Enhancing Safety: The Challenge of Foresight

ESReDA Project Group *Foresight in Safety*

Conclusion of the report

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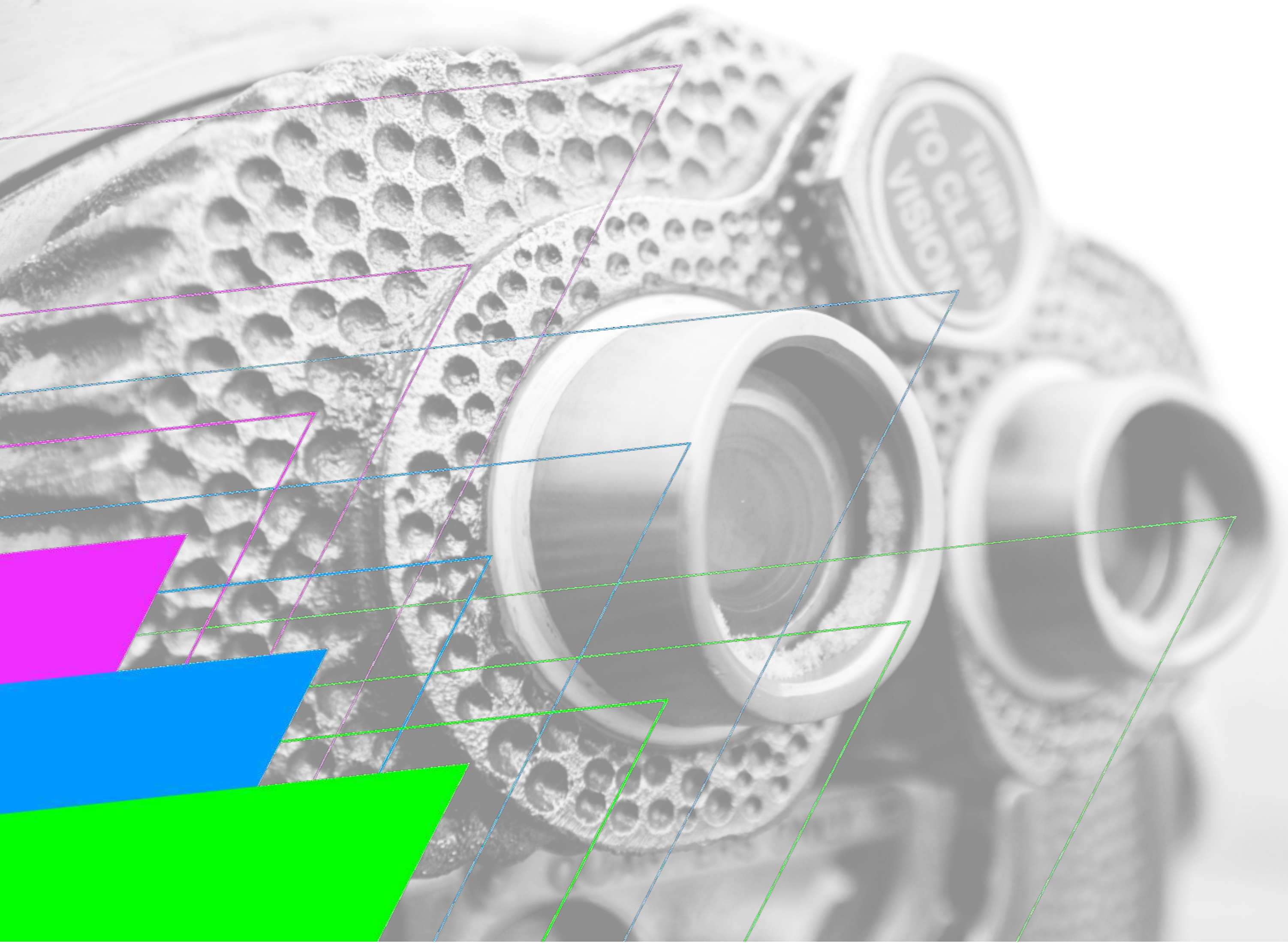

ESReDA
European Safety, Reliability & Data Association

Conclusion

ESReDA Project Group on 'Foresight in Safety'[121]

This conclusion sets out the key messages of the ESReDA Project Group on Foresight in Safety. Please note that each of the other thirteen chapters has its own conclusions.

Overview

The ESReDA Project Group on Foresight in Safety ("the Project Group") is a diverse team of researchers and practitioners. Safety is a multidisciplinary field, and works by exchanging different visions and approaches. The context of foresight in safety is ably summarised in Figure 2.1 of Rasmussen and Svedung (2000)[122]. Although multidisciplinary, some of the knowledge in the field of safety arises from the efforts of researchers working in their own discipline. That means that pretty well everyone else working in the field is either integrating this knowledge, or applying it, or both. Against this background, the Project Group has asked how the concept of foresight applies in safety and what challenges exist.

The word 'foresight' is not new in safety, but neither is it settled. In fact, the connotations of the word are evolving and contended. Since Roman times, the concept of foresight has been used in law to decide matters of blame and causation after harm has occurred. Those legal cases focus on whether the event was itself foreseeable and whether enough effort went into foreseeing it and avoiding it. Although commonplace, foresight resists exact definition or description as a function or capacity. Nevertheless, knowledge can still be shared about the conditions that govern safety foresight and the processes that achieve it.

Collating the Project Group's key messages brought to mind a quotation from Santayana[123]. The first sentence is very familiar: "*Those who cannot remember the past are condemned to repeat it*". The quotation continues, "*In a moving world readaptation is the price of longevity…*" and that our institutions must give "*birth to a generation plastic to the contemporary world and able to retain its lessons*" (Santayana, 1905).

Foresight: Dynamic, Not Static

Foresight is a projection based on our knowledge and beliefs at a given moment. But, new data or further reflection may well change the possibilities we foresee. It is usual to have less knowledge when committing to a particular design or policy, than later when the results of our decisions unfold. By shoring-up our provisional arrangements in the light of new information, we can mitigate the paradox of 'learning later' but having to 'commit now'. The principle for foresight is to remain skeptical and critical, permanently ready to update our models and challenge assumptions. But this principle and the related mindset is costly and it is not without its practical challenges.

Change is a basic concept in safety and unites all its branches (process safety, occupational safety, etc.). The concept can be found in textbooks and programme reports from the 1960s to the present day. At its simplest, safety sees any change as '*the mother of twins: progress and trouble*' (Johnson, 1980[124]). Foresight is used to keep an eye on, and head-off when necessary, the troublesome twin. However, by the 1970s, the rapid rate of technological change was recognised as a new phenomenon in its own right, and our old tools of foresight seemed inadequate. By the 1980s, it was recognised that when change is discontinuous, previous technological precedents may be irrelevant to foresight or even misleading. All these views remain current, and have implications for the practice of foresight in safety.

Foreseeing accidents and trouble from incremental change is more *retrospective*; whereas radical, discontinuous change relies more on creative, *prospective* foresight. Examples of the latter include 'gene driving' technology that forces genetically engineered changes in individual organisms to be expressed with high

[121] The conclusion has been prepared by John Kingston, Ana-Lisa Vetere Arellano and Yves Dien on behalf of the project group.

[122] Rasmussen J. Svedung, I (2000); Proactive Risk Management in a Dynamic Society, Swedish Rescue Services Agency. (https://www.msb.se/RibData/Filer/pdf/16252.pdf#page=10 – Retrieved on July16, 2020)

[123] Santayana, G. (1905) The Life of Reason. [online: http://www.gutenberg.org/files/15000/15000-h/15000-h.htm]

[124] Johnson, W.G. (1980) MORT Safety Assurance Systems, Edited by Marcel Dekker, Inc.

likelihood in subsequent generations. Another is the difference of chemical properties between regular and nano particle sizes. For instance, nano gold is a poison, whereas regular gold is biologically almost inactive. Foresight of radical or disruptive change is challenging, even more so when changes interact. In many areas, notably technology, it is increasingly unsafe to assume that the near future will be an extension of the past. There is a pressing need to enable foresight in such systems.

In areas characterised by rapid or discontinuous change, foresight can be blinded when technology and organisation are seen in isolation. Within safety, the term 'socio-technical' has almost become a cliché: often used, but superficial and patchy in its application. In practice, however, technology and organisation appear often to be managed, researched and educated, as two separate domains. This separation creates a void in foresight, which needs to be open to the safety consequences revealed by both perspectives and their interaction. The challenge of rapid and discontinuous change requires the 'sociotechnical view' to be refreshed, as Rasmussen and Svedung called for twenty years ago. An example of an approach that does this is the ESReDA Cube model[125].

In summary, foresight in safety:

- *is a continuous process, because knowledge and systems continually change;*
- *has difficulties seeing possibilities created by radical, discontinuous change;*
- *integrates the social and the technical knowledge of systems at every level;*
- *is applied skepticism.*

Foresight: A Multi-Actor Activity

We take it as axiomatic that foresight about safety improves when several perspectives are shared and debated by different actors. However, there are multiple challenges. Mostly, these stem from the messy reality of foresight activity in the practical world. Foresight is as much an issue of *agency, structure, power and influence*, as it is a function of expert knowledge, experience and method. This is true both of organisations and society in general. For all these challenges there are solutions, but only if we recognise that there is a need for them.

Within foresight in safety, as in risk management generally, the 'stakeholder' concept is increasingly recognised as relevant. A stakeholder is, according to Freeman (2010), *'…any group or individual who can affect, or is affected by, the achievement of a corporation's purpose'* [126]. Stakeholders can be within the risk-owning organisation or outside of it, but Freeman's definition implies that stakeholders are within the overall system.

Where the corporate capacity for foresight is at stake, appearances of consensus are deceptive. Within organisations it is usual for individuals and groups to have a range of different opinions about future possibilities. An organisation is not a "monolithic whole". Within an organisation different visions coexist concerning the way the "system" is working, its level of safety, and unsafe functioning or unsafe acts. By the same token, except in the simplest cases, foresight cannot be monolithic. However, organisations invariably adopt single positions on matters, albeit hedged with contingencies. This practice is pragmatic and expedient; it allows the organisation to make progress, to get on with providing its services. Foresight, in contrast, is more like a competition between individual visions of the future than a common denominator of these visions. Furthermore, the best informed vision is not necessarily always the winner, because influence and power also count in the competition of ideas.

Therefore, the apparent consensus in an organisation's risk assessments and policy documents needs to be treated with caution. Specific risk analyses and policies will

[125] *The ESReDA Cube is a conceptual model focused on the "learning from accident" process. It represents learning as a three dimensional space taking account of "what needs to be learned", "who should learn" and "how it is learned". The Cube was developed by ESReDA Project Group "Dynamic Learning as the Follow-up from Accident Investigation". This document can be found at https://esreda.org/wp-content/uploads/2016/03/ESReDA-dynamic-learning-case-studies-180315-1.pdf*

[126] *Which is defined here as "…any group or individual who can affect, or is affected by, the achievement of a corporation's purpose". Freeman, R.E. (2010). Strategic Management: A Stakeholder Approach. Cambridge University Press.]*

be based on facts known with different levels of confidence. Some of the facts will be indisputable, but not all of the facts. Yet, decisions and policies have to speak with one voice. However, what they say is the product of compromise and uncertainty rather than a ringing consensus about the meaning of immutable facts. Therefore, decisions and policies are invariably simplifications, and may become *oversimplifications* unless reviewed. The danger in such 'faux consensus' is that it lures senior decision-makers toward complacency, because it suggests that a matter is settled. In contrast, for the sake of foresight, the matter is best treated as a momentary stock-take in the continuous, diligent search for future possibilities. Foresight is *now*, based on the best knowledge today; not as we saw the matter yesterday. As well as evolving knowledge, stakeholders and situations change. This means that a single position can only be tenable in the short term. Organisations need to support foresight as a continuous exchange of perspectives, even dissenting views, within their communities.

An assumption of the multi-actor view is that different actors can communicate and debate. If actors are to agree about foresight and early warning signs, there must be some measure of shared knowledge about how things work. In industrial safety, this usually means that actors share a level of technical knowledge of their organisation's operations. For example, in asset management, a field related to safety, the relevant standard[127] notes that shared technical knowledge helps top management make sound, well-supported decisions.

Open debates favour safety, but very few actors will coincide on all points. As mentioned, consensus about foresight and decisions is an ideal, but the path to it is paved as much by disagreement as agreement. In contrast, some organisations tend to treat disagreement as poor conduct. In general, to avoid being seen as trouble-makers, individuals will abandon defence of their viewpoint. Therefore, we should not be surprised when people speak out only *after* the accident they foresaw. It is not reasonable to expect heroism and self-sacrifice to be the safety backstop for cultures that discourage individuals from giving voice to foresight.

Historically, we should discriminate between two groups of individuals who open up debates: as those individuals who warn against mishaps based on their professional judgement. First, mostly engineers who understand the design assumptions and limitations. Their judgement is often based on evidence but not always... Secondly, people who criticise the appearance of phenomena they do not fully comprehend or are only partially informed, but base their judgement on social media and 'influencers'.The COVID 19 situation has demonstrated a public debate on social distancing, herd immunity and personal protective equipment.

Position and qualifications are, however, not an infallible guide to who has valid foresight (the response to the Covid-19 crisis illustrates this, too). The reliability of knowledge has never been easy to assess, and it is increasingly challenging. As a source of of facts social media deserves caution, but so do claims of any kind, including those made in peer-reviewed journal articles. Furthermore, the characteristics of the knowledge underlying foresight varies with the context. Sometimes, the situation allows testable answers to black-and-white questions. But, at other times, our knowledge is far less categorical and the problems open-ended. Describing the latter, Hardin (2002[128]) writes "*In an economic theory, it makes sense to say that you know one thing and I know a contrary thing in some context. I might eventually come to realize that my knowledge is mistaken and therefore correct it, especially after hearing your defense of your contrary knowledge. But there is no role for a super-knower who can judge the truth of our positions. We are our own judges. If we wish to seek better knowledge, it is we who must decide from what agency or source to seek it*". In safety, the situation often arises that risks created by one group are borne by a different group; pollution risks, for example. Often, the group exposed to the risk base their foresight on anecdotal observations and general knowledge. Through self-education and professional assistance, such groups arrive at a point where the content of their claims can no longer be dismissed[129].

Another issue is when views about what constitutes reliable knowledge are incommensurable. Although it can be said that *'Everyone is entitled to his own opinion, but not his own facts'*[130], dispute about facts—and even what constitutes

[127] *ISO 55000:2014, section 2.5.2.*

[128] *Hardin, R. (2002) Street-Level Epistemology and Democratic Participation. Estudio/Working Paper 2002/178. http://www.march.es/ceacs/ingles/publicaciones/working/archivos/2002_178.pdf*

[129] *A recent illustration from the field of patient safety can be found in the report of the UK Independent Medicines and Medical Devices Safety Review. HMSO (2020) First Do No Harm: The report of the Independent Medicines and Medical Devices Safety Review. [online at: https://www.immdsreview.org.uk/downloads/IMMDSReview_Web.pdf]*

[130] *Attributed to Daniel Moynihan: https://en.wikiquote.org/wiki/Daniel_Patrick_Moynihan*

a fact—is a recurring feature in contested foresight. As stated earlier, influence and power also count in the competition of ideas—but who wields the power is not always obvious, neither are differences of epistemology.

We recognise that suppressing dissent and disagreement may sometimes blind the organisation's foresight of credible future accidents. Therefore, as well as shared technical understanding, we need also to encourage, and not suppress, the expression of different views. We need to be able to disagree well[131]. As Espejo[132] points out, *'a consensual domain is none other than the play of a particular set of interacting models'* (1989; 445-446). However, as suggested, in many organisations, the suppression of dissent (including self-censorship) is, unfortunately, normal.

Order in society is sustained by various forces. However, one of the effects can be the discounting of views, even data, that do not fit with the current orthodoxy. Well-investigated accidents show that this riddles foresight with blind spots. A question for the practice of foresight is how to better tolerate and enfranchise dissident voices within our organisations and social structures. At present, the public record contains an ever-expanding file of whistleblowing cases showing that many organisations are immature in this respect. And outside of industrial safety, in the wider realm of social goods and social ills, the question is just as relevant. Although beyond the scope of this work, new models are appearing to support constructive debate and the decision-making authority of institutions. We note, for example, the operation of citizens assemblies in Ireland[133] and elsewhere.

Foresight requires flexible approaches to anticipate the 'unthinkable'. Assumptions are constraints on the range of possibilities from which foresight proceeds. Constraints make foresight possible (in the unconstrained system, *everything* is possible!) but these assumptions will also rule-out some possibilities that may, in fact, be valid and worth thinking about. An investigator remarked of his own practice: *"I must think the unthinkable even if I dismiss it on the basis of evidence'. At least think about it."*[134] In all professions that contribute to safety, this self-honesty appears to be fundamental to extending foresight. We must try hard not to fool ourselves. But there are various disincentives, such as our credibility in the eyes of one's peers, a desire to be seen as a team player, and a wish to avoid the discomfort of dissonance.

The Project Group noted that the visualisation of hidden or weak signals has an important role in predicting possible incidents and accidents. The etymology of the word invites us to think about *foresight* as *visions* of the future. However, as the foregoing discussion makes clear, it is helpful to consider foresight more as a *process* in which stakeholders strive to communicate, debate and make change happen. It brings to mind the advice: "As visual metaphors never perfectly fit the target domain, they also trigger sense making and discussions about the risks and the shortcomings of the chosen metaphor. In this way they help to clarify risk understandings in groups by sparking lively debates" (Eppler and Aeschimann, 2009; p82).[135]

The term 'multi-actor' suggests humans, but technology has reached the point where we need to recognise that some actors are non-human. Big Data analytics is a relatively new paradigm; dating back to about 2010. Big Data analytics can improve predictive ability and generate safety-related foresight in a number of ways, helping to detect emerging safety threats. Big Data may be a means to identify early warning signs that would be missed by human observers. The technology shows promise, but at the same time generates new risks, for example the opacity of algorithms for non-expert users. It is perhaps too early to reach conclusions about the contribution of Big Data analytics to safety foresight. That said, the development of autonomous vehicles is processing prodigious quantities of data to shape the algorithms necessary. This may well become the definitive case study of foresight in safety through Big Data. People working in safety need to keep an eye on developments in Big Data and machine learning.

Big Data holds the promise of extending safety foresight, but also of compromising it. The offer of powerful, objective prediction is a strong inducement to use the

[131] *Stephens, B. (2017). The dying art of disagreement. Keynote speech, 24 September 2017. The Lowy Institute. online: https://www.lowyinstitute.org/publications/dying-art-disagreement. Accessed, 4 June 2020.*

[132] *Espejo, R. (1989). A cybernetic method to study organisations. In: The viable system model: interpretations and applications of Stafford-Beer's VSM. Edited by Espejo. R., and Harnden. R., John Wiley & Sons, Chichester.*

[133] *https://www.citizensassembly.ie/en/previous-assemblies/citizens-assembly-2016-2018-/*

[134] *John Fitzgerald, quoted at https://www.basw.co.uk/resources/psw-magazine/psw-online/think-unthinkable Accessed 2nd June 2020.*

[135] *Eppler, M.J; Aeschimann, M. (2009). A systematic framework for risk visualization in risk management and communication. Risk Management, Vol. 11, Iss. 2, (Apr 2009): 67-89*

tools of Big Data. However, there is evidence[136] that without careful governance these tools can further entrench social inequality and bias. Furthermore, for all their power, these systems will not be omniscient. This, coupled to their opacity, creates a challenge to safety assurance. Therefore, embracing Big Data, like many new technologies before it, places high stakes on both sides of the balance.

Expertise is essential for foresight. Experts see warning signs in data, and foresee possibilities that are invisible to non-expert. However, how to qualify as an expert is an issue. Knowledge can be of different types, with some types being more often recognised as having the hallmark of expertise. For example, qualifications awarded by professional bodies and universities provide tangible evidence of expertise. In contrast, the extensive empirical knowledge of experienced individuals is less easily measured and may consequently be undervalued, or even discounted, as expertise. Furthermore, irrespective of their background, experts are unlikely to perform well in foresight tasks if they lack independence[137]. History is littered with examples of this kind of bias—scientific opinions about the link between tobacco smoking and cancer; and about the link between tetraethyl lead petrol additives and lead poisoning, to name just two. Foresight is a projection of expert knowledge, but expert knowledge is not an objective quantity.

As noted earlier, memory is a critical aspect of foresight. A significant example of this is the recall by decision-makers of the futures foreseen by experts in earlier life-cycle phases. Of particular significance is foresight by *designers*, which informs their assumptions and design choices. These are too easily not communicated to actors later in the life cycle. The B737 MAX case illustrates this point: pilots missing crucial knowledge about the behaviour of technical systems[138] that was well-understood by designers. Another point here is that the technical system in question was a radical departure from the expectations of pilots; an instance of disruptive rather than derivative design.

Experts are also needed to provide interpretive balance to safety metrics. There is a trend in many areas of safety towards monitoring through metrics. Measurement is to be applauded, but no matter how well-designed, the construction of metrics requires various assumptions and simplifications. Useful though these data may be, they cannot be the whole truth; and treating them as such will blind foresight to other, valid interpretations. We should be alert to spurious objectivity in safety as in any field, and experts can provide countervailing voices. This is especially important if a measure is used as a target[139] or key performance indicator.

This being said, non-experts are especially useful for providing 'out-of-the-box' ideas, and are able to ask questions which are less influenced by expertise and bureaucratic fragmentation and professional norms.

Within its multi-actor view of foresight in safety, the Project Group noted the importance of regulators. Who is a regulator and what is regulation, are both relevant questions? Regulators include statutory agencies: the enforcers of safety and environmental protection laws. However, *regulation* can also be seen more widely: as the operation of networked groups of stakeholders who support, or sanction, risk-owning entities in pursuit of safer products and activities (Braithwaite, 2017[140]). Foresight and regulation connect in many different ways: as a competence, as communication, and as an object for regulatory interventions.

Regulators can generate and disseminate foresight through their interactions with actors at different system levels. The privileged access of enforcement agencies allows them to inform their foresight, to communicate it widely in industry and to renew legislation when new knowledge is obtained (e.g. the precautionary principle). The Project Group noted that the value that regulatory agencies can bring to safety foresight depends on a number of factors. In particular: close cooperation between operating companies and regulatory inspectors, (ii) regular discussion and follow-ups of lessons learned, with a focus on near misses, (iii) regular discussions and follow-ups of possible scenarios (iv) specific skills and competencies for the inspectors and other regulatory personnel, and (v) follow-up of recommendations by regulators. In addition to these five points, a basic assumption is that regulators can properly engage with risk owner's models. This is not always possible. For example, a fundamental challenge to effective regulation, including self-regulation, is caused by the "black box" nature of many

[136] *An overview is provided by O'Neil, C. (2016) Weapons of Math Destruction. Pub. Crown.*

[137] *"It is difficult to get a man to understand something, when his salary depends on his not understanding it." Upton Sinclair (1994) "I, Candidate for Governor: And How I Got Licked". University of California Press.*

[138] *The Manoeuvring Characteristics Augmentation System (MCAS).*

[139] *Goodhart's law.*

[140] *Braithwaite, J. (2017) "Types of Responsiveness". In: Drahos, P. (Ed.). Regulatory Theory: Foundations and applications. Acton ACT, Australia: ANU Press. Retrieved June 12, 2020, from www.jstor.org/stable/j.ctt1q1crtm*

machine learning models. This inscrutability makes it difficult for risk owners to build and test mental models of system operation, for regulators to check the underlying assumptions and inner workings of the system, and for the legal system to inspect the logic underlying the model's predictions in case of an accident.

In summary, foresight in safety:

- *is most acute when several perspectives are shared in a community;*
- *is vulnerable to power imbalances between stakeholders;*
- *depends on ready willingness to review past decisions and commitments;*
- *is more efficient when stakeholders share operational knowledge;*
- *requires stakeholders to be able to disagree well;*
- *is more effective when dissenting voices are listened to—not necessarily agreed with—but taken into account and discussed;*
- *may be helped by Big Data and machine learning, but could be hindered by it;*
- *will vary between experts, even when all their views are valid;*
- *can be blinded by metrics, especially when the metrics are used as targets;*
- *is an example of the value that regulators can add to safety in cooperation with industry.*

Foresight: Memory and the Future

Foresight of future unwanted possibilities involves making associations between monitoring data, mechanisms of failure, and preventative and mitigating actions. This knowledge is partly discovered by experience, but also created by imagining, modelling and theorising. For example, causal models can be created using incident scenarios. This allows the systems modelled to be modified, detection set-up, and interventions planned.

Well-investigated accidents tell us that loss of memory is a recurring root cause of disasters, and a vulnerability in many organisations. What needs to be remembered are monitoring data, safety performance indicators, mechanisms of failure, preventative and mitigating actions, and the causal models in which all these elements cohere.

Organisational memory is likely to be vested in many different substrates, both human and non-human. Substrates include: the memories of the individuals who populate the organisation; the technology into which designers' have encoded their foresight, and documentation of various sorts, in particular on processes. There is almost always scope to improve the reliability and capacity of these substrates for the sake of safe operations.

When trying to avoid forgetting, it is tempting to equate memory with storage. We know a lot about storage and might prefer to put our effort into the things we understand best. However, all the storage in the world cannot deliver faultless memory or perfect foresight. Human memory is these days seen as a process rather than a store of facts. Similarly, foresight for safety assumes that organisational memory is a continuous process that integrates all the different substrates within the organisation. Therefore, as well as storage in databases, documents, people, and artefacts, we must attend to the whole process for the sake of foresight.

Early Warning Signs have been a recurring concept in the Project Group's deliberations. Foresight entails identifying the events and conditions that signal the increasing likelihood of an unwanted event. Before a thunderstorm, the gathering of black clouds and distant thunder are early warning signs. Seen this way, foresight links current knowledge to future possibilities. In the field of safety, early warning signs are crucial links in this chain.

Knowledge of early warning signs and associated actions are what needs to be remembered in the organisation. Memory needs to **store** this knowledge reliably. Moreover, to be remembered, knowledge must also be encoded in the first instance, and **retrieved** at point of need. Encoding, storage and retrieval of this information can be made the subject of assurance. Knowing how to use this knowledge in different contexts and situations is a competence that is not trivial.

Loss of memory is a critical failing in foresight. It means that early warning signs will go unheeded; we wait under the darkening sky and are surprised when lightning strikes. Theoretical models, such as the encoding-storage-retrieval model just mentioned, can inform ways to prevent this kind of forgetfulness. Moreover, to preserve its memory, industrial practice must recognise the effects of organisational 'macro' phenomena such as plant ageing and outsourcing. In addition, accidents themselves have value as stories. Stories are a means to revive memories of early warning signals and to remind about the seriousness of what they presage. Rules alone seldom communicate the experiences that gave rise to them.

In summary, foresight in safety

- *is a process closely related to memory;*
- *depends on memory in general, and of early warning signs in particular;*
- *is precarious, because organisational memory does not look after itself.*

Foresight and Risk Assessment

In industries with complex operations, foresight has become almost synonymous with analytical risk assessment. However, foresight is also deeply implicated in the monitoring and review process that exist in parallel to risk assessment. The analytical approach to risk, developed in aerospace in the 1960s, was quickly adopted in the US military industrial complex, and spread globally and sectorally to most industries by the 1990s. Within that tradition, risk assessment is usually seen as comprising several sub-processes, including risk identification, risk analysis and risk evaluation.

Foresight is closely associated with the risk identification step of risk assessment, although how closely depends on how one defines these terms. To some extent, risk identification is actuarial; it is informed by past failures and successes. However, risk identification—the foreseeing of possible futures—is also creative and relies heavily on the knowledge of the people involved, their imagination and the models they create. For that reason, risk identification is sometimes singled-out as the least reliable part of the risk assessment process. *Least reliable* does not, however, equate to *bad*; it simply means that, all other things being equal, no two analyses of the same system will produce exactly the same risk model. This implies that there is room for discussion, and for humility, in even the most robust and meticulous risk analysis.

To better capture risks, risk analysis approaches are needed that are more open to different worldviews and opinions. However, the qualitative roots of a risk analysis can sometimes be obscured by the complexity of quantitative evaluations made. For example, Vesely et al. point out in their classic handbook[141] that a Fault Tree Analysis is *"a qualitative model that can be evaluated quantitatively"*. Quantification is often necessary, but it may create an impediment to the qualitative discussion and review that we have argued is essential to foresight in safety. We note the ISO standard on risk management[142] emphasises that communication and consultation are intimately connected to the risk assessment process. How to make this communication work between technical people and lay people is one of the questions that workers in the field of safety continue to grapple with. Another is how to make opaque risk models discussible, a point made earlier in respect of Big Data and visualisation.

In summary, foresight in safety:

- *is greatly informed through risk assessment, but not synonymous with it;*
- *involves combining qualitative and quantitative knowledge—a challenge for communication and debate in the multi-actor arena;*
- *has to be approached with humility, as despite all efforts there is always room for discussion and improvement.*

Foresight in Safety: A Wider Perspective

Most of this chapter has been in the context of an organisation or within a sector. However, foresight with a wider perspective is necessary to avoid the shocks and embrace the opportunities that originate from beyond those boundaries. The hallmarks of an international approach are, according to the Project Group, a global warning system (of early warning signs), a rapid and trustworthy information system, global decision-making procedures, necessary reserve capacity, and international cooperation to avoid global inequality in disaster management. The last COVID19 crisis can provide examples of successes and failures in that respect.

We mentioned earlier how the rate of socio-technological change was recognised in the 1970s. Within safety, this challenge to foresight has driven innovation in

[141] *Vesely, W.E., Goldberg, F.F., Roberts, N.H., and Haasl, D.F. (1981) Fault Tree Handbook. NUREG-0492, US Nuclear Regulatory Commission. [Online: https://www.nrc.gov/docs/ML1007/ML100780465.pdf, accessed 12 June 2020]*

[142] *British Standards Institute, 2018. BS ISO 31000:2018. Risk management — Guidelines. Geneva, Switzerland: International Organization for Standardization (ISO).*

modelling and risk analysis. However, the changing safety landscape extends beyond these. To keep pace with rapidly evolving technological advancement, globalisation and demographics, diversity of worldviews and stakes, safety foresight requires a greater embrace of governance principles.

Risk governance at all levels (in the sense of Rasmussen and Svedungs' model) is significantly challenging. Foresight in safety is a subset of foresight in general. According to an online EU foresight guide,[143] foresight is defined as "*a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilizing joint actions. It can be envisaged as a triangle combining "Thinking the Future", "Debating the Future" and "Shaping the Future". Foresight is neither prophecy nor prediction. It does not aim to predict the future – to unveil it as if it were predetermined – but to help us build it. It invites us to consider the future*".

The Project Group sees a need to incorporate foresight thinking into the classical risk management approach. The aim of the change is to bring about a more integrated way of thinking, debating and shaping the future. Part of this change would be for stakeholders to consciously incorporate *megatrends* when designing processes and making decisions. Megatrends are "*large, social, economic, political, environmental or technological changes that are slow to form. Once in place, megatrends influence a wide range of activities, processes and perceptions, both in government and in society, possibly for decades*"[144].They are the underlying forces that drive trends that are observable now and will most likely have significant influence on the future[145].

The megatrends viewpoint allows foresight of the dynamic, unfolding nature of large, complex systems. At this scale, an iterative approach appears to be critical to foresight in safety. However, the field of safety has yet to rise to the methodological and sociotechnical challenges inherent in an iterative approach. This is starkly illustrated in major accidents, but also in everyday examples of the inflexible bureaucratic approach that characterises much of safety practice. The present authors endorse the value to foresight of managing details—such as by sophisticated record-keeping and cost-control—but note that these practices do not really acknowledge that complexity creates its own patterns. Therefore, the Project Group recognises a need to develop know-how and supporting tools to address the dynamically complex and evolving safety landscape with foresight thinking at all governance levels. In rising to this challenge, it goes without saying, perhaps, that advantage should be taken of new technologies to complement conventional approaches.

The history of major accidents leads us to believe that vigilance for anomalies is critical to foresight. Once an anomaly is recognised as an early warning sign, and the connection made to future possibilities, there is usually time to act. Latent flaws can be uncovered and fixed. (And, on a good day, we'll also ask "if this was wrong, what else should we be looking for"?). This kind of vigilance has many enemies, among them, production pressure, a changing workforce, plant ageing and inadequate monitoring[146]. However, we also note Turner's point[147] that risk management is based on beliefs, not certain knowledge. Overestimating the reliability of knowledge can cause us to overestimate the reliability and safety of the systems we create. In foresight, a modicum of doubt and humility should always be welcome and, when decisions are taken under pressure, a modicum of forgiveness in hindsight. This mindset is far from easy to sustain and its added value can only be appreciated from time to time and in the long run.

Change management, education and learning offer opportunities to improve foresight in safety. This is in contrast to safety regimes based on compliance, control, deregulation and privatisation. The challenges are: to integrate change management in a broad, multidisciplinary management model; to stimulate the development of competence, flexibility, insight and responsibility instead of conventional education; and a culture of dynamic learning, instead of static, rule-based training among all actors with safety responsibility, including safety professionals.

[143] *http://www.foresight-platform.eu/community/forlearn/*

[144] *http://ssl.csg.org/Trends/Megatrends%20Definitions%20and%20Categories.pdf*

[145] *https://ec.europa.eu/knowledge4policy/foresight_en*

[146] *For example, see 'normalisation of deviance' as described by Vaughan, D. (1996). The Challenger Launch Decision. Risky Technology, Culture, and Deviance at NASA, The University of Chicago Press.*

[147] *Turner, B. (1978) Man-Made Disasters. Wykeham Publications.*

In summary. Foresight in safety needs:

- *approaches designed to cope with radical and discontinuous change;*
- *to find ways that recognise complexity in systems;*
- *a global approach to collating and sharing data and knowledge;*
- *to embrace governance principles;*
- *to include wider megatrends in its imagination of future possibilities;*
- *to be unceasingly vigilant.*

In closing, there is still a lot to learn within the *foresight in safety* landscape. This text is the continuation of a journey that started a few decades ago because of concerns about quality of accident databases, of accident investigations, of learning from accidents and foresight in safety. It is the Group's mission to get acquainted with this complex and evolving landscape. Against this backdrop, members of this Project Group will take stock of what it has learned and start a new ESReDA Project Group on *Risks, Knowledge and Management*. This will continue to look at activities and disciplines related to risk assessment, identification of early warning signs and emerging risks, foresight, investigation of events and lessons learning, management of barriers and lines of defence, reliability, and change of policies and culture; however, it will focus on knowledge management aspects of these. And the learning odyssey continues...

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