Beyond Compliance – The Future Role of Risk Tools?

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ABSTRACT

The management of risks associated with major accident hazard facilities has historically focussed on safe operation rather than areas such as improved financial performance or increased productivity. With major advances in Information and Communication Technology (ICT) and the maturing of technology in other domains, the emphasis has moved beyond straight-forward compliance with safety legislation.

With greater global competition and much more challenging margins, there is now less opportunity to invest in activities that do not contribute directly to the bottom line, or are perceived as such. ICT advances, along with growth in Internet technology, has 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.

Technological advances mean that the move from pure compliance based systems to performance based risk management or Risk Based Operations is now possible and desirable. This paper reviews the history of Quantitative Risk Assessment (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.

1. INTRODUCTION

Over the last 30 years, the management of risks to life associated with the operation of major accident hazard facilities has evolved steadily. This has been driven by a number of major accidents including Flixborough (1974), Seveso (1976), Bhopal (1984), Piper-Alpha (1988) and, more recently, Toulouse (2001) and Fluxys (2004), and subsequent legislation such as the Seveso directives in Europe and the EPA Risk Management Plan regulations in the US[1]. The management of these risks has generally been focussed on safe operation rather than other areas such as improved financial performance or increased productivity. With major advances in Information and Communication Technology (ICT) over this period and the maturing technology used for software tools and related models, the emphasis has moved beyond straightforward compliance with safety legislation.

During the 1980's, oil and chemical companies were cash rich and highly proactive over safety issues with large budgets and often setting internal standards beyond the needs of legislative compliance. However, the business environment has progressed with greater global competition and much more challenging margins. There is now less cash available for 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 these ICT advances with the maturity of models for QRA and related technologies means that the move from pure compliance based systems to performance based risk management or Risk Based Operations is now possible and desirable. The "Q" of QRA need not only be fatalities, but effects on the environment, downtime or dollars. 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 impacts on people, operations or assets analysts are better able to estimate the likely costs of an incident or incidents in terms of down-time, asset damage, personal injury and loss of life, brand damage, environmental clean-up, litigation and compensation, and so on. With the use of real-time information on the status of operations, mangers can assess the likely impacts of decisions on safety and business risks.

2. 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.

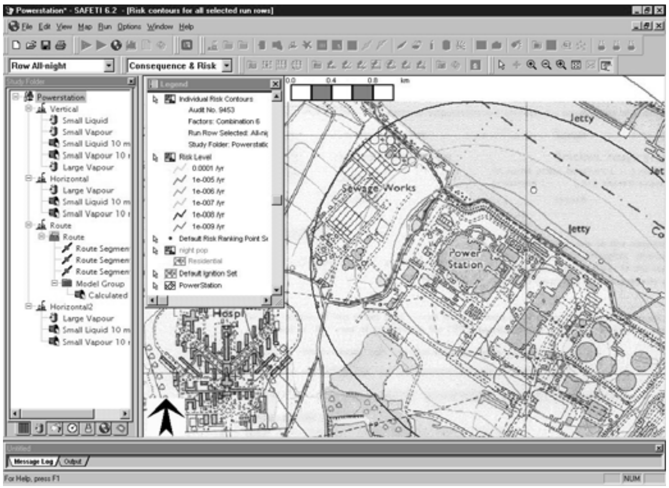

Figure 1 – Typical Individual Risk Contours displayed using SAFETI

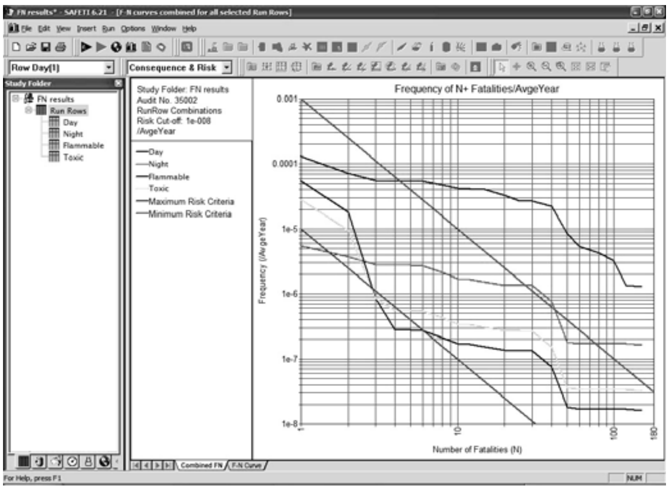

Figure 2 – Typical FN Curves for Societal Risk displayed using SAFETI

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 modeling 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.

This is the case for a number of reasons, not least the fact that QRA studies in tools like SAFETI[3] have been created over many years and have taken many man years of effort which their owners are loath to "throw-away". 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. Also, this approach where individual failure cases are assumed to be unrelated does not require a spatially based model to be developed, However, such a model containing plant geometry is a pre-requisite when extending these models to business or financial risk[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 this data is just as applicable during the operational phase of a plant life-cycle as it is to earlier phases like design and construction. The first step to using risk information in making operational decisions is to create this kind of data re-use capability throughout the asset life-cycle.

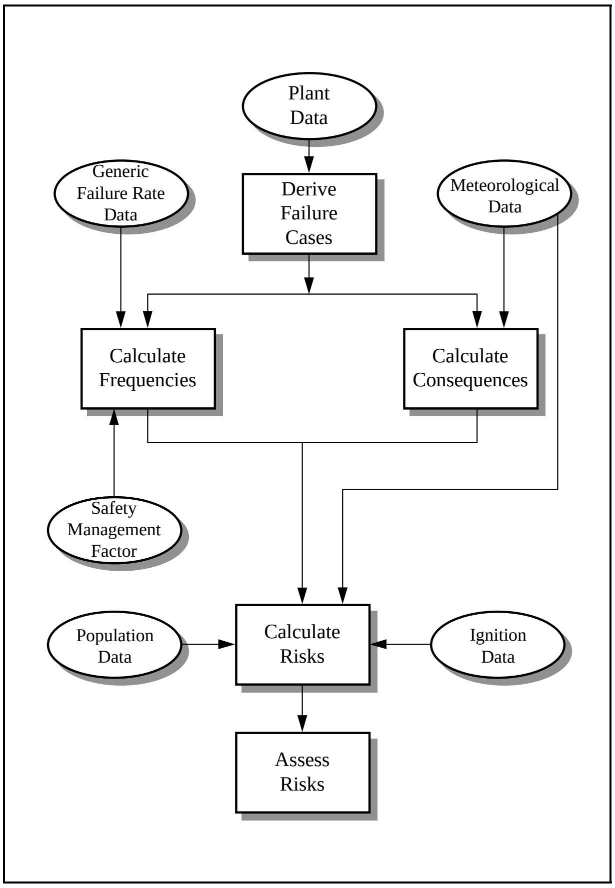

Figure 3 – Classical risk analysis methodology

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. 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 is used and shared. The data itself has a value to the organisation in proportion to the extent it can be distributed and shared.

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. The combination of maturity in risk modeling, 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 kept up-to-date, this wealth of information is of enormous value. 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.

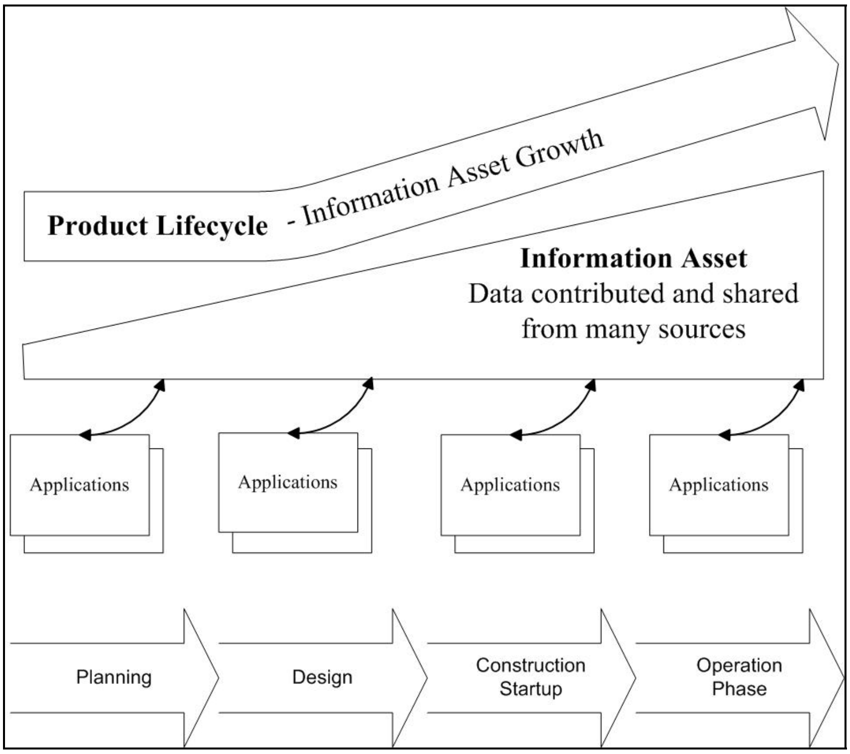

Figure 4 – Information Asset Growth through Asset Lifecycle

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 this 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. We are now working on a prototype to extend this to "Business Risk" which, as well as looking at the potential for loss of life, also includes financial losses associated with other drivers like business interruption, equipment damage and so on. We now go on to discuss our vision for the future role of risk tools in the two key areas of RBO and Business Risk.

3. BUSINESS NEEDS

At the heart of the Business Risk approach is the need to manage risks and to 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] which 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 standard 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. But from the Process Business Risk standpoint they have all resulted in significant preventable losses.

4. THE PROCESS BUSINESS RISK CONCEPT

The Process Business Risk concept provides an opportunity for extending conventional safety focused QRA to manage these additional risks. Typical outcomes that may result in financial losses are:-

- 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.)

The first of these items above has traditionally been considered when performing a QRA for a hazardous facility. Typical output produced by extending this to cover the additional items above through a Process Business Risk analyses may be total loss rate or F/$ curves, analogous with the F/N curves from a QRA and as illustrated in Figure 5 (reproduced from reference 5).

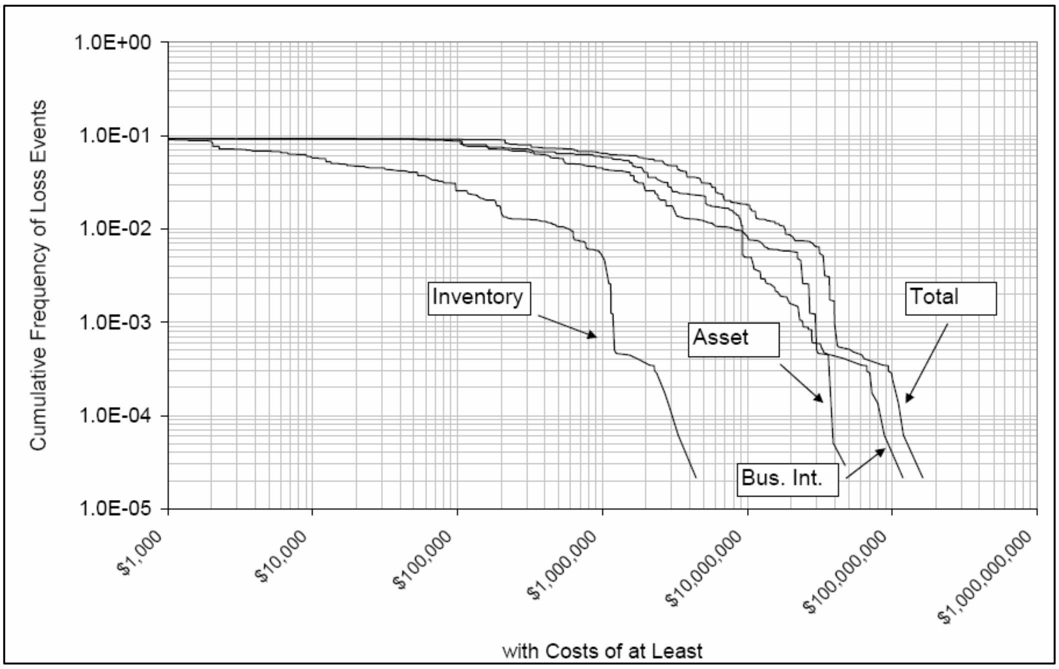

Figure 5 – Typical F/$ Curves for different Components of a Business Risk Model[5]

Similarly, typical uses of this approach may include some or all of the following:-

- Benchmarking operational risk levels
- Trending risk over time
- Comparison of risks for different operational conditions
- Demonstrating a culture of CSR (Corporate Social Responsibility) and adherence to the principles of triple bottom line (3BL) reporting
- Assessment of exposure to financial risks due to major hazards on process plants
- Evaluation of the relative effectiveness of different risk mitigation strategies for reducing exposure to financial risk
- A decision support tool for implementing cost effective risk reduction measures (e.g. using cost benefit analysis)
- Justification for reduction of insurance premiums and deductibles by demonstrating reduced exposure to financial losses

By developing Process Business Risk technology which focuses on more than compliance with safety legislation, this is a first step to linking more directly with other business processes. This is a key facilitator for longer term extension to full Risk Based Operational monitoring using the same risk based techniques linked directly with more mainstream operational systems.

5. FROM COMPLIANCE TO 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 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.

Within plant operations there are generally three main systems supporting the operational processes; Enterprise Resource Planning (ERP); Enterprise Production Management (EPM) and Enterprise Asset Management (EAM), all of which overlap to some degree as sown in Figure 6.

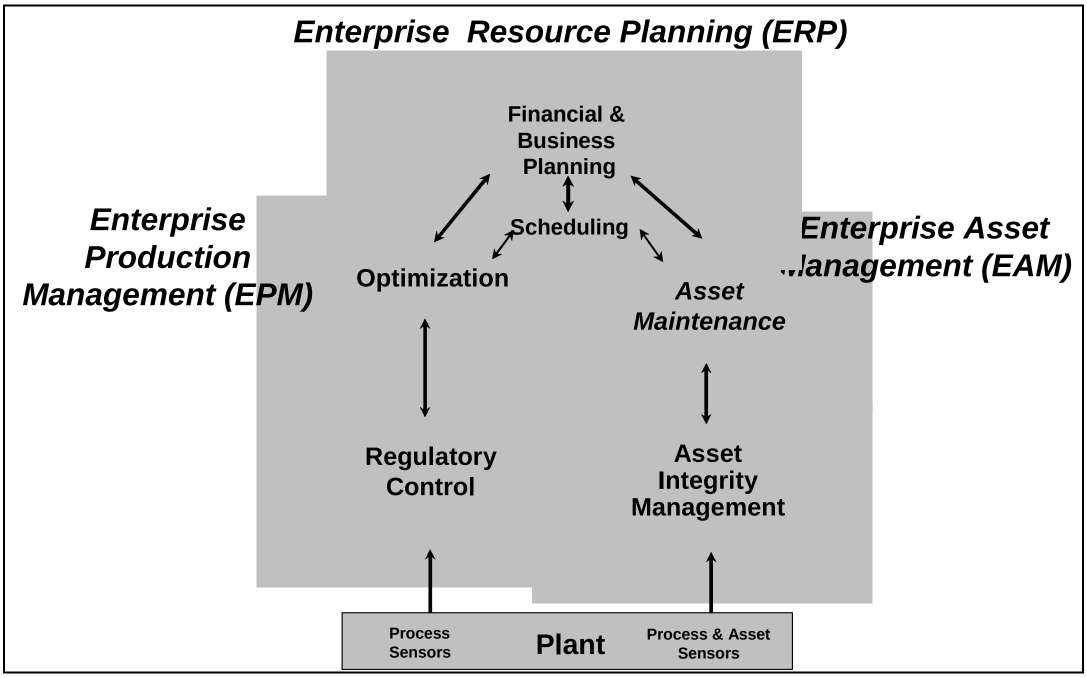

Figure 6 – Relationship between ERP, EPM and EAM systems for a typical plant

ERP systems are an integrated set of information systems designed to tie together more closely a variety of company functions including human resources, inventories and financials while simultaneously linking the company to customers and vendors.

EPM software is designed to manage, monitor, control and optimise the production processes within a process plant.

EAM software is designed to help companies maximise the value from its capital assets. The software is used to track, depreciate and maintain their fixed assets and capital equipment. EAM software is often integrated with ERP software for preventative maintenance planning as well as asset accounting.

Through integration of software for analysing business risks with these systems, real-time information can be used to determine the current level of risk to which a plant is exposed. It can also be used to determine the effects on risk of alternative courses of action and improve decision making whilst managing risk and safety.

Corporate knowledge and experience can be captured within the system and utilised real-time in decision making to help avoid high risk scenarios. As data are real-time the system can also indicate when a high risk situation has developed giving operational managers another source of information early to help mitigate such situations.

Classical risk analyses are performed on plants operating under normal conditions. With appropriate set-up a business risk based operations system could be highly effective at assessing and assisting managers in minimising risks during non-standard operating conditions such as start-up and shut-down and during maintenance activities.

6. 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 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.

The first step in achieving this kind of integration between risk and operations is to further develop risk tools beyond the domain of compliance with safety legislation. We are in the process of developing a prototype Business Risk software tool which takes this first step.

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