean-up costs, fines and impact on flora and fauna
- Plus many others (legal costs, loss of reputation, brand image, compensation, etc.)

Results can presented in the form of cumulative frequency of a loss of $x or more for each type of loss as shown in Figure 5.

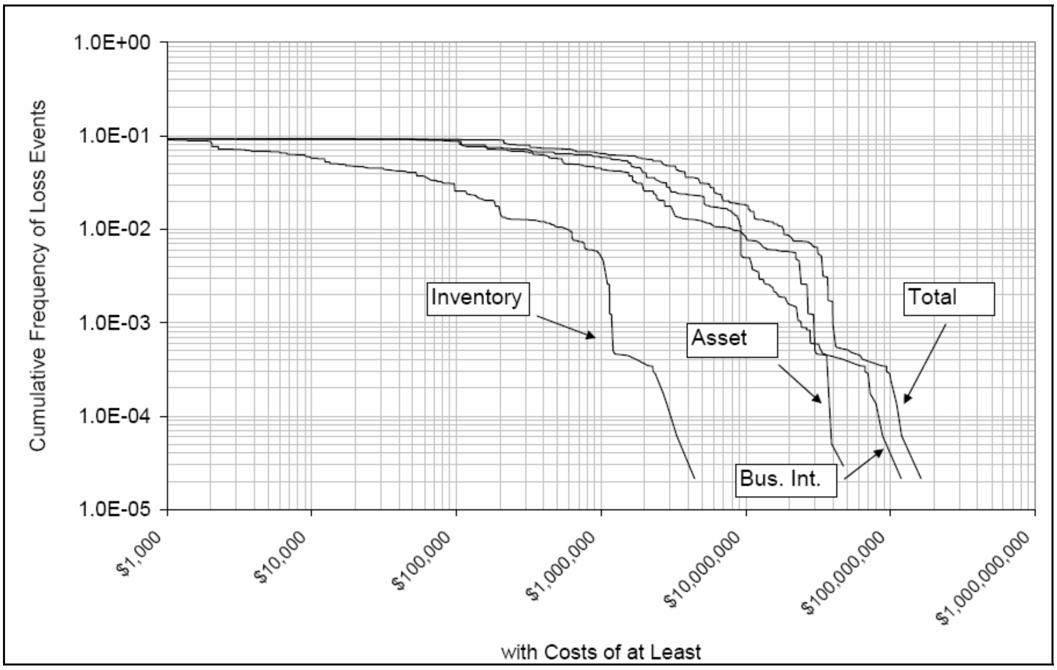

Figure 5 – Typical F$ Curves for different Components of a Business Risk Model[5]

Results may be interrogated to find the process hazards which are contributing the most to certain types of loss so that these can be targeted with risk reduction measures. This type of approach has also been used in reducing insurance premiums and negotiating deductibles. It can easily be seen how this approach could make a significant contribution to CSR and demonstrate the financial benefits through reduced exposure to financial loss of risk reduction measures.

However this is still a static analysis, relying on periodic updating. It is not directly connected to operational systems so that plant operators can use risk based systems to support operational decision making. This is addressed in the next section.

6 THE MOVE INTO OPERATIONS

The concept above could easily be performed as an infrequent analysis by a risk expert with a report to the management. However, the true value of the approach is realised when it is integrated with the operational management and planning systems. Steps have been taken in this direction. For example, today we see the integration of RBI analysis tools with inspection databases which store detailed technical inspection results, to interchange data and optimise inspection strategies. Further integration with ERP and CMM systems allows an optimised inspection plan to be implemented. This is a huge step forward but the inspection plans are optimised infrequently and there is no real dynamics with the operations.

Based on experiences gained in the North Sea through the UK Offshore Safety Case regime the focus was put on the barriers in place to mitigate risks. An approach arising from this is the Bow-Tie concept illustrated in Figure 6. In the centre of the diagram is the 'Top Event' or process hazard. To the left are the barriers or safeguards that aim to prevent the top event from occurring, to the right are all the safeguards that aim to mitigate the potential consequences from the top event.

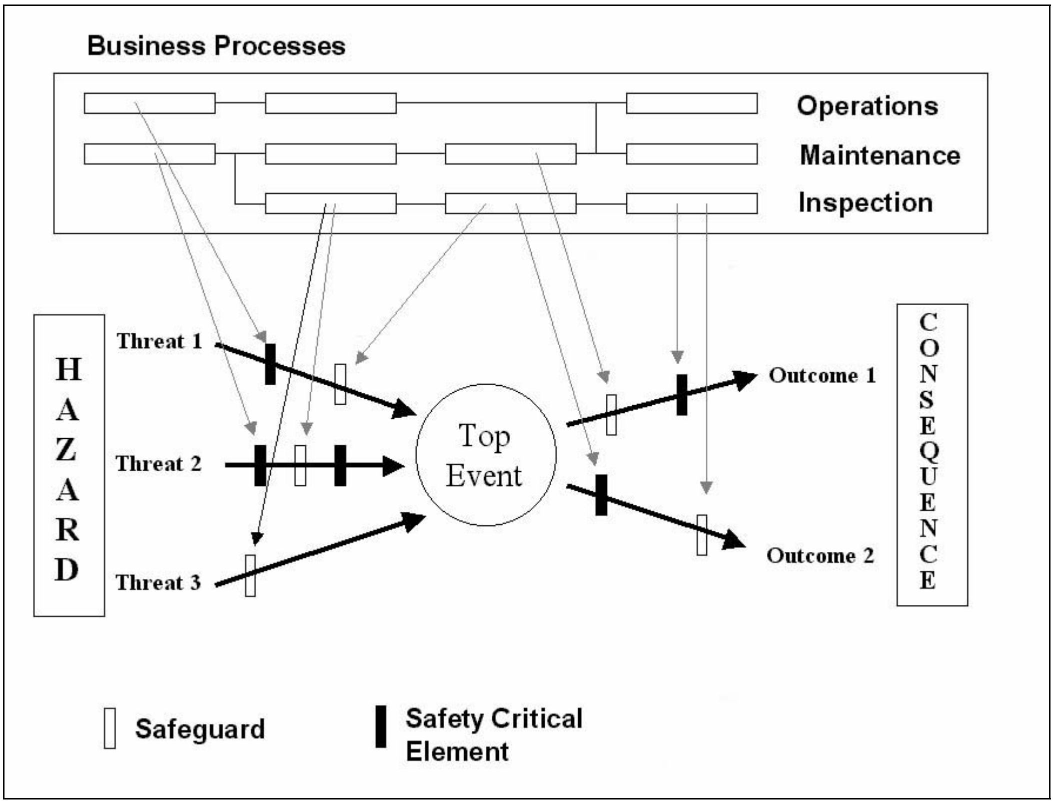

Figure 6, 'Bow-Tie' Diagram

Safeguards can be varied in nature from personnel with relevant experience to training to ESD valves to operational procedures to fire fighting equipment and so forth. Using this approach it is critical to know the status of each safeguard in real time to support decision making.

It can readily be seen that by analysing all potential top events and quantifying all potential outcomes for all types of losses a picture of the risk exposure at any point in time can be built up. Safeguards to the left of the top event affect the likelihood that the event will take place, in QRA terms the frequency of the event. Those to the right impact the potential consequences of an event and can increase or reduce the severity of a top event.

By linking real-time systems from the plant to the Bow-Tie changes the status of safeguards can be used immediately to update the risk picture. These data may come from ERP systems for scheduling maintenance or personnel lists, from computerised production management systems or the CMMS.

The status of the safeguards could be used as input to a digital dash board distributed over the company LAN using Internet technologies so that the risk status can be view graphically in a web browser. This would enable real-time risk to be communicated quickly and easily to the relevant decision makers of an operation.

One use of this could be with a matrix of permitted operations (MOPO) where certain operations are only allowed when specific safeguards are in place or perhaps procedures could define certain actions required when specific levels of risk were exceeded.

Today's ICT means that it is possible to integrate these systems, update analyses with sufficient speed and distribute and communicate the information to make systems like the one above meaningful and useful. Through this integration risk analysis begins to contribute directly to the bottom line.

7 CONCLUSIONS

QRA has traditionally been used to ensure safe operation, often from a compliance perspective. But, as demonstrated above, as well as costing lives, major accidents can have other social, environmental and economic consequences. Classical methodologies like QRA can be extended to assess a broader range of business risk and ICT is now at a stage where it can support such extensions.

Risk results can be linked through other techniques, like Bow-Tie diagrams, to risk indicators and other decision support systems. By doing this in real-time, operational decisions can be made based on current risk, not based on a single risk snap-shot taken at some time in the past. Furthermore, "risk" in this context does not just refer to risk to life. By linking with Process Business Risk, the risk from a number of standpoints can be considered simultaneously, like life, property, the environment and so on. Setting priorities in each risk category allows appropriate operational decisions to be made.

Live links from Process Business Risk tools to enterprise systems could be used to update the status of barriers and to aid operational decision making, enabling decisions to be made based on actual risk, not perceived risk. Using this kind of system, major contributors to risk can be identified for action and the consequences of these actions will be apparent immediately.

These systems also provide an environment for corporate learning and capturing of best practice. By incorporating the lessons learned from day-to-day operations into the risk analyses, the safeguards and operational procedures business risks can be reduced and managed more visibly. Also the impact of decisions on business risks can be quantified before they are taken and various options analysed so that risks can be minimised whilst production is optimised.

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