



Hazards forum



The Hazards Forum Newsletter

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

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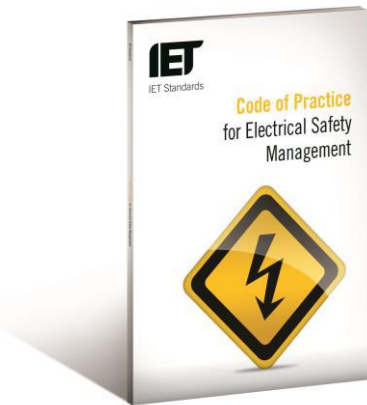
Hazards Forum Executive Secretary: *Brian Neale*

December 2014

Managing Electrical Safety

Paul Bicheno
Portfolio Development Manager, IET Standards Department

Managing Electrical Safety



The Institution of Engineering and Technology (IET) manages a Health and Safety Policy Panel which identifies issues applicable to the health and safety sector and provides guidance to IET members, government and the public (<http://www.theiet.org/policy/panels/health/index.cfm>). The members of the panel are from a broad range of industry sectors.

Members of the policy panel agreed that the level of knowledge associated with the range of personnel that would be responsible for managing electrical safety within organisations could be improved. There are many technical publications on specific aspects of electrical safety but no single document providing a comprehensive overview of the fundamentals of electrical safety in the workplace. In co-operation with the IET Standards department a project was

initiated to produce a comprehensive good practice guide to highlight a range of activities that need to be addressed to ensure a structured approach to managing electrical safety. The result of applying the guide is confidence that risks associated with an electrical system are adequately covered. The structured approach was seen as an important aspect of the project to avoid issues associated with a 'firefighting' or 'gap filling' approach often witnessed by panel members when dealing with a broad range of individuals within organisations. Another important aspect of the structured approach is to offer a way of involving people, gathering evidence and to determine where improvements are needed. The resulting project was published by IET Standards as the 'Code of Practice for Electrical Safety Management' in September 2013 (<http://www.theiet.org/resources/standards/index.cfm>).

Who is the Code of Practice for?

The project committee recognised that a number of people responsible for electrical safety within an organisation may not have an underpinning background in electrical safety. The resulting publication has been written to enable both technical and non-technical people to understand the broad range of activities and key requirements that need to be considered. It is not intended to provide an introduction to the first principles of electricity or attempt to replace the detailed procedures which may already be in place in organisations. Instead, it aims to bridge the gap between these areas of knowledge by providing comprehensive good practice recommendations and advice. As the included activities are based on good practice health and safety principles there is also no differentiation on applicability related to both the size and type of organisation. This means that the code of practice is applicable to a range of responsible people in small, medium and large scale organisations across a broad range of industry, commerce and the public sector, as most organisations have some form of electrical system.

Examples of typical job roles that should find this useful include:

- Operations or engineering managers
- Building or facilities managers
- Project or production managers and engineers

- Health and safety managers and consultants

In the broadest context the code of practice will be applicable to all employees, managers and trainees who are involved in or managing electrically related work who do not have an overview of electrical safety systems. This includes administrators, inexperienced electrical workers and those that may not have electrical skills as their core discipline. It can also be used by those contracting out electrical work to ensure that it is done within appropriate safety management principles.

What is the process?

The code of practice highlights four important aspects to consider. Three general areas (policy, procedure, and people) would be regarded as applicable to all organisations. The final one (specific issues) deals with certain aspects of electrical systems that may or may not be relevant to an organisation. Each of these has an associated group of topics to address (potentially 26 in total). Some example topics taken from each of the above groups include:

- Electrical safety policy
- Leadership
- Safe working practices
- Procedures
- Incident investigation
- Appointments, roles and responsibilities
- Training
- Competence
- Working on or near exposed live electrical parts
- Buried cables on your land

An important element of the overall approach to the project was to include an evaluation tool in the form of self-assessment questions associated with each of the topics. This makes the whole process more practical to the end users as they are able to determine a response to the questions. The questions are designed to determine what level of activity is in place for the respective topics. As can be envisaged this produces a detailed summary of what an organisation actually does (or not) in the context of managing electrical safety. Each topic follows a simple template and includes one or more questions related to the topic as well as some key requirements in the form of simple bulleted lists. The resulting self-assessment summary can then be used to determine any required improvement action plan and report the outcome to interested parties across an organisation.

What does the Code of Practice enable you to do?

An organisation can recognise where they need to improve and be better placed to request assistance in particular areas of their business if using external resources. They can better understand what they need to do to follow recognised good practice activity and produce a prioritised action plan tuned to their particular business needs. Resources whether they are internal or external can be used effectively so that they are addressing the relevant issues and should therefore provide effective management. A final point to highlight is that the intention is not to regard the self-assessment and resulting evaluation as a one shot activity: it should be included within a continuous improvement plan. Organisations change, which mean there is normally an evolution of infrastructure, equipment, processes and people where the underlying risks and the required control measures will also potentially change.

UK to Host International Conferences in 2015 and 2016

Jacqueline Christodoulou
CEO, Safety and Reliability Society

Two safety, reliability and risk international conferences will be held in the UK in the next two years. **Advances in Risk and Reliability Technology Symposium (AR²TS)** will be held in 2015 and bi-annually going forward.

The symposium will be an international forum for presenting and discussing recent advances made in the general area of reliability, risk, availability and maintainability. Contributions will be provided from both the university sector and from industry. It will be of benefit to both practitioners and academics involved in this field who want to keep in touch with the latest developments and perhaps through discussion, influence the future direction of work.

The AR²TS event, now in its 21st session, will take place on the 23rd – 25th June 2015 at Burleigh Court, Loughborough University. An initial call for papers has taken place but if you feel you have a paper or poster to offer please contact the Safety and Reliability Society by email at info@sars.org.uk or by telephone on 0161 918 6663. Please see the conference website for booking and more details www.ar2ts.org.uk.

The **European Safety and Reliability Conference ESREL 2016** will be held on 25-29 September 2016 in the Conference Centre of the new Technology and Innovation Centre (TIC) in the heart of Glasgow.

It aims to bring together industrial and academic experts in safety and reliability, focussing particularly around core areas of expertise and industrial needs, in energy (oil and gas, renewables, nuclear), aerospace, and defence in particular. The Programme Committee will be led by Lesley Walls (Strathclyde), while the meeting will have three co-chairs - Terje

Aven (ESRA), Richard Denning (SaRS) and Tim Bedford (Strathclyde).

Glasgow's unique location provides not only the ideal industrial context for an ESREL conference, but also close proximity to the Scottish Highlands and Islands, golf courses, whisky distilleries and much more. Glasgow is a city of industrial heritage and invention. Importantly for ESREL, it is a modern city of innovation and higher education, with 3 universities and a number of industrial innovation centres, and it is a friendly and open city with a long tradition of welcoming visitors.

This will be first time since 2000 that ESREL has taken place in the UK, where it was last convened in Edinburgh attracting more than 500 delegates to multiple streams over three days.

These international conferences a major opportunity for everyone involved in safety and reliability to come together at an event where cutting edge research meets industry innovation. The AR²TS conference has traditionally nurtured links between academia and industry. The last ESREL conference held in the UK in 2000 forged partnerships on all levels that have lasted and it is envisaged that ESREL 2016 and AR²TS 2015 will provide an opportunity for industry, academia and professional institutes to meet, share knowledge and network to the benefit of all.

Suggestions regarding potential collaborations from academia, industry and professional institutes are welcome. If your organisation is interested in early details about sponsorship or exhibition opportunities at the conferences or wishes to register interest, please contact the Safety and Reliability Society by email at info@sars.org.uk or by telephone on +44 (0) 161 918 6663.

Managing Risk in a Connected World – Time for the Next Generation

Neil Carhart

On **Tuesday 23rd September 2014** the Hazards Forum hosted an **evening event** at the Institution of Mechanical Engineers, One Birdcage Walk, Westminster, London.

The event began with a welcome from the Chairman of the Hazards Forum, Rear Admiral (retd) **Paul Thomas** CB FREng, who also thanked the event's sponsors, the Institution of Mechanical Engineers. He then introduced the chair for the evening, **Dr Neil Carhart**, Research Associate at the University of Bristol and Editor of the Hazards Forum Newsletter.

The future safety of high hazard operations will be led by an up and coming new generation of safety and risk managers who now operate in a world of 'Big Data' with far more information and connectivity than past generations. This event examined how they view the future, the role of learning and how they wish to shape and influence the safety of their respective industries.

The first speaker of the evening was **Dr Mark McBride-Wright**, Safety Engineer within the Risk, Safety and Environmental Group of Granherne (KBR). Mark's talk was entitled '*Diversity: The Key to Securing a Varied and Competent Engineering Workforce*'. Mark is a chemical engineer with experience in Hazard Identification (HAZID), Hazard and Operability (HAZOP), Inherently Safer Design (ISD) and Environmental Identification (ENVID) workshops. Prior to joining Granherne, Mark worked in the Global Risk Practice of Environmental Resources Management (ERM) as a Risk and Safety Consultant. Mark is also a committee member of the Institute of Chemical Engineers (IChemE) London & South East member group and is actively involved in engaging with universities in the region. Currently, he is working on

initiatives involving promotion of diversity and inclusion within engineering. Mark will share ideas on how to introduce modern risk methodologies to a new generation of engineers operating in a connected and dynamic world.

The second speaker was **Dr Emma Taylor**, Principal Consultant for the Global Risk Practice of Environmental Resources Management (ERM). In her presentation, Emma reflected on 'Bridging the Gap' between the expectations of individuals from different generations and with different experiences. Emma studied Physics at University of Oxford, and Safety Engineering and Risk Management at the University of Aberdeen, and is a Chartered Engineer and a Member of the Institute of Mechanical Engineers. Her previous roles include Operations Manager for a safety and risk consultancy in London, and Principal Engineer for Airbus Space and Defence, working with the European Space Agency to design and test spacecraft structures. She is focussed on developing the next generation of engineers, enabling them to input to design and operations of offshore oil and gas facilities.

The final speaker of the evening was **Nikki Bell**, a Chartered Occupational Psychologist working in the Foresight Centre at the Health and Safety Laboratory (HSL). Nikki has worked at HSL for six years and during this time has focussed on the areas of behaviour change and knowledge management. Nikki is HSL's Technical Team Lead for knowledge management. Her current work focusses on the development and application of techniques to support the capture and sharing of business critical knowledge, fostering a knowledge sharing culture and engaging staff to share knowledge. Nikki was previously

employed by the Ministry of Defence (MOD) for three years, and was involved in a variety of research projects in occupational health and employee relations/motivation, the results of which were used to inform Army policy. Nikki is a member of the British Psychological Society and the Health and Care Professions Council. She presented on 'Sharing knowledge across five generations in the workplace'.

The Chair set the scene for the evening's event by highlighting a recent report by EngineeringUK¹ which concludes that the UK engineering industry needs to recruit 1.86 million people with engineering skills into the industry between 2010 and 2020. This diverse group will present a complex range of expectations and needs in terms of training and working. The challenge is not just in safely and efficiently meeting the demands of the present, but also in simultaneously developing the capability to meet the demands of the future. Adequately preparing the next generation of engineers is central to achieving this.

The first talk of the evening was delivered by **Dr Mark McBride-Wright** on the topic of diversity as the key to securing a varied and competent engineering workforce. He began by reflecting on the figures produced in the EngineeringUK report. The engineering industry is facing a significant future skills shortage which may impact its ability to meet the needs of tomorrow's society. The industry must be attractive to as diverse a group as possible if the necessary numbers can be recruited and retained to overcome this gap.

Mark described his personal journey and the motivation behind his interest in the subject he now practices as a career. In 2005 he moved from Edinburgh to London in order to study for a Masters in Chemical Engineering at Imperial College. Inspired by a fourth year design project he followed this with a PhD between 2009 and 2013 conducted within the Qatar Carbonates and Carbon Storage Research Centre. His research looked at the viscosity and density measurements of mixtures of CO₂, brine and hydrocarbons over a range of

temperature and pressures. The results of these experiments were used to develop and validate models for predicting thermophysical properties and phase behaviours in industrial contexts. In addition to his interest in this field of research, he also explained being driven to work in a stable, global industry. This led him to work as a consultant in Global Risk Practice for Environmental Resource Management, before joining Granherne KBR as a Process Safety Engineer.

After reflecting on some of the personal motivations for his choice of career, he posed the question of the Hazards Forum audience. What was your motivation for joining the engineering industry? Mark suggested some possible reasons which had been mentioned to him by fellow engineers including the desire for a morally rewarding career, job satisfaction, continual development, the opportunity to interact with other disciplines and inspiration from Trevor Kletz and Frank Less. Understanding what motivates people to join an engineering profession is an important step in attracting and securing a competent workforce.

Mark then turned to look at some of the ways in which the next generation of Safety Engineers may require proficiency in a broad and developing number of areas of engineering, and particularly the skills in working with multiple stakeholders. One such area is 'Big Data', or data sets so large that traditional methods cannot process them effectively.

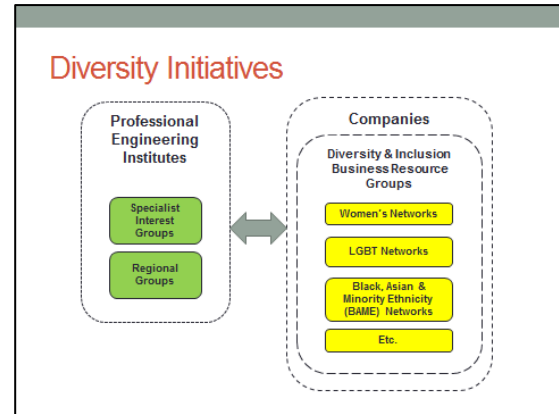
Industrial facilities still struggle with unexpected shutdowns and incidents. Current risk assessment methods cannot predict risk dynamically. There are however data sets available which might provide the information necessary to make advances in this. Harnessing process-specific big data with information on precursors may indicate when risks are in the developing stages. If adequate methods are developed this presents opportunities such as greater transparency in risk information, automatic problem identification, better informed fact-based decision making and more

effective monitoring of maintenance measures. Predictive assessments of big data could complement current Process Safety Management (PSM), hazard identification and Quantitative Risk Assessment (QRA) techniques, and thus lay the foundation for next generation risk assessment².

Furthermore, under the current paradigm Safety Engineering is often perceived as an independent function, sometimes even as an “add-on” to the other functions. It requires specialised training and expertise, and can suffer from communication gaps with other engineering disciplines. Future Safety Engineers need to become better integrated into existing engineering disciplines. Increasing complexity means they also need to be more innovative and creative in their approach to system diagnostics.

Bright and enthusiastic students are needed to meet the challenges of these developing areas of importance. This exists within the context of the general skills shortage and gaps across the engineering industry. There is a pressing need to attract the high number of people with the right skills. However, there are barriers to achieving this. For example there is a perception that engineering is a non-inclusive domain, which may not be welcoming or appealing to people in minority groups. There are fundamental ethical reasons why this needs to be addressed, some of which are also represented in legal requirements. Creating an industry attractive to as diverse a selection of the population as possible is the only way the skills gap will be fully addressed.

A lack of diversity should not be a reason for people choosing another profession over engineering. Nor should it be a reason for current engineers to be leaving the profession and contributing to the attrition rate seen in the demographic of female engineers.



Initiatives to address barriers to diversity are necessary at every level, not just within organisations, but across sectors and the engineering profession as a whole. These need to work together to ensure the industry is inclusive to all potential members of the next generation of engineers.

For the second part of his talk Mark looked at some specific ways in which the skills and knowledge gaps the industry is facing could be addressed.

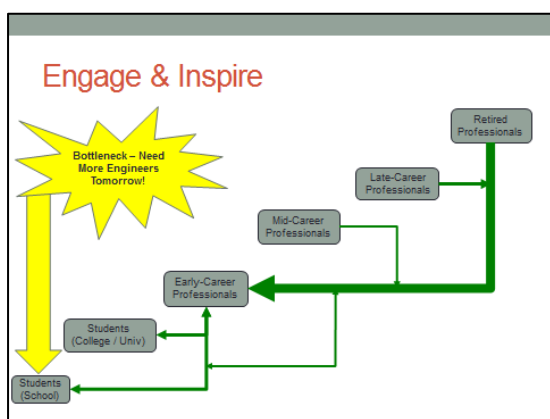
One important area concerns *Knowledge Sharing Initiatives*. New engineers joining the industry may be trained in the necessary skills, but they will not have the same levels of knowledge and experience as those who have been working within the industry for some time. The communication of essential knowledge concerning project risks, occupational health and safety, risk management, process safety engineering, technical safety, personal safety, policies and procedures, acronyms etc. is vital.

There is a flow of engineers and engineering training from schools, through college or university to early-career professionals, right through to retirement. There is potential for a knowledge bottleneck, as well as a resource bottleneck, as those leaving the industry take with them more knowledge and experience than those joining. It is essential therefore that those further along their professional journey engage with, and inspire, those nearer the start. More established engineers should be encouraged to consider how best they could give back to the industry by sharing

the lessons they have learnt. Knowledge Sharing Initiatives provide a means to achieve this.

These initiatives could include developing new safety engineering workshops, integrating training with university and college syllabuses, and providing students and early-career professionals with better access to safety and risk experts.

Both social and professional networks can provide a means to efficiently share knowledge and experiences. Technologies are developing to facilitate this networking and knowledge sharing. Creating and sustaining these networks can help address many of the challenges the industry is facing.



Mark concluded his talk by summarising his thoughts on preparing for the next generation. Safety engineering in the future will require a broad-reaching knowledge and a range of skills, some of which will be new to the industry. There is currently a bottleneck in the pipeline for attracting talented students into the industry and an attrition of existing talented engineers to other professions. To overcome these challenges it is imperative that the engineering profession is appealing to as diverse a population as possible. The key to this is in considering how each of us can individually be a role model for existing engineers and the next generation. We must then take action to become that inspiration.

The second speaker was **Dr Emma Taylor**, Principal Consultant for the Global Risk Practice of Environmental Resources Management (ERM).

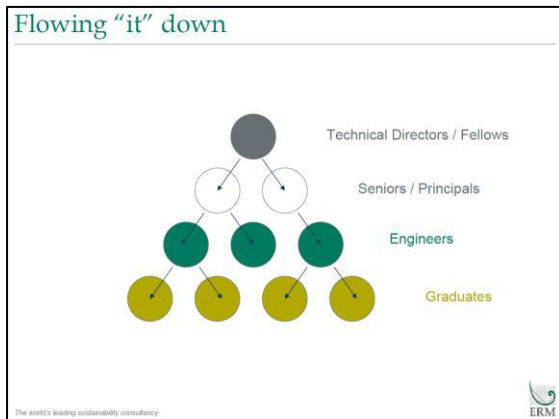
Emma set the scene for her talk by highlighting how everybody in the room believes in managing major hazards and they have a personal commitment to protecting people and protecting the environment. Their commitment to this is evidenced in their attendance at the Hazards Forum event, as they look for ways to pass the baton on to the next generation, or receive it depending on their stage in their career. Noting that the baton in question is the ability to manage major accident hazards, protect people and maintain the environment for future generations, she commented also that describing what needs to be passed on can sometimes be difficult to define – what exactly is “it” that we believe the next generation need to know.

The talk presented her individual view, based on her personal experiences working in the O&G and aerospace industries. She reflected on the fact that people don’t often think about engineers having a calling in the same way they may think doctors have a professional calling. Nor do they tend to associate engineers with a passion for their profession in the same way they may associate actors with a passion for their craft. Emma urged that we do not let these perceptions distract us from the quiet purpose with which we execute our jobs. It should not dilute our intent or commitment to the goals of Safety Engineering.

Emma described how she is lucky to have been mentored by those with direct experience of the challenges involved in protecting people and the environment, and how those experiences had led to a clarity and urgency in their commitment to our profession. She expressed it as being “authentic and core to their role as an engineer” and emphasised the message that personal leadership is as important as technical skills, and competency in execution of those skills.

She outlined her talk as putting forward a framework for characterising exactly what “it” is we are looking to pass on to the next generation, and the tools and approaches through which this can be achieved, as

well as an examination of what the barriers might be.



The talk did this by exploring three themes or framing questions:

- Is there a bridge or “disconnection” between the generation of 20 year olds and the generation of 40 year olds?
 - It is clear that between these generations there have been significant transformations such as the internet, data, connectivity, and social media, to name just a few examples.
- What is “it” we are looking to pass on?
 - She raised the question that this could just be knowledge, or perhaps there might be more to “it”?
- How do we transfer “it” between the generations?

It is also worthwhile noting that whilst this flow down from the experienced engineers is primarily a transfer of knowledge to the next generation within the safety community, the goals of our industry and our skill sets are such that we cannot achieve our aims without collaboration, getting the understanding and buy-in from the broader engineering community, as well as legislators, financiers and other stakeholders. This informs and shapes the scope of the task of preparing the next generation. Sometimes our advice might not be welcomed, so we need to find ways to work through that barrier to ensure that the objectives are met safely.

In answering the first question, as to whether there is a bridge (or a disconnect) between the generations, it is important to recognise that not all of those in their 20s are the same, and not all of those in their 40s are the same. So how can we evaluate the strengths and weaknesses of the different generations? How can we go about answering our first question, without being able to travel back in time to really experience how other generations operate?

Emma described how she was lucky enough to have personal experience of that gap by going back to university after graduating in 1993 and a 15 year career in aerospace and space industry engineering, R&D and academic research. In 2008 Emma joined the new cohort of 20-something students at the University of Aberdeen’s MSC in Safety Engineering and Risk Management. This allowed her to reflect on how things had changed since completing her first degree. She commented that it was the “next best thing to a time machine”! For example, in terms of engineering education, people are taught in a different way and a broader range of topics are taught. Learning skills have evolved, such that the students demonstrate more flexibility and creativity. There are also much more sophisticated uses of IT and data management.

This experience demonstrated to Emma that there is a bridge between generations through which it is possible for information to flow. The next question however is what exactly is “it” that we are looking to pass between the generations?

Emma focused not on development of new technologies and tools (e.g. more advanced CFD), but on the rapidly increasing collection of standards, guidance, best practice, regulation and legislation. In previous generations it may have been sufficient to provide someone with a small number of books to read in order to pass on vital information, but now it is in effect a never ending task to pass knowledge on in this way. She suggested that the old approaches are no longer sufficient on their own, and raised the question as to where and how should we

focus our efforts to transfer the knowledge to the next generation?

One tool for achieving this, and structuring the learning, is to break it down into a framework of four categories:

- Knowledge and Understanding (facts and information);
- Cognitive skills;
- Key skills;
- Practical skills.

Using this framework it is possible to take something that you want someone to learn, to guide them from A to B, and onwards to the point at which they can develop and apply the skills for themselves.

It is clear that professionals in the field, those with experience, need to curate the knowledge base. They need to select those documents which contain the most important information and provide them for discussion. Emma put forward the concept that this forum could be considered to be a “Book Club”³. In terms of development, this type of informal discussion is equally as important as the study of the technical content, and helps develop the implementation skills that complement the initial Knowledge and Understanding framework. The discussion should present real world scenarios in order to demonstrate the facts and information having relevance in practice.

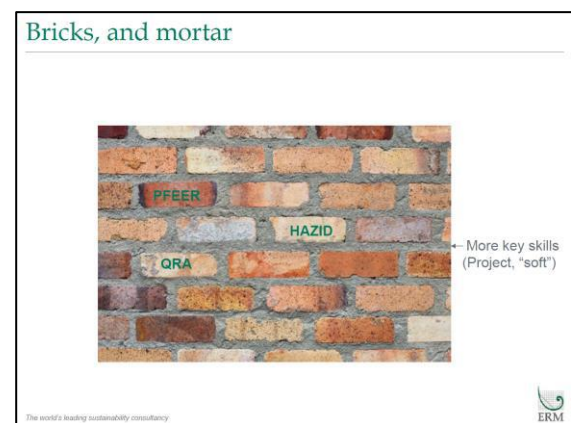
Emma then raised the question as to whether this approach would provide the next generation with everything they need to manage the major hazards of the future? She set out a model where key pieces of legislation and tools used in the Oil and Gas sector provide a framework for management of major accident hazards, including:

- Quantitative Risk Assessment (QRA);
- Hazard and Operability Study (HAZOP);
- Prevention of Fire and Explosion, Emergency Response (PFEER) Regulations.

Each of these, along with the supporting documentation (including standards, industry guidance and best practice), could be thought of as a cornerstone, or brick in the “wall” of hazard management. Each is then supported by a number of other documents containing facts and information, including those supporting the implementation of Quantitative Risk Analysis (QRA) and Hazard Identification (HAZID).

However, there is also the “mortar” between these bricks, and this represents a different type of “it” that needs to be passed on between generations. This type of “it” consists of another category of key skills.

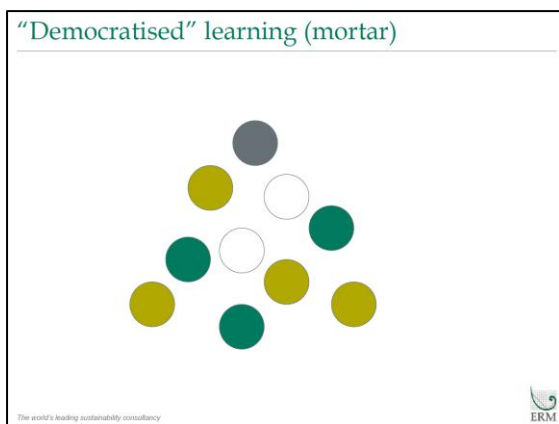
The Chartered Engineer competency framework from the UK Engineering Council (UK-SPEC) provides a guide for what these key skills (or “mortar”) ought to be. This could include things such as project management, contract and financial awareness, marketing, and awareness and use of engineering code of conducts. Personal awareness and understanding of how to interface with others are also important skills. These form the “ecosystem” around which the Safety Engineer deploys their technical competencies.



Emma put forward her view that, from day one of their graduate careers (or earlier!), Safety Engineers should be introduced to the full scope of CEng competencies and encouraged to develop their understanding of them, even if they are not using them directly as part of their day to day role. Also included in the scope of these key skills, bonding together the core

technical knowledge “bricks”, are the softer skills such as negotiation, influencing to consensus, team building, leadership skills, cross-sector communications, building rapport, and setting strategies and visions. These are things that all engineers will need to draw on during their career, even though they are perhaps perceived as being more relevant to those in management roles.

The development discussions between those persons with career experience and the younger generation should also consider these skills. Using real world examples they should explore together what worked and what did not work in particular situations where major accident hazard management provided an engineering challenge. She observed that people should not feel that they need to go on a formal training course to develop and best implement these soft skills that are core to achieving our objectives of protecting people and the environment through management of major accident hazards.



Emma put forward the view that access to these development opportunities should be “democratised” and that courses are not the only path to access and improve these skills. Discussions with senior engineers, along with mentoring and coaching, should be seen as equally valid routes to development of these competencies.

As the complexity of projects increases and the required number of interfaces with people within and outside of the Safety Engineering community increases, the more important these skills become in

achieving our goals of protecting people and the environment. These wider skills are therefore an equal part of the “it” we should look to pass on to the next generation along with technical knowledge and understanding.

To conclude her talk, Emma returned to her earlier reflection on those who mentored her, and their personal commitment to managing major accident hazards, protecting people and protecting the environment. She observed that all Safety Engineers should be looking to develop that sense of personal contribution and commitment; an understanding of what and how we contribute to the overall goals of our profession.

She closed the talk by posing the question “What kind of engineer are you?” to the audience. There are many different types of technical specialists, but we need to look beyond these categorisations to answer properly this question. We all have an individual set of cognitive and soft skills that each engineer will implement in a different way in different contexts, but beneath even these is the driving purpose which shapes the kind of engineer we become, and the personal impact we can make⁴.

In conclusion, the more we understand our personal contributions to Safety Engineering, and how we work together to protect people and the environment, the better we become placed to develop the next generation of engineers.

The final talk was given by **Nikki Bell**, a Chartered Occupational Psychologist working in the Foresight Centre at the Health and Safety Laboratory (HSL).

Nikki began her talk by describing HSL⁵, which employs about 400 people on its 550 acre site in Buxton. HSL supports the Health and Safety Executive in incident investigation and national inventions to improve health and safety, as well as generating new knowledge and foresight to inform evidence-based policymaking. HSL also provides direct support to industries looking to improve their Health and Safety performance through tools,

technical services, bespoke research, training and consultancy. All of this contributes to delivering HSL's mission: 'Enabling a better working world'.

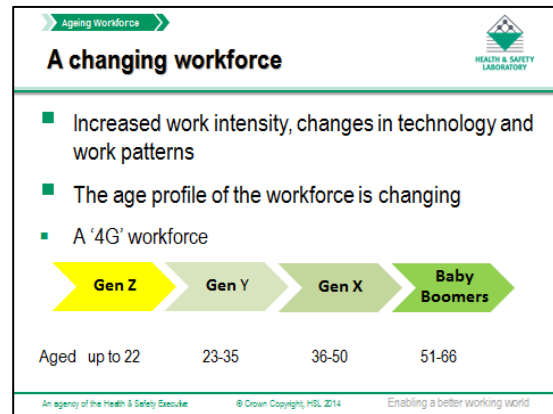
The HSL workforce is made up of many different disciplines from safety engineers and explosives experts to microbiologists and occupational psychologists. As a result, identifying optimal and innovative solutions to H&S problems for regulators and industry is a key outcome of HSL's multidisciplinary working.

HSL recently established the Foresight Centre which brings together 'futures', knowledge sharing and consultancy specialists in order to help businesses address current, emerging and future Health and Safety challenges. The knowledge sharing specialists are working to facilitate and further promote the connections between disciplines.

Nikki then described the work of her Foresight Centre colleagues into demographics, the nature of work patterns and the implications for the next generation of workers. For example, not only has there been a change in the technologies associated with the way we work, there is evidence that the intensity with which we work is also increasing. Furthermore, working patterns are changing. This is influenced by a number of factors including the economic climate and industry needs.

The average age of the UK workforce is increasing in line with the ageing population. This trend is predicted to continue as default retirement ages become less common and the age at which people receive a state pension increases. This presents advantages as it means organisations can retain critical knowledge for longer, but it also raises potential new challenges such as transferring the knowledge across generations. As people stay in work longer it means there is more diversity in the number of different generations working side-by-side. This has been referred to as a '4G' or 4 Generation workforce (see below), but some organisations also include those aged

over 67, so could be classed as having a '5G' workforce.



Work at the Foresight Centre has shown that broadly these generations tend to be influenced by the societal values at the time they were born. Stereotypes have been formed relating to each group, for example, Baby Boomers continuing the 9 to 5 work ethic and traditional career paths of their parents. Generation X does not necessarily follow this pattern. Generation X also grew up surrounded by increasing use of the PC and see technology as a distinct function, whereas younger generations see it as an integrated part of their lives. Generation Y, brought up in a world of fast moving communications technology are often stereotyped as 'digital natives' who can manipulate technology in different ways to their advantage. Similarly, Generation Z has a lifelong experience of technology and influence the demand for its use. From Generation X onwards the accesses to knowledge and freedoms offered by technology are unprecedented to those that went before.

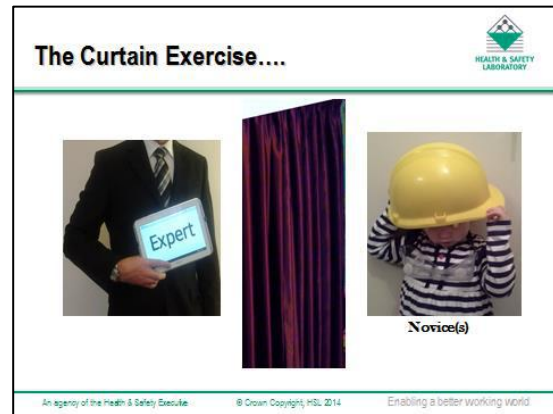
Despite this generational stereotyping and compartmentalisation, there is evidence to suggest that there are equally important, if not more important, differences within each generational group than between them. One 35 year old may not have the same expectations, approaches to work or learning styles as another. Individual life experiences can have an influence. As such, it is not possible at present to specify Knowledge Sharing techniques or approaches for particular use within each generation, or for bridging the gaps between them.

Despite the ageing workforce, people do still retire or move between industries, taking with them valuable knowledge. As discussed by the first speaker of the evening, the workplace is also becoming increasingly diverse in ways other than age. As a result, knowledge retention and the exact ways in which this is best achieved for those with different expectations and working styles is becoming increasingly important. We need to know more about changes in working patterns and technology, how these interact and the implications for Health and Safety.

Having described the background to the challenge, Nikki then presented a number of Knowledge Sharing techniques chosen for their pertinence to modern working and broad application across all generations. There are, however, many more which may be better suited to specific audiences and circumstances. These techniques can generally be split into two groups: those designed to capture knowledge which is readily documented and those designed to share knowledge which is more tacit in nature. Years of experience can result in tacit knowledge that resides in an expert's head; this can manifest itself as intuitive reaction. In some instances, the know-how can be captured, documented and then passed on at a later stage, in other circumstances the knowledge is best transferred by connecting people.

For example, a popular method is the one-to-one interview with an expert. Experience so far has mainly been with those approaching retirement, but it may also provide a way to capitalise on the knowledge and experience of someone new to the organisation. Once elicited in this way the method could result in recorded or documented outputs such as mind-maps, flowcharts or procedures. However, most peoples' know-how does not translate well when written down. Deep-rooted tacit knowledge can be difficult to express in words and often is only fully revealed when confronted with the relevant situation. Simply trying to write it down may result in missing

important things which only occur in context. Connecting people, perhaps though harnessing modern technology, setting up learning experiences and scenarios, can be important for bringing tacit knowledge to the surface and transmitting it between individuals.



The Curtain Exercise is an example of such a tacit knowledge elicitation and communication approach. It allows for staged work situations, providing an insight into how experts make decisions in practice. Nikki described an example where on one side of the curtain was an expert who analyses Personal Protective Equipment (PPE) from accidents as part of the investigation process, and on the other side were two novices in this type of work. The curtain or screen forces the expert to articulate every stage of their thought process rather than responding instinctively, masking their tacit knowledge and internalising their decisions. The expert had nothing, while the novices had the PPE. The novices were not allowed to act until instructed to do so by the expert. The expert would therefore act out the process through the novices who could ask any questions they felt relevant. The decision making processes which came to light were recorded, but the novices felt the head-to-head learning was the most valuable activity.

In certain safety critical circumstances the task would need to be simulated in some way, or recorded so as to not interrupt the expert. Questions could then be asked of the expert after the task by watching the recording back with the novices.

Another approach is an informal seminar-type event. Nikki described an event where an expert photographer brought example photographs, gave an overview of how they were taken and answered detailed questions from the audience. This can be a useful technique for sharing best practice and expertise, and avoids re-inventing the wheel. This sort of approach allows an expert to share their knowledge with a larger audience in a shorter space of time than head-to-head discussions. It also lends itself to demonstrations and presentations.



Tacit knowledge can also be shared within Communities of Practice (CoP), which bring together people who share common goals, problems or interests to regularly exchange knowledge and experiences. This can include on-line communities harnessing collaborative technology. However, it is important to also meet in person when the community is established to motivate participation, and periodically throughout its lifecycle to sustain member involvement. CoPs rely on trained community facilitators in order to best succeed. If a question is asked and nobody replies, then the likelihood of them using the facility in the future reduces. The community facilitator must organize the face-to-face meetings, ensure the purpose and expectations of the CoP are clear, help people to engage with the community and answer their technical questions.

'Knowledge Marketplaces' or 'Swap Shops' are another method for knowledge transfer. This activity aims to identify and connect together those who have knowledge they can offer to others with

those who require the information. The HSL has run several such Knowledge Marketplaces, and they show potential; particularly in helping those new to the company to identify who knows what, and build their networks accordingly. This could be done simply using paper and physical boards, or could utilise modern technology (e.g. social media).



Nikki concluded her talk by summarising the lessons from the experiences of the HSL into four key points. Firstly, let those with the knowledge, or those who require knowledge, drive the selection of an approach to knowledge sharing. This should take into account the type of knowledge, the task in question, and the wider context, such as whether there is a common language between the interested parties. Secondly, focus on how those involved would like interactions to occur. This needs to take into account the different values and behaviours of people within different demographic groups. Thirdly, there are many different capture and share methods, but these are not set in stone and can be combined and adapted. Finally, as workplaces and workforces change, there are questions that still need to be addressed. The Foresight Centre is continuing to investigate these, including identifying changes in the age profile of the workforce, working patterns and the way in which work is carried out, and exploring the Health and Safety implications of these changes.

Following the three talks the Chair thanked the speakers before inviting comments and questions from the audience. A lively discussion session

followed, which continued to highlight the importance of making connections and collaboration. It was highlighted by one audience member that industry had perhaps made greater advantages at encouraging this, and meeting the expectations of younger generations in general, than academia had. Academia, which is still very compartmentalised, both physically (with closed offices as opposed to the open-plan layouts now favoured by industry) and organisationally. Many of the structures of academia can make interdisciplinary work difficult, and this may be preventing it from providing graduates who meet the skills needs of the engineering industry in the 21st Century.

In drawing the event to a close, the meeting's Chair highlighted the common thread that had emerged from each of the talks and the discussion period. Making connections, engaging with each other across demographic groups and sharing knowledge are critical to safe and successful engineering. Everybody has a role to play in constructing a bridge between generations and other groups,

and ensure the sharing of knowledge and experiences.

The Hazards Forum Chairman concluded the event by reiterating thanks to the speakers and the evening's sponsors before inviting the audience to continue their discussions over refreshments.

¹EngineeringUK (2014) 'The State of Engineering'

²For more information see Pariyani et al (2013) 'Processes risk assessment uses big data' [<http://ggo.gl/XUqj7x>]

³To discuss this initiative more and potential participation, please contact the Secretariat at the Hazards Forum via the usual email address: (admin@hazardsforum.org.uk)

⁴Craig, N & S. Snook (2014) From Purpose to Impact, Harvard Business Review, May 2014 [<http://goo.gl/7ij0kT>]

⁵For more information on the Health and Safety Laboratory, please visit: <http://www.hsl.gov.uk>. Nikki would welcome communication from those interested in any of the issues discussed: Nikki.Bell@hsl.gsi.gov.uk

Parliamentary and Scientific Committee

The latest issues of "Science in Parliament", the journal of the Parliamentary and Scientific Committee of which the Hazards Forum is a member, has among its contents the following articles. Any member who would like any further information on any of the articles below should visit the PSC website www.ScienceInParliament.org.uk

THE RISE OF SCIENTIFIC COMPUTING – A UK SUCCESS STORY	Professor Robin Grimes
TRUSTED TIME	Leon Lobo
ANTIMICROBIAL RESISTANCE AND THE ANTIBIOTIC PIPELINE	Tracey Guise and Professor Laura Piddock
GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE	Professor Bruce Yardley
BUILDING A STAR ON EARTH	Dr A E Turrell
WORLD-CLASS SMART MATERIAL – BORN IN BOLTON	Daniel Keating
INTELLIGENT MOBILITY ACROSS THE UK'S TRANSPORT SYSTEM	Professor Sarah Sharples
BRITAIN'S INNOVATION SECTOR HAS THRIVED DURING THE RECESSION	Professor Richard Brook
RADIOTHERAPY –THE STATE OF THE NATION	Dr Alexandra Stewart and Professor Andy Beavis
DID WE REALISE OUR POTENTIAL	Address to the P&SC by Professor David Lane, Professor Sir Nigel Shadbolt and Professor Dek Woolfson
RECOGNISING INSPIRATIONAL SCIENTISTS AND ENGINEERS (RISE)	
A LEVELS – ARE THEY FIT FOR PURPOSE?	Address to the P&SC by Dr Michelle Meadows, Professor Ian Haines and Dr Sarah Main
A ROBOT WALKS INTO A BAR...	

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.

Date	Event	Venue	Contact/further information
January			
14 th	IET Event: The World of IT Security – Past, Present and Future	Royal Institution of Great Britain, 21 Albemarle Street, London W1S 4BS	www.theiet.org/events/local/211352.cfm?nxtld=208107
20 th	IChemE Event: High Reliability Organisations	1 Portland Place, Marylebone, London W1B 1PN, UK	www.icheme.org/highreliabilityorganisations
22 nd	SaRS Event: Offshore QRA	Birchwood Golf Club, Kelvin Close, Birchwood, Warrington WA3 7PB	http://www.sars.org.uk/branches/the-north-west-branch/
27 th	SaRS Event: Root Cause Analysis – What's the purpose?	BAWA, 589 Southmead Road, Filton, Bristol, BS34 7RG	http://www.sars.org.uk/branches/western-branch/
February			
10 th	SaRS Event: A common approach to transport safety – are helicopters different?	BMT RCL Segensworth, 12 Little Park Farm Rd, Fareham PO15 5SU	http://www.sars.org.uk/branches/solent-branch/
18 th	ICE Event: Engineering Underground Space	Institution of Civil Engineers, 1 Great George Street, Westminster, London SW1P 3AA, UK	www.ice-conferences.com/ice-engineering-underground-space/about/
25 th	ICE Event: Commercial issues for built environment professionals	ICE NW Regional Office, 9th Floor St James's Building, 79 Oxford Street, Manchester, M1 4EG	www.ice.org.uk/Events-conferences/Events/Commercial-issues-for-built-environment-profes-(1) icenw@ice.org.uk
March			
4 th	IChemE Event, Hf Supported: Human Factors in Health and Safety, Module Two	Edinburgh, UK	www.icheme.org/humanfactors courses@icheme.org
24 th	SaRS Event: ASCOS: Streamlining Certification in the Aviation Industry	BAWA, 589 Southmead Road, Filton, Bristol, BS34 7RG	http://www.sars.org.uk/branches/western-branch/
24 th	Hf Event: Annual General Meeting	Institution of Civil Engineers, 1 Great George Street, Westminster, London SW1P 3AA, UK	admin@hazardsforum.org.uk
24 th	Hf Event: Are there Three Safety Cultures in the Nuclear Industry (Provisional)	Institution of Civil Engineers, 1 Great George Street, Westminster, London SW1P 3AA, UK	admin@hazardsforum.org.uk
26 th	IET Event: Nuclear Engineer for Safety, Control and Security	Bristol Marriot Hotel, Bristol SS1 3AD	http://conferences.theiet.org/nuclear/index.cfm?nxtld=210978
April			
28 th	SaRS Event: The contribution of test and analysis to the No Fault Found (NFF) issues within the UK MOD	589 Southmead Road, Filton, Bristol, South Gloucestershire BS34 7RG, UK	http://www.sars.org.uk/branches/western-branch/
May			
12 th	IChemE Event, Hf Supported: Hazards 25	EICC (Edinburgh International Conference Centre), The Exchange, Edinburgh, EH3 8EE	www.icheme.org/hazards25 hazards25@icheme.org

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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