Hazards forum

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Views expressed are those of the authors, not necessarily of the Hazards Forum

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September 2015

New Health and Safety Executive Observer to the Hazards Forum

ANDREW CURRAN BSc (Hons) PhD FSB FCMI Hon FFOM

The Hazards Forum is delighted to welcome to the Executive Committee a new member. Upon the retirement of Jane Willis from HSE as Director of Policy and Operational Strategy and a number of years of significant contributions to the Hf Executive Committee, we welcome Andrew Curran as the new HSE Observer.

Professor Andrew Curran is Chief Scientific Adviser and Director of Research at the Health and Safety Executive. In this role he has responsibility for the professional leadership of the 850 scientists, engineers and physicians who work in HSE, and also for the development and delivery of HSE's science strategy. Andrew is the Chair of the Sheffield Group (a global network of national health and safety research organisations), Chair of the Scientific Steering Group of PEROSH (Partnership for European Research in Occupational Safety and Health) and is a Board Member of ICOH (International Commission for Occupational Health).

Andrew has published widely in the field of occupational health, and he continues to deliver keynote presentations at International conferences. He is an Honorary Professor at Sheffield University, and an Honorary Fellow of the Faculty of Occupational Medicine (UK).

Risks of Risk Management Systems

Neil Carhart

On **Tuesday 16th June 2015** the Hazards Forum hosted an **evening event** at the Institution of Civil Engineers, One Great George Street, Westminster, London.
Much reliance is placed by companies and other organisations on the systems they use for managing risk. These systems typically have to deal with the significant complexities and uncertainties characteristic of real world application. There is also the possibility that such systems could unintentionally introduce additional hazards and risks. The interaction of people with risk management systems introduces a further dimension with the potential for both positive and negative impact. This event will seek to explore two examples of risk management systems from different sectors, as well as the human and organisational issues within large organisations.

The event began with a welcome from **Dave Fargie**, a member of the Hazards Forum Executive Committee. He thanked the co-sponsors of the event, the Institution of Chemical Engineers (IChemE) and the Institution of Civil Engineers (ICE), before handing over to the chair for the evening.

The event was chaired by **Nathan Baker**, Director of Engineering Knowledge at the ICE.
The first presentation of the evening was given by **Professor Richard (Dick) Taylor and Dr Neil Carhart**, who described recent work at Bristol University's Safety Systems Research Centre aimed at equipping large engineering organisations with new approaches to further reduce the risk of incidents. They discussed their analysis of twelve major events across a range of industry sectors and the precursors it identified which predispose organisations to 'organisational incidents'. The presentation also included examples of how the issues identified might begin to be addressed by integrated condition monitoring of defences and by dynamic modelling of inter-related organisational factors.

The second talk was given by **Mike Johnson**, Senior Principal Consultant, DNV GL. Mike gave an overview of the recently republished Oil & Gas UK document "Guidance on Risk Related Decision Making" which offers a framework for risk based decision making in the Oil and Gas sector. He discussed the content and application of the framework as well as highlighting some of the practical challenges of deploying it in organisations. He also described some of the human and behavioural aspects needed to ensure its successful use.

The final presentation was delivered by **Derrick Ryall.** As Head of the Public Weather Service at the Met Office, Derrick is responsible for the delivery of weather forecasts and advice to the public, responder community and government to protect life and property and drive economic growth. The accuracy and usefulness of forecasts has improved dramatically over the years allowing ever more 'weather decisions' to be made. Whereas just 30 years ago a forecast was perhaps of more interest than use, weather forecasts and warnings now drive a whole range of mitigating actions. The talk looked at how and why forecasts have improved over the years and how the risk based 'National Severe Weather Warning System' is a vital part of communicating weather risks.

Dick Taylor, Visiting Professor in the Safety Systems Research Centre (SSRC) and Neil Carhart of the International Centre for Infrastructure Futures, both at the University of Bristol, gave the first presentation on '*Managing the Organisational and Cultural Precursors to Major events - Recognising and Addressing Complexity*'. The research was initially funded by the NII (now ONR) and by BNFL. Dick began by reminding the audience that sadly serious accidents (and near-hits) still occur quite regularly in all 'high-hazard' industries and that major rail accidents, petrochemical industry events such as the Buncefield explosion and Gulf of Mexico accident, and nuclear events such as Fukushima, all illustrate the potential for major loss of life, environmental damage, and impact on industry in terms of production, company value, and reputation. They can also have a significant impact on national infrastructure. In 2010 the UK Government classified major industrial accidents as 'Tier 1 Risks' to the UK and emphasised the need for developing increased resilience.

The research team at the SSRC (which includes Dr John May, and for much of the research discussed here, Dr Lorenzo van Wijk - in addition to the two presenters) have studied collectively the findings from reports into major events from a range of 'high hazard' industries and drawn out the key organisational and cultural precursors 'underpinning' these events [1]. It was shown that whether events occurred in normal operation, during outages or involved one-off projects, the precursors identified were strikingly similar. The research allowed common findings to be drawn out and categorised, initial ideas for model defences to be developed and has led to the development of draft statements of good practice ('Expectations') and draft question sets designed to probe operational reality which should be useful across all the industry sectors involved. To illustrate the relevance of organisational safety culture failings and elicit precursors, twelve events were studied. These were:

1) Port of Ramsgate walkway collapse (UK, September 1994)
2) Heathrow Express NATM tunnel collapse during construction (UK, October 1994)
3) Longford gas plant explosion (Australia, September 1998
4) Tokai-mura criticality accident (Japan, September 1999)
5) Hatfield railway accident (UK, October 2000)
6) Davis Besse pressure vessel corrosion event (USA, February 2002)
7) Loss of the Columbia Shuttle (USA, February 2003)
8) Paks Nuclear Plant fuel cleaning event (Hungary, April 2003)
9) Texas City oil refinery explosion (USA, March 2005)
10) Loss of containment at the THORP Sellafield reprocessing incident (UK, 2005)
11) Buncefield explosion (UK, December,2005)
12) Nimrod aircraft crash (Afghanistan, September 2006)

The similarity between 'precursors' of socio-technical failure in several of the events was also later pointed out in the Haddon-cave Report into the Nimrod crash (12, above)

Organisational and cultural findings contributing to each event were assembled from the published reports for each of the twelve cases studied and grouped under eight generic headings (domains). These could have been formulated in various ways, but those listed in the slide shown below were found useful in classifying the findings in such a way that related tools discussed later, could be developed.

The research has also attempted to draw out specific learning related to issues for regulators and more detailed work has been carried out recently (reflecting both industry and academic interest) into studying the specific issue of 'management of the supply chain' (contractor management), which was a significant factor in several of the events.

Dick then proceeded to discuss examples of some of the findings from the study which have been the basis for the identification of ‘expectations’ and development of ‘diagnostic questions’, in two of the eight areas, starting with **Oversight and Scrutiny**.

When failures occur in systems and /or as a result of a weak organisational culture, this can be put right before a major failure occurs by oversight systems designed to alert different layers of the organisation to the deficiencies. Failures in oversight were (perhaps unsurprisingly) a common feature of all of the events studied. Among the specific issues identified were the following:

- The need to have in place a hierarchical, layered system of checks and balances. In some cases there was only a conventional audit process - often solely within the line and consequently lacking clear independence. In some cases this did not look beyond paper systems and did not identify failures to comply in practice with requirements, or recognise deficiencies in the underlying safety culture. It is vital that oversight and scrutiny processes are 'joined up', with appropriate information available to decision makers at a level appropriate to the nature of the decisions that they are asked to take.

- Oversight processes were sometimes ineffective because they were either poorly resourced, reports and feedback were not given sufficient weight and/or were not the subject of sufficient questioning by the recipients of the reports. This was sometimes reinforced by a 'good news culture' in which 'unpalatable' feedback was not highlighted or acted upon.
- In some cases, information being fed up to senior leaders was aggregated such that weaknesses relating to particular plants or functions were 'lost' and could not easily be identified and addressed. Thus 'blanket' business decisions (such as 'across the board' cuts in resources) were applied even where inappropriate.
- Early warning of emerging issues can most effectively be identified in the oversight process if key measures and issues are integrated. In some of the events, this 'helicopter view' was not obtained. It is not sufficient to rely just on performance indicators even where these are designed to measure process safety performance. An effective system uses these together with audit findings, event reports and through the commitment of senior leaders to question safety performance systematically to the same depth and intensity to which financial and project related programmes would usually be scrutinised - for example through regular face-to-face scrutiny meetings between leaders and their direct reports. In few of the events studied, did leaders appear to exercise a formal, integrated process.
- Safety Departments (which might be expected to provide independent authoritative advice) were in some cases not sufficiently resourced or competent and/or did not have sufficient authority to stop potentially unsafe operations.
- Failure to detect weaknesses also arose from the use of unsuitable process safety metrics. In some cases over-reliance was placed on metrics relating to personnel/industrial safety and it was wrongly assumed that successful performance in these areas of safety would 'guarantee' excellence in 'process safety'. In nearly all cases, suitable metrics relating to process safety were not available or contained only lagging indicators.
- There was evidence in many cases that leadership teams at the top of the organisation were unaware of the reality of safety shortcomings at plant level. Findings were not always questioned, in some cases possibly because of a lack of expertise at this level about the process safety issues involved or a lack of true independence and questioning but, in some cases, because it appeared that the needs of the broader business agenda did not 'align' with the information being made available.

Further examples were discussed concerning **Organisational Learning**. For most of the events studied there had been previous events from which there was suitable learning available. If this had been acted upon, the event would probably not have occurred. Although there is an asymmetry in the process, in the sense that successful learning is not always given the same 'exposure' as failure, there appears to be a need to investigate how effective learning can be better achieved and. Among the issues identified were the following:

- Reporting of learning opportunities was poor in many cases, for a variety of reasons, including apparent concerns from staff that their reports would not be part of a 'just' or 'blame free' response, that 'bad news' would not be welcome at more senior levels, that there was insufficient knowledge to recognise precursors and/or that there was simply a culture of mistrust or complacency which did not encourage open reporting.
- Previous events had not been investigated on a systematic basis. This was reflected in a failure to investigate some events at all, and in

other cases there was a failure to consider deeper root causes. For example, learning stopped at recognising that competence was poor or that procedures had not been addressed and there was not a recognition of the need to probe more deeply.

- Learning from events was often not shared within the organisation or beyond as part of an effective feedback programme. The opportunity was not taken to encourage team discussion, peer review and for resulting actions to be scrutinised to assess whether they had been effective or could be more widely applied.
- In most cases there were historical events which provided significant learning opportunities. Some of these had happened in the organisation and others were from other companies within the same industrial sector. Where these had been recognised as learning opportunities, they had often faded in significance within the corporate memory. They were often not embedded in training.
- The existence of ‘organisational silos’ also meant that important knowledge which might have minimised the risk of the resulting event was not transferred. There was, for example, a failure to transfer learning between engineering or technical staff and operations staff, or to share learning with contractors.

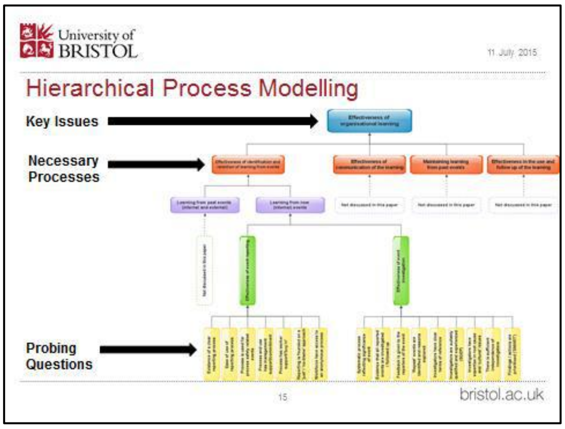
From 'findings' such as these, sets of 'Expectations' were then developed as statements of good practice drawn from the research into the events, which if recognised and implemented, should enable organisations to build stronger defences against the occurrence of future events. Work with various organisations has demonstrated that the findings can be used to check that the issues drawn out in the studies are suitably recognised in corporate policies and expectations.

It is important that duty holders and regulators are able to assess whether the knowledge of these organisational and cultural event precursors has not only been recognised but that it has been 'absorbed into the blood stream' of the organisation. Thus the next vital step is to ensure that actions and practices are actually in place to ensure that they are carried over effectively into operational practices at all levels from the boardroom to the workplace. To this end, the 'Expectations' have been reformulated and developed into sets of draft 'penetrating' diagnostic questions which actively explore whether 'reality aligns with expectation'. Initial work has already been carried out to refine some of these question sets by working directly with industry.

These questions could be used to assess the vulnerability of organisations to the identified issues. This might be regarded as analogous to the use of systematic processes to assess risks arising from engineering and human factors-related issues through the use of well established, engineering-based techniques such as PSAs fault trees, and Hazops etc. An important objective of ongoing research is thus to develop tools based on a deeper understanding of the more fundamental issues being investigated here. This will enable operating organisations (and regulators) to address these often neglected factors on a systematic basis as is done for 'engineering' vulnerabilities. As a first step, work has begun on using Hierarchical Process Modelling (HPM) to develop a vulnerability tool using the question sets as an input to this. It builds on significant related research and experience in the Systems Centre at Bristol University. Useful though this is likely to be in raising awareness and providing an initial basis for assessment of vulnerability, the research carried has shown that fully to understand the issues involved and to allow actions to be taken which fully address the precursors it is vital to understand the complexity and interactions between them. It is also important to incorporate understanding of psychological factors in individual and group decision making. For example, typically a list of recommendations follows on from an event investigation, each comprising simple, self-contained, logic pertaining to a particular perceived shortcoming in an organisation's approach (e.g. 'raise the rate of event or 'near hit' reporting'). Whilst intuitive, this ignores the complexities of modern organisations and how individuals and groups respond. Where systems are not well understood, well-intentioned interventions can themselves introduce new unanticipated vulnerabilities. In organisations, vulnerabilities often remain hidden until multiple socio-technical conditions *align* to provide a pathway to system failure. The current research aims to address these dynamics, complexity and coupling factors and will attempt to incorporate the wider 'people issues' involved. If successful, it should enable development of new diagnostic tools and associated interventions through techniques such as System Dynamics (SD), which are able to fully address systems related issues and sometimes repetitive modes of system breakdown (archetypes) within practical frameworks which reflect industry needs. Dick then handed over to **Neil Carhart** to discuss some of these developments.

Neil began by reiterating that the findings of the original research underlined the fact the major events are often caused by the same underlying causes, regardless of the industry in which they occur. Having identified some of these causes, he then described some of the ways in which this knowledge can best be structured and used.

One way that has been investigated is Hierarchical Process Modelling. This takes each of the eight identified key issues and decomposes them into the processes necessary to address them. These processes relate to the 'expectations' described by Dick. These processes can be further decomposed into sub-processes forming a hierarchy. At the bottom of the hierarchy, specific probing questions have been developed to collect evidence and gauge whether those processes are performing well or not. This assessment can be aggregated back up the hierarchy, through the sub-processes to evaluate an organisation's performance against the key issues, and ultimately to assess its overall resilience.



This provides a simple, user-friendly tool, however it does not take fully take account of the underlying complexity. Each of the issues Richard discussions, each of the areas evaluated by the questions at the bottom of the hierarchy, do not exist in isolation from one another. Each is part of an interconnected web of factors.

In practice, it is common to overlook these complex interdependent networks of issues. It can be difficult to address the complexity in a way that is simple to use. Instead, models and tools are employed that are easier to implement, and that diagnose relatively simple corrective actions. These models (e.g. Heinrich's Domino Model) and tools (e.g. Root Cause Analysis, Failure Modes and Effects Analysis, etc.) often try and reduce unwanted events to the end product of a liner and sequential chain of cause and effect. Even richer models like the Swiss Cheese Accident Model rely on a form of linear sequence and propagation. Systems Theory however offers complementary ways to actually model the underlying complexity. These tend to see hazards and safety not as the product of a chain of events, but as emergent properties of the web of complex interactions.

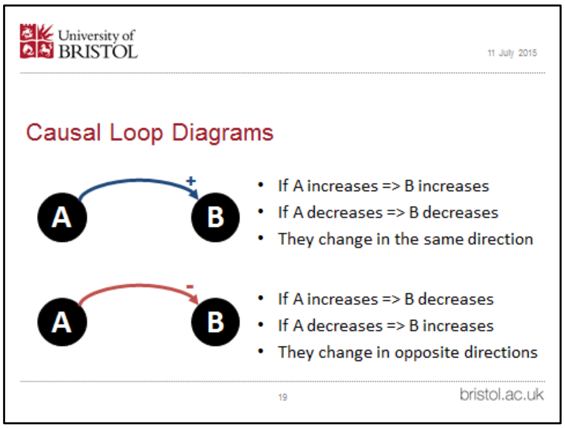
The Fifth Discipline by Peter Senge [2] is a popular book in systems thinking which deals with the organisational learning. Senge suggests ways in which thinking about hazards and safety in terms of systems could help improve resilience and reduce unwanted events. He says that we tend to focus on individual events which results in a reactive view, but these events are caused by patterns of behaviour. These patterns of behaviour are themselves generated by the structure of the system. The structure (which could be the rules of a game, the physical design of an offshore platform, or the procedures of an organisation) can have such a strong influence over behaviour that it is often possible to predict with some confidence what sorts of behaviours a structure will produce. Understanding the structures that causes unwanted behaviours can therefore be of value.

One of the ways we can build those structures is Causal Loop Modelling. Neil provided a brief overview of how these work. Causal Loop Models are about the relationships between variables. It suggests just two different types:

1) Positive causal influences are where a change in variable A influences a change in variable B in the same direction, e.g. an increase in variable A causes an increase in variable B. A decrease in variable A causes a decrease in variable B.

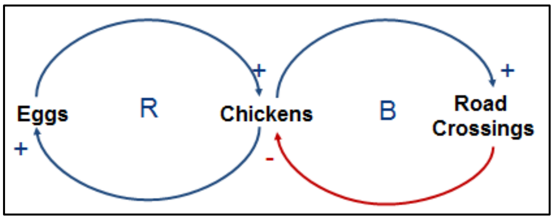
2) Negative causal influences are where a change in variable A influences a change in variable B in the opposite direction, e.g. an increase in variable A causes a ***decrease*** in variable B. A decrease in variable A would cause an increase in variable B.

Diagrammatically, positive links are often shown with a positive "+" symbol at the head of an arrow connecting the two variables, while negative influences are shown with a "-" sign.



Crucially, with just these two types of relationship we can create models that account for feedback, rather than being sequential and linear.

Neil described a simple example of this [from 3] shown below. In this example there are three variables: the number of eggs, number of chickens and number of road crossings. As the number of eggs increases, the number of chickens increases. This is shown with an arrow from Eggs to Chickens with a "+" sign at its head. Similarly, as the number of chickens increases the number of eggs increases, shown with another "+" arrow from Chickens to Eggs. Together these two causal links form a reinforcing feedback loop. If either variable changes, all other things being equal, that change is reinforced. On the right-hand side, as the number of chickens increases, the number of road crossings increases. Chickens are not good at crossing roads, so an increase in road crossing would causes a decrease in the chicken population. This is shown by an arrow from Road Crossings to Chickens with a "-" sign. If Road Crossings were to decrease, the number of Chickens would be allowed to increase, the "-" sign does not necessarily mean "decrease". These two links create a balancing feedback loop which will act to counter any increase or decrease in the chicken population.

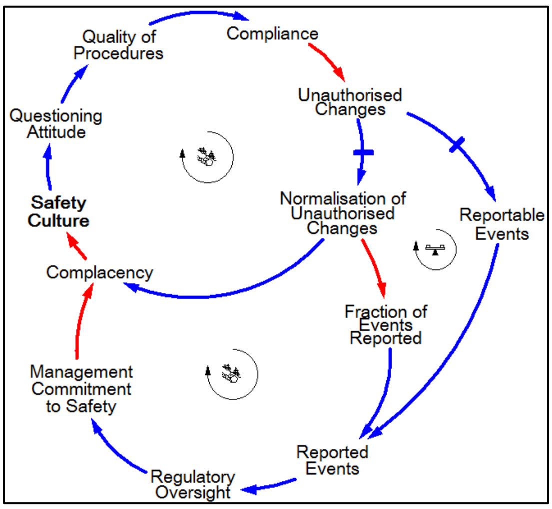


This feedback is often overlooked, despite the fact that it can have dramatic effects. An unconstrained reinforcing feedback loop can cause exponential growth. Humans also tend to be poor at estimating the scale of such changes.

This has led to the development of simple causal loop diagrams, some of which could be considered as Archetypes. These are common structures seen time and time again related to hazardous situations. Neil described such a model he created with a group of industry experts illustrating a nuclear safety event in Japan [4]. The system was **thought** to consist of two feedback loops.

At the top is a Reinforcing Loop that essentially says "as safety culture gets better, people work to improve procedures and break the rules less, which ultimately improves the safety culture"

This reinforcing loop can work in the other direction. If safety culture starts to decline, there may be an increase in Unauthorised Changes. If this happens though, the Balancing Loop shown on the right hand side of the diagram comes into action.



The unauthorised changes are reported to the regulator who places actions on the operator to improve.

While this is how the system was thought to be structured by those involved, it was actually incorrect.

As Unauthorised Changes increases, the staff were becoming normalised to them. This led to **less** of the Reportable Events actually being reported to the regulator. A second Reinforcing Loop existed, shown at the bottom of the diagram, negating the Balancing Loop.

This set up a situation where the structure meant both the operator and regulator thought the system was performing well while in reality it was slowly getting worse.

In essence this diagram takes one of the organisational issues described by Richard and illustrates the underlying structure which created it.

Neil concluded the first talk by summarising how the study of 12 major events had shown common organisational and cultural precursors and underlying causes. There are ways in which knowledge of these can be used in a straightforward way to improve organisational resilience. Systems Theory provides additional ways in which we can also understand the complex networks which link these issues and create undesirable behaviours.

The second talk of the evening was entitled '*Risks, Uncertainty and Decision Making – Oil and Gas Guidance*'. **Mike Johnson**, was on the subject of the 'Guidance on Risk Related Decision Making' document issues in 2014 by Oil and Gas UK Ltd [5]. This guidance is specifically for risk-based decision making as distinct from situations with well-defined, clear and easy ways of progressing. It concerns uncertain situations where the benefits must be weighed against the risks.

Mike described his background within the industry, starting when he joined British

Gas in 1978, researching what was the beginning of risk-assessment techniques in the oil and gas industry. This was applied to a Public Enquiry into what was then British Gas's Liquefied Natural Gas facility at Canvey Island. After this Mike became involved in major hazards research at Spadeadam Test Site – a remote location in Cumbria within an MOD site that has been operational since 1977. It is now operated by DNV GL. This work covered large scale experiments, particularly those involving explosions. This experience has given Mike first-hand experience of the sorts of hazards which could occur within the oil and gas industry.

The guidance produced by Oil and Gas UK is intended to provide a framework for risk based decision making. It does not provide detail of how to assess risk, but provides guiding principles for decision making. It is concerned with the sorts of methods available, and the context within which they may be used.

It is particularly relevant to the harder decisions where there is no obvious path or process available. The guidance also looks briefly at more familiar situations.

The guidance is consistent with UK legislation and has a focus on major accident hazards. The previous guidance, to which this is an update, was produced in 1999 by the UK Offshore Operators' Association (UKOOA), which has now become Oil and Gas UK. There was a need to update this guidance as it made reference to legislation that is now out of date, but there was also a perception that the guidance needed to be simplified. This was perhaps epitomised in the guidance's communication of the risk management framework. This is meant to inform decision makers, depending on the decision context, what type of activity they are dealing with and what factors play a role in the decision process. It was felt that as presented, this framework was quite difficult to interpret, particularly to those with less experience of working with it. As a result there was a move for it to be simplified.

Why is such guidance needed? Firstly, oil and gas operations have major hazards, as mentioned in the previous presentation. The industry spends considerable effort managing those hazards. It has conflicts between the high-valued productions against low-frequency, high-consequence risks. These are events that many operations will fortunately never witness, but may still occur somewhere in the industry. Therefore all those involved have to take the relevant actions.

Mike illustrated this with an example published at the IChemE Hazards Conference in May 2015 [6]. The example concerns the Lomond Platform in the North Sea, and the integrity of its caissons. Caissons are tubulars that hang from the bottom of an offshore platform. They fulfil various functions such as the disposal of fluids, the intake of seawater for fire-fighting, and also bring some of the risers into the platform. The location and movement of the caisson will be restricted by a guide bracket. These are important as if they fail, the caisson can begin to move resulting relatively quickly in fatigue, which can eventually result in the caisson breaking away from the platform. They are generally partly submerged in the water, so movement can be a threat without the guides holding them in place. They represent a significant asset integrity issues for aging North Sea platforms.

In 2010 a caisson, weighing several tonnes, failed and dropped into the water. In doing so it missed a 120 bar, 20 inch gas pipeline by just a meter and a half.

The decision that had to be made concerned a neighbouring caisson to the one that failed. This caisson, weighing around 15 tonnes, was located directly above the gas pipeline, whereas the failed caisson had been slightly displaced.

The gas export pipeline is fitted with a check valve intended to stop the flow of gas if the pipe is ruptured. If it doesn't work there are 58km of gas to the next valve, meaning a potential release that would of several hours. Unfortunately the condition of that valve was not known, and because if its construction and installation it was not testable.

This leaves the operator with a difficult decision. The failure of a platform riser can have significant consequences, as seen in the Piper Alpha disaster. That resulted in a major fire because of the fuel in the pipeline.

Having set up this real-life example, Mike returned to the guidance to give context to the actions that were taken. The guiding principle is that the risk needs to be below an upper tolerability limit; generally in UK law this upper limit is an individual risk of death once in 1,000 years. If below that then the risk should be demonstrated to be as low as reasonably practicable (ALARP) and there should be significant certainty in the assessment that this is the case.

The level of risk undertaken to demonstrate that the risk is as low as reasonably practicable should be proportionate to the complexity of the problem and the magnitude of the risk (or potential consequences). In the case of the offshore platform, the driving concern came from the scale of the potential consequences that could arise.

The guidance is also structured in terms of looking at what is more effective. Eliminating the hazard is more effective than trying to prevent or mitigate the consequences. There is a hierarchy of action which is consistent with the Health and Safety Executive guidance.

The guidance states that there is no position for a reverse ALARP argument. That is to say, if there was a safety system that is no longer functioning, and the platform only has a short lifespan left, ALARP cannot be used to argue that it does not need to be replaced. If it was good practice before, it remains good practice. The ALARP principle cannot be used to reverse that.

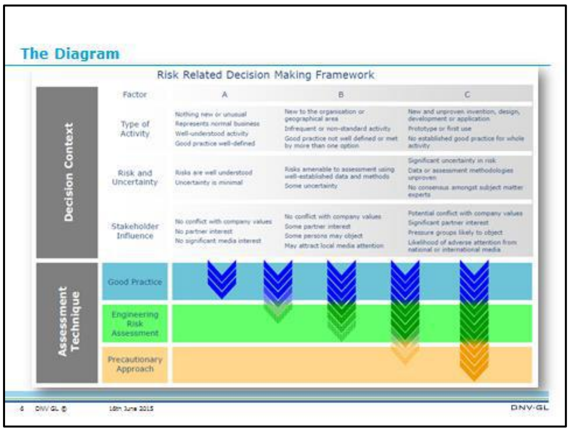
The real risk must be represented. This means, for example, looking at the condition of the assets under consideration rather than using generic data. There are also warnings over taking too narrow a picture of risk, or making decisions which just transfer the risk to someone else. The final piece of guidance Mike highlighted was the need to take uncertainty into account.

The guidance provides a framework and process for making decisions. It looks at the context of the decision being made. The context is affected by the degree of novelty, the perceived risks and the stakeholders involved. The methods it makes available invoke industry best practice. If a certain method is used throughout the industry, then there needs to be a very good case for not using. If it is not followed then there is an onus to do something at least as good, if not better.

If good practice is not well defined, then engineering risk assessment may be used. This could be consequence modelling, risk assessment and other general tools. The precautionary approach, using conservative assumptions, should also be followed where there is significant uncertainty and high potential consequences.

These decisions have to be taken in a way that enables the people doing the technical work to communicate that message up the organisation. They have to communicate the arguments to senior management in a way that can convince them to make difficult decisions.

The revised framework sets out the elements to define the context: the type of activity, the risk and uncertainty, and the stakeholder influence. These are shown in the upper portion of the model. They govern the choice of approach (good practice, engineering risk assessment and precautionary principle) as shown in the lower portion of the model.



Situations represented by the left hand side are those which are well known, and therefore lend themselves to the sorts of good practice which may well be defined in codes and guidelines. Situations represented by the right hand side are more likely to be unique, and involve uncertainty, and therefore require a multitude of approaches.

Mike then returned to case study of the caisson on the offshore platform. It was important to keep the risk assessment as simple as possible. This helps to make sure the assumptions clear, the ability to test the uncertainty is clear and easy, and it facilities the communication of the decision up to the senior management.

There were four cases considered. Personnel on-board vary depending on whether the platform is in normal operations or whether construction and repair work was being carried out. Also, because the condition of the subsea isolation valve on the pipeline was unknown, it was necessary to consider situations where it was working and where it was failed. The consequences assessment was based on the full rupture of the pipeline.

Essentially the situation presented high consequences, but also high levels of uncertainty.

In each case the risk assessments suggested that operation would be at levels of risk above the tolerable limits. This was communicated to senior management and the difficult decision was taken to immediately shutdown the platform.

Workshops were held to decide short-term and long-term measures, and more information was gathered during the shutdown to reduce the uncertainty. In the short-term a caisson restraint was designed and installed, and frequent visual inspections were conducted. It was concluded though that the additional restraint was not a suitable long-term solution. This accelerated the process of removing the caisson at not inconsiderable cost. This allowed the operator to justify restarting production. However, in winter 2013/14 the restraint partially failed, causing damage to the caisson. This also exposed through-wall defects in the caisson. The platform was shut down again. In total 78 days of production were lost while the caisson was removed.

Mike then summarised the key messages from his presentation, and crediting the contributions of the voluntary working group that had worked on the guidance. The guidance on risk related decision making from Oil and Gas UK has been updated. This is intended to provide guidance on the methods to be used in different decision contexts, in particular helping people to structure arguments to make difficult decisions that may incur significant expenditure on events with a very low likelihood of occurring. This is particularly relevant for complex and rare decisions, such as the one illustrated in the case study.

The final presentation, '*Weather Warnings – The Journey*' was given by **Derrick Ryall.** He positioned this topic as a very different form of risk management than that described in the previous talk: the journey that weather forecasting has had from being something of interest, to something that drives the risk based decisions that allow us to mitigate the very real costs of weather impacts.

Looking back at weather events over just the last couple of years, it is not hard to see the sorts of impacts and costs that could occur. While the UK doesn't quite experience the sort of extreme weather events that occur in places like North America, the impacts can still be disruptive and expensive. Many people will remember the storm-damage to the Dawlish rail line in the early part of 2014, cutting off rail connections to the south-west, the flooding on the Somerset Levels and along parts of the Thames. There has been repeat flooding at Cowley Bridge on the rail line between Exeter and Paddington, which has also occurred at the same time as flooding and a landslip on the Waterloo line, and flooding on the M5, simultaneously cutting off several routes in to and out of London.

Heathrow Airport has a throughput that means that it runs at about 98% capacity. If there are any delays or cancelations it can fundamentally affect hundreds of flights. Until relatively recently, unexpected fog in the morning could have had impacts lasting two or three days to correct. They are an example of weather forecast users that now actively plan based on the information it provides. Whilst fog is difficult to predict, as is snow, a risk based warning system means that the operators at the airport can plan short-term flight throughput informed by the forecasts. Understanding the risk of fog can help plan for reduced flights, introducing greater buffers in the system to the disruptions. The advanced warning means that they can contact airlines and cut out flights from the schedule in order to manage load. That means that nowadays, a large event such as severe morning fog, causes a much shorter period of disruption than it may have done previously.

Derrick then described a particular storm event that occurred in Hampshire in late 2013. The Association of British Insurers run catastrophe models which can make predictions about how much a particular weather event may cost based on history. In one example they estimated that the forecast event would cost around £300 million in insurance claims. A few months after the event had occurred they revised this down; only around £100 million in claims had been made. This was largely attributed to the fact that people were warned of the event. The local authorities, emergency services and other organisations were prepared.

A few weeks later Hampshire County Council described how on the Friday afternoon, having been informed of the risk of the event occurring on the following Sunday, they were able to deploy equipment and 4-wheel-drive response vehicles. The rail companies were able to anticipate stopping trains on the Sunday morning, and were so prepared that services were returned by the afternoon. What could have been a significant event, only caused around half a day of disruption. The journey weather forecasting has taken to reach where we are today is of great interest.

Weather has had profound effects on society for centuries. Derrick was able to investigate the Met Office archive, exploring the early documentation of the empirical links between warning signs and weather risks (e.g. "red sky at night…").

In 1541 an act or parliament was passed that actually banned the forecasting of weather; the Witchcraft Act. At that point there was no forecasting skills per se, just a few empirical observations.

Moving much closer to the present day it is possible to track the development of forecasting as we know it. D-Day for example arguably involves a history changing weather risk based decision. Hand-drawn charts were produced to forecast the weather on the day of the landings. By this point people had started to understand the basic dynamics of weather, the concept of weather fronts and the domination of pressure fronts. In the charts produced in 1944 it is possible to see each of the observation point. Observation points existed across the Atlantic and across Europe. This allowed a fairly comprehensive picture of the weather to be built up. Whilst forecasting was generally not beyond a day or two, observations gave the hints how weather might change. The importance of the weather was understood, and a great deal of effort was undertaken to collect those observations on a regular basis. Observations in the Atlantic suggested a ridge of high pressure approaching.

The German charts produced around the same time show a comparative lack of observations. Their limited observations formed a picture that suggested a low pressure, stormy system with no break. They were not aware of the narrow window of opportunity for the Allied forces being brought by the high pressure.

In part weather observations also helped in breaking the Enigma code, as the start of every transmission from U-Boats was about the weather.

Moving on to 1987, a big storm hit the UK, famed for Michael Fish reassuring a viewer on a national forecast shortly before that there would not be one. The charts at this time were still drawn by hand, but there was a greater understanding of weather systems. Very early models were in place, although the supercomputer available then to run these models was about as powerful as a modern smartphone. These coarse models didn't always result in very accurate forecasts. The key point here though is that even if it had been forecast, it is unlikely that anyone would have chosen to, or been able to do anything with that information. There was cynicism and scepticism over the forecasts. Therefore there was no established process in place to react to the forecast. That is the fundamental change between then and now.

Modern forecasting has advanced considerably from the late 1980s. Whilst not perfect, it is possible to see how the simulated models are getting more accurate. The ability to forecast weather has phenomenally improved. Derrick presented a statistical analysis that showed how forecast accuracy has improved year on year. We are at a position now where a 4-day forecast is demonstrably as accurate as a 1-day forecast in the mid-1980s.

One of the key reasons behind this is that we measure the weather very well. More than half of the computing time to make a weather forecast is used to collect and structure the observation data. This data comes from automatic weather stations, ships and increasingly planes. Satellites, both polar and geostationary play a big role in making observations.

The picture of what the weather is doing at any point in time is combined with ever better models of the underlying physics of weather systems. More and more powerful computers enable the ability to build more refined models. These computers generate about a hundred terabytes of data per day.

These detailed modes are not immediately of use to most people. The information and insights they produce need to be simplified and communicated. How do you best take all of the available information and help people make decisions that actually reduce the impact of weather? The key advance in recent years, arising from work with the civil contingency community, is the Severe Weather Warning Service. This is an impact based warning system. It presents events on a colour-coded risk matrix with probability on one axis and impact on the other. In the past, a warning would have been issued depending on the amount of severe weather. But the response co-ordination organisations advised that this could be of limited use as the same amount of snow or rain can have very different effects depending on where they occur. This is the first impact-based warning system of its kind. This impact risk is communicated to Category One and Two responders to allow them to plan their decision making.

Derrick concluded with a case study event occurring in the South West in 2012. A 30-hour forecast, using the most advanced models, indicated a high volume of rainfall. The chief forecaster issued a red warning, the top level, based on the probability and impact.

About 15 years before a major flood had arrived with no warning, bringing local businesses, such as a small garage, very close to collapse. The story was very different in 2012. The red warning had triggered stories in the newspaper which had increased awareness of the potential flood. Local Resilience Forums, Gold Command, the Police, Fire Service and Environment Agency were all prepared. The owner of the local pub was able to seal his door with silicone in anticipation and the garage had helped move every car and their equipment to higher ground. While a very small story, when multiplied to the number of business and individuals around the country that can react to warnings, then the impacts can be significant. The large-scale science, communicated with a risk-based system, allows individuals and businesses to make appropriate decisions and actions to mitigate risk. One of the things we are beginning to see are more and more individuals taking action. The sum of the small actions can have large effects on safety and financial impacts.

The chair thanked the speakers before opening the floor to **questions from the audience**. The first question reflected on the first presentation, and how most of the discussed causes of risk seemed to be under the control of the management of the organisation. The analysis is fascinating and compelling, but what can be done with it? Is the implication that the leadership of the organisation is the critical issue?

Dick Taylor first responded that leadership could very often be crucial. Leaders do not, of course, deliberately put themselves into the position of creating a major event; it is certainly not in their interest to do so. But in many of the disasters investigated, at various levels of the organisation, leaders in hindsight were surprised that they had missed weak (or in some cases strong) signals which would have alerted them to the risk of an event. One of the things that has been done in the SSRC research that may help leaders is the development of the 'probing questions' referred to in the talk. Following many of the events, the inquiries identified specific cases of “blind-spots” amongst the leadership, and areas where they had failed to act. Sometimes this could be from lack of competence or commercial pressure but was sometimes because they were unaware of the real situation. In testing draft question sets with leaders, some issues were shown to be very well covered, with evidence easily produced to demonstrate that, but in other cases it was clear that areas had been overlooked and action was then taken to 'plug the gaps' . In some instances this is about motivating the leadership team to develop the previously mentioned sense of 'chronic unease' referred to by Professor Jim Reason. There is no simple answer to the question, but the awareness that comes from knowledge of the common underlying issues is important, as is the need for those in a leadership position to probe and continually ask difficult questions of themselves and others.

It is also very easy to implement quick, knee-jerk responses following events e.g. encourage more near-miss reports. But without an understanding of the system these can be unhelpful, or even have counter-intuitive effects. The probing questions and use of system dynamics has helped to highlight the dangers of reacting without fully considering the consequences.

Neil Carhart reiterated the importance of understanding the system before acting. If the system is made up of many interacting components, a change in one location can have unforeseen effects elsewhere in the system. An attempt to make improvements in one area may have negative consequences in another area, or may ultimately be bad for the whole system. Also, there are certain systemic structures which can be associated with relatively predictable failure modes. These structures, which could be rules or procedures, affect choices and behaviours in such a way that failure becomes likely, regardless of the individual following them. If the system is structured such that the leadership isn’t getting the right information, or such that it rewards risky behaviours, it doesn’t matter who is involved, failure becomes increasingly likely. Understanding these structures means they can be identified and removed or counter-acted.

The second question suggested that there was an additional problem to those discussed by the first speakers. There are two groups of people in the world that use the words risk and risk-management with completely different meanings. There are those that use them to mean practical risks and practical measures, and there are those that use them to mean commercial risk, costs and programme risk. The second group can be managed through insurance and transfer of risk, or by allowing contingency in the budget. People at top levels of management tend to use risk more in the sense of commercial risk, than in the sense of practical risk.

Dick Taylor responded that while there wasn't time to discuss it during the presentation, there was a recurring theme which was identified in many of the events studied referred to as "Business Environment". This captures just the sort of important issues raised by the audience member. The business may properly be run to provide a profit, or a good public service etc. but the changes which may be seen to drive improved business performance can have adverse impacts on safety and it is important that the impact on safety of organisational change is assessed before being introduced. . The nuclear industry started thinking about the issues around change management back in the early 1990s. The regulator introduced a license condition for the industry specifically to cover change management. That meant that when an organisation wanted to cut back the number of people working in an area, compared to a baseline that they were obliged to provide, or decrease funding, or make any other major organisational change, there was a formal process in place to assess the safety impact of this. The focus within the industry and the license condition has helped draw attention to the risks, but there are sometimes deeper issues that need to be considered. In some cases this can be linked to the earlier point about leaders inadvertently promoting a 'good news culture'. Dick described a potential situation where those at the top of an organisation might make a decision requiring major change, but in assessing its impact people can pick up very quickly, that any feedback that may question or slow the change would not be welcome and the assessment process may not be as rigorous as it needed to be. These 'psychological' factors in the process need to be understood and addressed if the assessment of the safety impact of change is to be properly addressed rather than 'going through the motions' Part of the solution is raising awareness of potential issues and the seriousness of the potential consequences within safety critical industries. Another part is in understanding how the system might not be providing all of the information necessary to make a fully informed and balanced decision, questioning the conclusions and ensuring that there is full accountability for decisions taken.

Nearly all of the 12 events investigated for the research exhibited some contribution from commercial factors so it is an important area to address.

Mike Johnson added that there was a balance between the benefits and the risk of failure. He referred to the lessons of a professional poker player, who described the need to have a willingness to fail far more times than succeed. The reward for succeed is so much greater than the cost of failing. The problem with a lot of risks that we face is that the immediate and certain cost of taking action is apparent, whereas the risk of not taking the action is less tangible.

Nathan Baker followed up on the point by asking whether the changing global environment is bringing in risks and actions we are going to have to take in order to solve bigger global problems?

Mike referred to the potential consequences of climate change, which could be so huge, that the option to do nothing does not seem sensible. Paying something to avoid those consequences should be a fairly simple thing to think through because of the scale of the consequences. If you were to approach it with a formal risk assessment, you would have to do something about it. We see the immediate costs of doing something about it, but don't take into account that in 30 or 40 years' time the consequences could be very severe. This is even more pressing when you take into account the probability of those consequences.

The third question from the audience asked about short term and long term actions. The hazards of the present are influenced by decisions taken in the physical or organisational design many years in the past. The timescales can span generations and the underlying systems can seem too complex to understand, so how can we act proactively to address them? There are potentially significant consequences of not understanding this complexity, and at the very least there is a danger of losing credibility which can affect future trust.

Mike responded by considering the design of the caisson in the case study he described. There were many organisational changes and changes of ownership of the platform of concern. The owners at the time did not necessarily have a full picture of what they were taking on or the initial decisions that the designers, many years previously, and working for a different organisation, had made.

Neil referred to the use of System Dynamics and Causal Loop Modelling as a way of exploring and understanding the complexity of the underlying system. He advocated the use of Group Model Building as opposed to the use of expert modellers. That is to say: involving the experts who work with the system every day in the construction of the models, rather than an expert in the particular modelling technique building a model and trying to impose the conclusions onto the organisation. It should be a participatory process as so much of the value, in terms of understanding the complexity comes from actually constructing the model.

Drawing out the causal links that represent the physical or organisational system with the managers, operators and engineers who work with it, forces those people to articulate their knowledge and assumptions about how it works. They are forced to make their mental models explicit and open to feedback and questioning from others. The group can learn together and collectively build a model representative of the system.

The structures that these types of models represent may have been originally put in place a long time ago. The effects of small changes to that structure could have long term consequences on behaviours and activities.

Derrick Ryall picked up on the issues of credibility, referring again to Michael Fish's infamous forecast. Any number of successes can essentially be forgotten by one or two errors. As forecasts get better and better, you try and produce information which is better at helping to make decisions, decisions which can cost quite a lot of money. We are talking about a science or prediction that has a lot of uncertainty in it whether we like it or not. It will continue to have uncertainty. One of the successes we are beginning to have is in communicating that uncertainty, not in complex probabilistic language but in ways people can understand. This can be as simple as communicating the different alternative outcomes. Trying to educate people about uncertainty can help manage expectations. Of course underlying this is still a need to make better and better forecasts.

Another audience member added that Derrick's presentation had made an excellent case for the importance of good quality information, tempered by uncertainty, for good quality risk-based decision making. They commented on a perception that the weather seemed to be more changeable, and asked whether the models had a capacity to learn or adjust.

Derrick described how the models are not empirical, but are instead based explicitly on the equations of motion. They are based on physics. When things ae pushed outside of the normal range, you don't always know how they will perform. But for the most part of weather forecasting that is not the case. For climate modelling, and climate change collecting historical data and analysing observations is more important. While there is some evidence of changing patterns, such as greater rainfall in certain places across the globe, in the UK the impacts on weather are less pronounce. The evidence for dramatic weather changes is not particularly strong within the UK. Though this is not to say there is no evidence.

What we ae seeing is peoples' expectations on forecasts increasing. Their exposure to weather forecasts and use of them is also increasing. As the models get better, and people understand and trust the forecasts more, it may affect their decision making. A greater belief in the forecast may mean they are prepared to accept greater risks in their actions.

The final question asked about organisational failures, and whether there had been any learning on people's memories of the raw hazards that their own or other industries had encountered?

Mike described how you can often see serious incidents affect those involved with them emotionally. Showing those who fortunately haven't been involved in events the evidence and consequences of those that have occurred elsewhere can also be profound. But this still needs to be constantly reinforced. The leadership can help by being clear about their expectations for the way in which things should be done.

Dick Taylor added that many of the events which had been studied had similarities to those that had occurred previously. Had the training, learning, knowledge retention and culture been different, the later event may not have happened. It was generally true that after a significant event the lessons were taken very seriously for a short period, but this often faded with time. The shuttle disasters of Challenger and Columbia are examples of this. Many of the lessons from Challenger had been forgotten by the time of the Columbia disaster. The report into the Texas City oil refinery event made it clear that had the lessons from the previous Grangemouth event been transferred across to other parts of the same organisation, they may have been very valuable. One of the really important things is to make it clear to organisations that they have to keep these events and their lessons alive in the corporate memory.

Nathan Baker drew the event to a close by thanking the audience for their participation, and the speakers for their fascinating talks. Dave Fargie reiterated those thanks on behalf of the Hazards Forum, and extended those thanks to the chair of the event and the events sponsors. He then invited all those present to continue their lively discussions over refreshments.

[1] Taylor, van Wikjk, May & Carhart, 2015, 'A Study of the Precursors Leading to 'Organisational' Accidents in Complex Industrial Settings', Process Safety & Environmental Protection, 93, p50-67, http://goo.gl/EG5xKP

[2] Senge PM., 1990, The Fifth Discipline: The Art and Practice of the Learning Organization.

[3] Sterman JD., 2000, Business Dynamics: Systems Thinking and Modeling for a Complex World. McGraw-Hill

[4] Carhart NJ, Yearworth M., 2010, The Use of System Dynamics Group Model Building for Analysing Event Causality within the Nuclear Industry. 28th Int Conf Syst Dyn Soc

[5] Oil & Gas UK, 2014, Guidance on Risk Related Decision Making, http://www.oilandgasuk.co.uk/publications/viewpub.cfm?frmPubID=827

[6] BG Group, 'Risks Associated with Caissons on Aging Offshore Facilities', Hazards 25, May 2015, Edinburgh http://www.icheme.org/~/media/Documents/Conferences/Hazards%2025/presentations/thursday/1440-Johnson.pdf
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Calendar of Events

Please check the Events section of the Hazards Forum website for more information at **www.hazardsforum.org.uk** and to see any updates in the calendar. These may include additional events or perhaps amendments to the Events shown below.
Please note that attendance is by invitation to Hf events.

Date	Event	Venue	Contact/further information
September			
7th	ICE Event: Coastal Management 2015	Hilton Amsterdam Hotel, Apollolaan 138, 1077 BG Amsterdam, Netherlands	http://www.ice-conferences.com/coastal-management/
8th	MaRIUS project Event: 2015 Drought Risk and Decision Making	Exeter College, University of Oxford, Turl Street, Oxford, Oxford OX1 3DP, UK	
15th	IChemE Event: Layer of Protection Analysis (LOPA)	Manchester, UK	www.icheme.org/lopa
22nd	Hf Event: Managing risk, quality and the environment in the global arena	Institution of Mechanical Engineers, 1 Birdcage Walk, London, SW1A, UK	admin@hazardsforum.org.uk
24th	SaRS Event: London Dinner 2015	The Royal Over-Seas League, Over-Seas House, Park Place, St James's Street, London SW1A 1LR	www.sar.org.uk/events/london-dinner-2015/ or contact the SaRS office on 01613938411
30th	IET Event: IET Safety Assessments	Austin Court, Cambridge Street, Birmingham, West Midlands B1 2NP, UK	http://conferences.theiet.org/safety-assessments/about/index.cfm
October			
7th	IChemE Event: Human Factors in Health and Safety – Human Factors and Design	Norton House Hotel, Ingliston, Edinburgh, UK	www.icheme.org/humanfactors
8th	SaRS Event: SaRS2015 – Leadership and Management in Safety Culture	Bristol Marriott Hotel City Centre, 2 Lower Castle Street, Bristol BS1 3AD	http://www.sars.org.uk/events/sars2015lmisc/
12th	SIESO Event: Complacency today- Disaster tomorrow	Manchester Conference Centre	sieso.mem@googlemail.com
20th-22nd	IET Event: System Safety and Cyber Security	Bristol Marriott, Hotel College Green, Bristol BS1 5TA	http://conferences.theiet.org/system-safety/about/index.cfm
November			
12th	IET Event: Mostly harmless – a review of qualitative analysis approaches	Birmingham University, Gisbert Kapp Building, 52 Pritchatts Road, Edgbaston Campus, Birmingham, B15 2TT	http://www.theiet.org/events/2015/222623.cfm
December			
1st	Hf Event: Interaction between the regulator and the regulated (provisional title)	Institution of Engineering and Technology, 2 Savoy Place, London WC2R OBL	admin@hazardsforum.org.uk

HSE eNews – Some Examples

++ Updates to Carriage of Dangerous Goods Manual ++
A number of updates have been made to the CDG Manual to reflect ADR 2015, along with changes to the asbestos pages, various organisational name changes, additions to the enforcement matrix, inclusion of vehicles with fewer than four wheels into CDG, and the addition of various links on the resources page.
http://www.hse.gov.uk/cdg/manual/index.htm

++ GMO Public Register Report Updated ++
The Genetically Modified Organisms (Contained Use) Regulations 2014 requires the competent authority to maintain a public register of information about all notifications concerning contained use. This contains information on premises and individual contained uses, the purpose of individual contained uses and the characteristics of the GMOs involved.
http://www.hse.gov.uk/biosafety/gmo/notifications/publicregister.htm

++ 'Norfolk Range' large wheeled dry powder fire extinguishers manufactured before 2009 ++
Norfolk Range large dry powder fire extinguishers, manufactured before 2009 by UK Fire International Ltd, may be affected by moisture ingress at a threaded joint at the base of the unit, rendering the unit inoperable.
http://www.hse.gov.uk/safetybulletins/norfolk-large-wheeled-dry-powder-fire-extinguishers.htm

++ Ministry of Manpower Singapore and Great Britain's Health and Safety Executive sign agreement on closer ties and shared learning ++
HSE's Chief Executive Officer, Dr Richard Judge, met with Ministry of Manpower (MOM) Singapore's Permanent Secretary, Loh Khum Yean, to commit to working together to drive world-class innovation, science and specialist expertise around health and safety in both countries.
http://press.hse.gov.uk/2015/ministry-of-manpower-singapore-and-great-britains-health-and-safety-executive-sign-agreement-on-closer-ties-and-shared-learning/

++ Further HSE enforcement notices issued at Bosley Wood Flour Mill ++
HSE continues to work closely with Cheshire Police and Cheshire Fire and Rescue Services at the Wood Flour Mill in Bosley. As part of the on-going investigation, HSE last week served a further Prohibition Notice (PN) on mill owners Wood Treatment Ltd, in relation to dust issues in a sheds on the site of the mill. The Prohibition Notice has been served preventing work activities until the issues identified involving the processing and bagging of large amounts of paper dust in one of the sheds on site, have been resolved.

This is the second PN served on the mill during the investigation into the fatal explosion on July 17 and inspectors are working with the company to ensure safety and further enforcement action has not been ruled out. An Improvement Notice was served alongside the first PN two weeks ago, with all notices related to conditions in the sheds.
http://press.hse.gov.uk/2015/further-hse-enforcement-notices-issued-at-bosley-wood-flour-mill/

The Hazards Forum's Mission is to contribute to government, industry, science, universities, NGOs and Individuals to find practical ways of approaching and resolving hazard and risk issues, in the interests of mutual understanding, public confidence and safety.

The forum was established in 1989 by four of the principal engineering institutions because of concern about the major disasters which had occurred about that time.

The Hazards Forum holds regular events on a wide range of subjects relating to hazards and safety, produces publications on such topics, and provides opportunities for interdisciplinary contacts and discussions.

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