RESILIENCE
SUCCESS CONSORTIUM

RESILIENCE CASE STUDIES

02 February 2015

Dealing with uncertainty in practice: Strengths and traps in human intervention

Authors:
Anne van Galen,
Anne van Galen Consultancy, France
&
Linda J. Bellamy
White Queen Safety Strategies, The Netherlands

CONTACT

Consortium
http://www.resiliencesuccessconsortium.com/

Anne van Galen
Anne van Galen Consultancy
La Balme
05120 les Vigneaux
France
T. +33 (0)492 436998
M. +33 (0)6 44308642 (France)
M. +31 (0)6 51262526 (Netherlands)
E. anne@avgconsultancy.com
W. www.avgconsultancy.com

Dr Linda J. Bellamy (Coordinator)
White Queen Safety Strategies
PO Box 712
2130 AS Hoofddorp
The Netherlands
T. +31 (0)235 651353
M. +31 (0)6 54648622
E. linda.bellamy@whitequeen.nl
W. www.whitequeen.nl

RESILIENCE CASE STUDIES

DEALING WITH UNCERTAINTY IN PRACTICE: STRENGTHS AND TRAPS IN HUMAN INTERVENTION

ABSTRACT

This report is a presentation of case studies carried out in the Netherlands, France, Belgium, the UK and Denmark for the European SAFERA project "Success in the face of uncertainty". The research was aimed at getting insight into how people in high risk natural and man-made environments manage uncertainties in order to identify key areas where organisations managing major hazards can operate more resiliently.

In a world where growing complexity and uncertainty are the norm, there is a need to become more resiliento in handling the potential for serious accidents from industrial operations. Resilience stands for being able to successfully sustain (safe) operations in response to variation and change for both foreseen risks and the unexpected. This is different from simply being robust - being able to withstand demands - in that resilience is more about renewal and regeneration. Many current risk management systems focus on permanent designed-in measures, standard procedures and rules to avoid incidents and things going wrong. These procedures, rules and permanent measures are generally designed to cope with foreseeable risks.

Interview case studies with professional mountaineers, rope access workers and people dealing with risk in the high hazard industry (e.g. supervisors, plant managers and HSE leaders) were used to better understand which mental characteristics foster human resilient intervention. Information about functioning in teams and organisational processes contributing to human resilience was also identified. The interviews were based on the four cornerstones of resilience: anticipation, learning, monitoring and knowing how to respond.

In aiming for success, the case studies show that there are certain cognitive traps involved, especially when there are pressures such as time restraints and competing goals. It was found that resilient intervention needs a human mind that is 'vigilant', 'aware' and 'switched on'. In many current industries the level of automation is high and the number of accidents is low, which does not promote these characteristics. As well as being switched on and having the ability to make good decisions and responses when the pressure is on, resilient intervention also needs time and resources for reflection when dealing with uncertainties, including hold points, second opinions and thinking together. This helps in counteracting cognitive biases in decision making - these being unconscious automatic influences affecting thinking about possible outcomes and their chances of occurrence. Cognitive biases circumvent making judgements in a thorough, methodological way and therefore can lead to erroneous interventions.

The characteristics of the resilient human mind are described using citations from the interviews. These characteristics could be used in selection, training and coaching of people that have to deal with unforeseen risks or to enhance the resilient mind in the context of teams and organisational processes. Furthermore suggestions are given on how to avoid some of the typical cognitive traps in decision making.

This study can provide a basis for a shared understanding and vocabulary in which the strengths and traps of human intervention can be discussed and managed, starting from the mental frameworks of people that handle risks on a daily basis.

Acknowledgements

This European research project has been supported by FONCSI (Fondation pour une culture de sécurité industrielle - France) and RIVM (Rijksinstituut voor Volksgezondheid en Milieu – The Netherlands). The research project was launched within the context of SAF€RA, a platform that aims to coordinate the research investment among the EU Member States in the field of industrial safety.

The researchers would like to thank first of all the people that have participated in the interviews. Not only have they reserved time in their busy timetables to reflect upon the management of risk, they have also shown the courage to speak openly about the successes and learning experiences related to their jobs.

In addition we would acknowledge the contribution of the other partners in the Resilience Success Consortium: Nijs Jan Duijm (Technical University of Denmark) for his contribution to this report as an interviewer and reviewer; Arthur Dijkstra (ADMC, the Netherlands) and Kirsten Jørgensen (Technical University of Denmark) for their review of this document; and to Olga Aneziris and Ioannis Papazoglou (NCSR Demokritos, Greece) for their involvement in discussions on the interview content in relation to uncertainty

Contents

1 INTRODUCTION

1.1 Background

This report explores the concept of resilience in relation to the human and organisational factors associated with working with high risks.

The concept of resilience in safety can be understood as the ability of a system to successfully sustain its operation under a wide variety of conditions. Resilience has been defined as:

> "The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions" (Hollnagel 2011).
>
> "The capacity of a system, enterprise, or a person to maintain its core purpose and integrity in the face of dramatically changed circumstances" (Zolli & Healy 2012).
>
> "The capacity of an individual, community or system to adapt in order to sustain an acceptable level of function, structure, and identity." (Edwards 2009).

The current report is aimed at industry, researchers, consultants and individuals working in the field of control of hazards which could cause physical harm to people. The research aims to provide a better understanding of the human and organisational factors involved in successful management of risks from a resilience point of view. The approach has been to explore the resilient mind and the organisational processes that foster and use resilient minds through interviews.

1.2 Objectives

This work is part of a research project "Success In The Face Of Uncertainty: Human Resilience and the Accident Risk Bow-Tie" (Resilience Success Consortium 2014) which addresses success rather than failure in improving management of safety. The part of the project reported here focuses on the following aspects:

- Identifying the resilient qualities of individuals as well as possible traps related to human intervention;
- Mental frameworks with respect to anticipation, learning, monitoring and responding to what is happening;
- Human intervention in the context of teams and organisational processes.

A central question in the overall research project is whether resilience concepts can be integrated into classical bow-tie approaches. The classical bow-tie is a linear model with a focus on the negative, the already occurred or foreseen accidents. The bow-tie provides a structure of the controls in place for preventing the release of a hazard in a particular context, particularly the more dangerous hazards that can result in catastrophic consequences. Its lessons are avoidance of failure through better controls. Resilience modelling is a mirror of this. It is about being proactive rather than reactive, about anticipation of the future and about success as a bouncing back in the face of adversity as opposed to avoidance of failure. In this respect the bow-tie could also be used to model risk control in a way that could be used proactively rather than reactively. For that purpose, new resilient components are needed.

1.3 Document structure

Chapter 2 argues that human resilient intervention is a necessary part of effective risk management strategies and how these interventions relate to 'anticipatory strategies'.

Chapter 3 describes the characteristics of resilience of the human mind in relation to the management of risk. The characteristics are explained by using citations from the interviews. The chapter also investigates some pitfalls that are related to the positive resilient characteristics of individuals.

Chapter 4 places human resilient intervention in the wider organisational context, focusing on how to support human intervention within teams and within organisational processes.

Chapter 5 addresses two specific problem areas of human resilient intervention in the light of current developments in society.

Chapter 6 contains the conclusions and suggestions for further research.

In Annex A the Resilience Questionnaire developed for this research can be found, together with an explanation of the method used.

Eighteen interviews form an integral part of this research report. Besides the results given here, one full interview report can be found in Annex B to prove an example. For other examples please refer to www.resiliencesuccessconsortium.com.

2 RESILIENCE AS A RISK MANAGEMENT STRATEGY

2.1 The need for resilience

Resilience is a strategy to adapt to variation and change in uncertain and complex environments. It has been stated that change in the 21th century is growing increasingly faster due to phenomena such as the enormous growth of the world population which doubled in the last 40 years, the growing importance of cities (half of the 7 billion people on earth live in cities), the interconnectedness of people through the internet, the growing complexity of social technological systems and the growing pressures on the environment.

According to Perrow (1999) there is a lack of insight into complex technological systems and this leads to so-called "normal" accidents, i.e. accidents that are unavoidable due to the complexity of the system. Adapting to change therefore becomes more important than ever. In the abstract to Hollnagel (2008) it is stated that:

"In the resilience engineering approach to safety, failures and successes are seen as two different outcomes of the same underlying process, namely how people and organisations cope with complex, underspecified and therefore partly unpredictable work environments. Therefore safety can no longer be ensured by constraining performance and eliminating risks. Instead, it is necessary to actively manage how people and organisations adjust what they do to meet the current conditions of the workplace, by trading off efficiency and thoroughness and by making sacrificing decisions."

In the high hazard industry, resilient human intervention is one of the tools to adapt to change and to cope with uncertainties and complexity. In the next section it will be made clear how resilient human intervention, or 'resilience engineering', relates to other risk management strategies like having rules and procedures or automating safety functions.

2.2 Anticipate the foreseeable and manage the unexpected

Many current risk management systems have permanent designed-in measures, standard procedures and rules in place to avoid incidents and things going wrong. These procedures, rules and permanent measures are generally designed to cope with foreseeable risks. Procedures and rules are intended to constrain behaviour and deviations from them may be termed "error" or "violation". Resilience engineering (Hollnagel et al. 2011) aims to enhance the adaptive capacity of a system especially when change and unforeseen risks come into play. Resilience engineering defines safety as the ability to succeed under varying conditions. In resilience engineering risk management is not regarded as an autonomous discipline; it is not possible to look at safety without acknowledging that it is an integrated function and that there is always a constraint on resources (time, money, effort) which will limit the possibilities to manage every risk.

2.2.1 The level of uncertainty and available response time

Uncertainty is a situation of inadequate information which can be of three sorts: inexactness, unreliability and border with ignorance (Funtowicz and Ravetz 1990). Some risks are more 'knowable' than others and some risks are not foreseeable at all, especially in complex situations where elements are interdependent and adaptive. In other words, the level of uncertainty differs from what is "known for certain" to "unknown". In the natural sciences, scientists generally refer to statistical uncertainty which can be expressed as probabilities or degree of belief. However uncertainties that cannot be adequately expressed in terms of chances or probabilities are deeper uncertainties where mechanisms leading to outcomes are not sufficiently known. Petersen et al (2013) talk of statistical uncertainty (probabilities of outcomes), scenario uncertainty (possible outcomes), recognized ignorance (known unknowns) and complete ignorance (unknown unknowns). It can also be said that high uncertainty means there is a high chance of failure.

There are uncertain outcomes due to, for example:

- Inherent variation in things
- Variability of human behavior
- Lack of/incomplete knowledge and ignorance (known unknowns, unknown unknowns…)
- Ambiguity of interpretation (underdetermined)
- Measurement inaccuracies of physical systems
- Behaviour of things in extreme conditions
- Complex interactions in time and space

Besides the uncertainties in operational situations the current research identified that in practice it is important at which speed a scenario develops. Having longer response times is obviously preferable. In order to reduce uncertainty and lengthen response times resilient approaches are needed. It is helpful to think of this in terms of the combination of these two factors as shown in Figure 5. To identify the need for resilient intervention it is useful to look at:

A: The level of uncertainty

B: The time available to react to risk related changes.

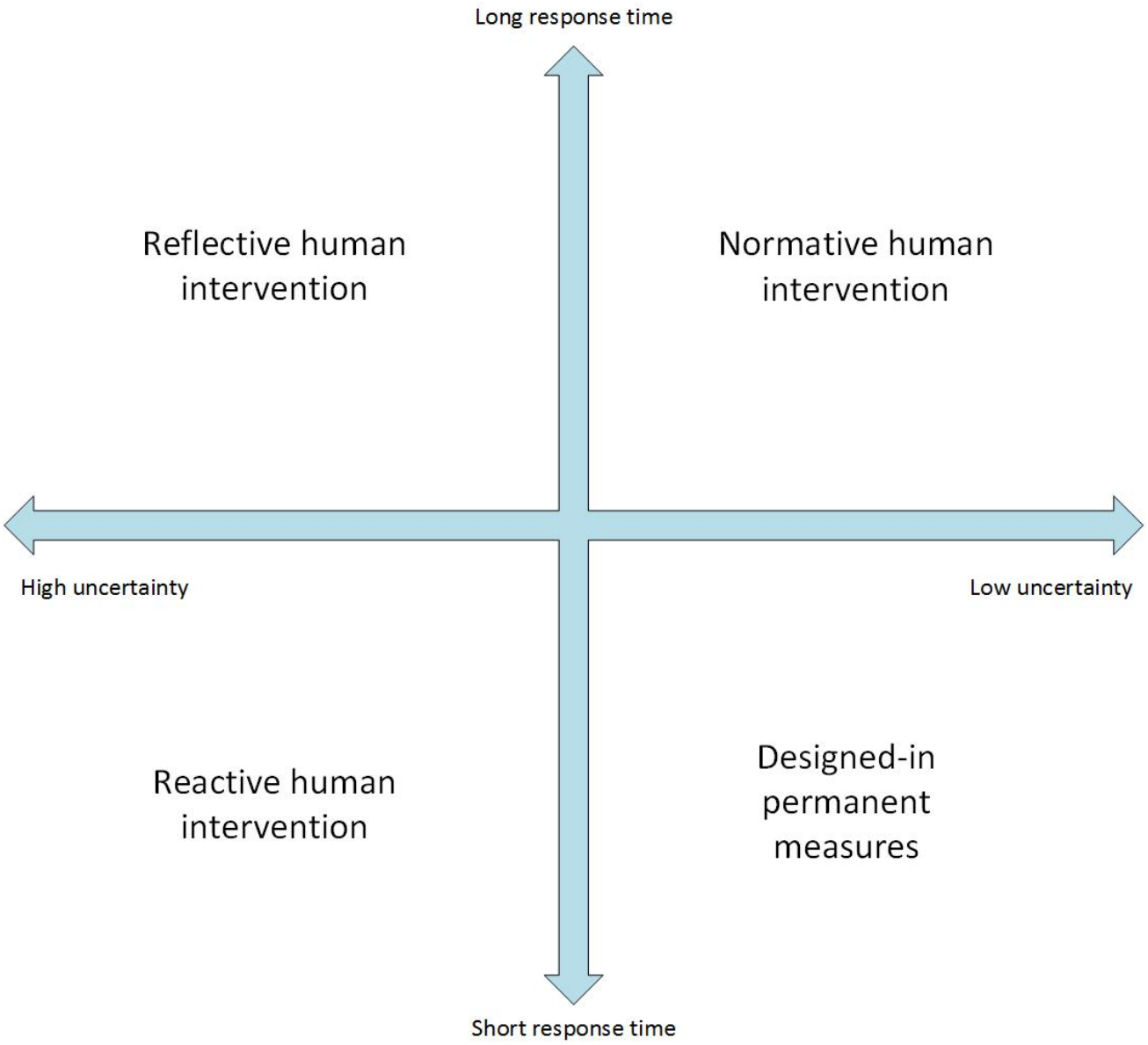


FIGURE 1 APPROPRIATE STRATEGIES DEPENDING ON LEVEL OF UNCERTAINTY AND THE AVAILABLE RESPONSE TIME

On the right side of this quadrant more traditional rule-based anticipated risk management is represented. For known risks and little time available to respond designed-in permanent (passive) measures might be the most suitable. In case of known risks and when there is more time left to respond it will be possible to manage risks normatively, i.e. by rules and procedures.

At the left side of the quadrant human resilient intervention is depicted. These kinds of interventions will be triggered by changed conditions with respect to the risk and require management of the uncertainties.

2.2.2 Two types of human intervention

The need for resilient intervention occurs when there is a change in conditions that cannot be responded to by the standard normative approach. Recognising that there is a change together with increased uncertainty is a trigger for intervention. The quadrant in Figure 1 shows that, depending on the amount of time left to react to change, there is something that could be called *'reflective human intervention'* and there is *'reactive human intervention'*. In the case of reflective human intervention it will be possible to reflect, to gather more information, have the right disciplines around the table, develop and follow golden principles or "lines in the

sand" (Hayes 2013) and be deliberating and mindful when taking decisions. Such behaviours will be aimed at uncertainty reduction.

In the case of reactive human intervention there is no time or almost no time to reflect. It will then come down to personal skill based on training and experience, and maybe on intuition (Klein, 1999). The less time there is left to react, the more it will be likely that interventions will not achieve the intended outcome..

Anticipation and making use of a resilience engineering approach are complementary strategies. Companies that want to improve their management of risks should enhance the possibility for resilience which will optimise uncertainty reduction and successful human intervention, without forgetting that evaluating foreseeable risks also requires other means, such as hazard identification and risk assessment, in combination with designed-in measures, procedures, etc.. The next chapters will focus on human resilience and how this fits into the wider organisational context.

3 RESILIENT MINDS

This chapter will describe characteristics of resilient minds using citations from 18 interviews that have been conducted using the resilience questionnaire that has been developed within this study (see Annex A for description of rationale, method and questionnaire). The key idea was that the questionnaire should promote verbal protocols describing mental processes, accounting for representations of risk-involved situations and the reasoning involved.[1]

Fourteen interviews were held with professional workers (e.g. operators), managers and HS&E leaders. "The professional worker" stands for a person who is identified as one of the very best at doing their job. (S)he will be the person that others could learn from and the person who can help make the workplace resilient (Colas 1994; Rasmussen & Svedung 2000; Jørgensen 2014). The qualities of these persons are made evident by analysing some common characteristics that stand out in the interviews in relation to the questions asked. Four professional climbers and/or mountain guides were interviewed; their real names are given because they are not representing companies. All are professional (expedition) climbers and/or mountain guides who have followed a long path from their first climbing steps to challenging routes on high, distant mountains. During their climbing careers they managed to survive various high uncertainty high risk situations, and overcame and absorbed various disturbances. The interviews focus on the knowledge and skill that have made them the resilient professionals that they are. Three interviewees are rope access workers who undertake dangerous maintenance work using ropes to get to and from difficult locations. Here it is a technical environment where rope skills are being used but where there are man-made hazards and where communication between contractor and client is important. There were nine interviewees from the chemical and petrochemical industries and two from the steel industry. These were either people in HSE management positions or they were operations managers or supervisors whose roles were primarily overseeing various operational and critical safety related issues.

FIGURE 2 INTERVIEWING APPROACH: START WITH MOUNTAINEERS AND PROGRESS TO HAZARDOUS INSTALLATIONS

[1] Models might be iconic, abstract, relational, sequential answering the question: How is risk modelled in the mind, how is it represented and projected into the future, what are its signals and cues in the environment and how is this mental model of changing risk influenced by personal and organisational factors?

The characteristics are structured according to the four cornerstones of resilience - anticipation, monitoring, responding and learning.

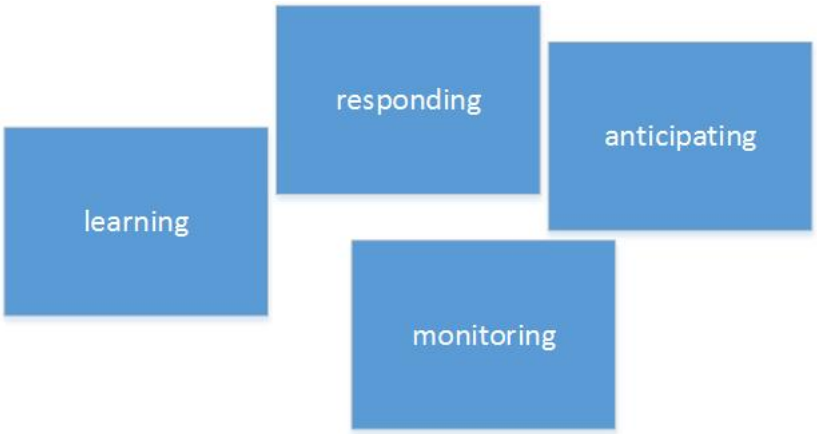


FIGURE 3 RESILIENCE CORNERSTONES

Note that many characteristics as found in the interviews and described in this chapter have an influence on more than one cornerstone of resilience.

3.1 Strengths versus traps, success versus failure

What are the characteristics of resilient minds? The questions that have been asked in the interviews aimed to focus on the positive characteristics. In other words people were asked how they were able to attain (organisational) goals despite unforeseen disturbances or variability. The interviewees were selected on the basis of their broad experience and their 'professionalism' judged by peers. It was interesting that in many cases people not only talked about their strengths and successes but were also open about their learning experiences, mostly induced by near misses, mistakes and accidents. What is more, it appears from the interviews that some characteristics that make people and organisations resilient are the same characteristics that make them fail or even 'accident prone'. This is in line with what is stated within resilience engineering, that failures are the flip side of successes and they both have their origins in performance variability on individual and systemic levels. (Hollnagel et al. 2006). Many times the characteristics that lead to failure can be linked to cognitive biases, the unconscious automatic influences on human judgment and decision making that relate to reasoning in uncertain conditions (Kahneman 2002). Several interviewees suggested that cognitive biases are at the basis of accidents but it seems that few remedies are known.

3.2 Anticipation: "The danger is like a snake"

3.2.1 Anticipation as a concept

Anticipation has been described as the ability to address the potential (Hollnagel et al., 2011); it is about knowing what to expect and how to anticipate potential changes, disruptions, threats and opportunities.

'Anticipation' as an abstract concept appeared to be the resilience-cornerstone which was the hardest to get concrete examples of from the interviews. Some interviewees made references to institutionalized risk assessments and putting together multidisciplinary teams to conduct them. These teams then are more able to dream up 'new scenarios'. This topic will be elaborated upon in paragraph 3.2.4. However, many respondents stated that 'dreaming up new unexpected scenario's' is not possible, since the nature of uncertainty lies precisely in the fact that we cannot foresee what will happen in the future.

This section describes:

- The uncertainty that people experience and the way they experience it in their jobs e.g. "the danger is not binary but like a snake".
- That resilient people are risk aware and vigilant, but not afraid;
- Why it is important to be good at thinking through the different scenarios;
- Why it is even more important to be dedicated to "getting it right".

These findings will be described in further detail using citations from the various interviews that have been conducted.

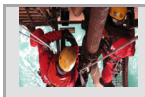
3.2.2 Uncertainty and danger come with the job

When asking people if they regarded their job as dangerous, it appeared that people are very much aware of the dangers they -or the people whom they manage- face on a daily basis. They fully acknowledge the *potential* variability of the environment, the processes and substances they work with, the behaviour of the organisation and their own variability. They suggest that many of the incidents or adverse events are simply the result of unexpected combinations of this variety and which goes beyond the imagination.

UNCERTAINTY 'The danger is arduous and snaky'
Arnaud Guillaume, mountain guide

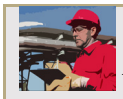
First of all: the environment we work in is so uncertain that you will make mistakes, always, whether you like it or not. You will make mistakes and – lets presume the consequences are not too grave - it is up to you to learn from it or not. …..The danger is not something binary. You start your course, go forward and suddenly you see 'the danger' and - hop - you turn back. The danger is tortuous. It is arduous and snaky. It is not necessarily present, but potentially it is there. Second there is you; you make an evaluation transposing your knowledge and experience into a particular situation. You are making an evaluation of two uncertainties. There you are, this is our problem…..

[T]here is not only the evaluation of the situation that will differ from person to person. The acceptance of risk will also be different from person to person. It is not only personal but also it will depend on the moment. It will be part of that certain environment, the current state of mind (état d'esprit) of the person whom it concerns.



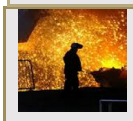
UNCERTAINTY 'There is nothing like 100% control'
HSE Advisor, Rope access company

No, I do not have the illusion that we can secure everything. Our work surroundings are constantly changing, as do our projects. We still have a lot to learn. There is nothing like 100% control.



UNCERTAINTY 'Reality exceeds imagination'
Senior company manager HSE, Petrochemical company

There are two main sources [of uncertainty], which are the variability of the parameters and the lack of knowledge or information. There are some things you simply don't know. Of course you know it afterwards, that's for sure, but if we take Buncefield for instance, which was in 2005, at that time I had 20 years of experience. If you would have asked me to imagine that type of accident, I would never have thought about it. By the way a consultancy did a study; nobody thought about it. The accident Macondo , BP Texas…. Of course afterwards it's very simple to explain. Fukushima, you see this too. So you have the uncertainties, simply the reality exceeds the imagination and that is true for natural hazards as well…



UNCERTAINTY 'There are always things that you do not control'
Production Assistant, Blast Furnaces

These processes involve risks. They only become dangerous if you do not manage these risks in a proper way. If I would regard this working environment as dangerous, I would not send anybody out there. It is a working environment with risks. And some of these risks we manage really well and others we manage a little less well. There are always things that you do not control, but often these are the things that you do not know about.

3.2.3 Risk aware and vigilant but not afraid

With uncertainty comes the expectation of having to face new unknown situations, unforeseen risks. This requires vigilance, a state in which attention must be maintained over long periods of time, watching for a signal that could occur at any time. Studies of prolonged monitoring and visual search indicate that rare signals will be missed unless they have high saliency, like a flashing light for example. Over time performance in signal detection declines; this is known as the vigilance decrement (Davies & Parasuraman 1982).

It has been stated that a resilient system must be both prepared and be prepared to be unprepared (Pariès 2011). Being constantly vigilant in an uncertain environment aims to fulfil these requirements.

It is important to mention that vigilance is not the same as being afraid. It seems that people who chose to stay in a job where high hazard risks are involved find the management of risk one of the more interesting parts of their profession.

RISK AWARE 'Constant vigilance'
Lionel Daudet, adventurer and mountain guide

Let's say that you are in a room together with a snake that moves around and therefore you will be in a dynamic state of constant vigilance, asking yourself from which side the danger comes from instead of floundering around or sleeping peacefully. This asks for a lot of concentration and energy. It is hard to be in a constant dynamic state. Attention is a synonym for vigilance.

One key - if you ask me – is that it is important not to feel and act like 'superman'. Pay attention to doubt and humility. These things will bring in another way of thinking, other perspectives into the world of enterprises. We often only think in a box like this and you really have to open up this box, be as open as possible. Look in three dimensions. Not only below and above but also right and left. This will make you more competent to deal with risks.

But if you are head of a nuclear plant, it would be a pity to wait for an accident before starting to learn. No, you have to be constantly alert, which is extremely difficult. Also in the mountains. In the mountains your vigilance is also killed by routine, habits, repetition of movements.

RISK AWARE 'their snakes are behind bits of pipe and in conduits..'
Group EH&S Compliance Manager, Healthcare

The problem is, their [maintenance]"snakes" are behind bits of pipe and in conduits and stuff like that. And it's not until they take the valve off or open a pipe that they get exposed to it. You know, that's half the problem. To change the analogy somewhat – you keep the snakes locked up with engineering solutions for the normal operators, generally, but the maintenance guys are the ones that have got to open the cage.

RISK AWARE 'Hold each other's hand and be very vigilant not to make mistakes'
Manager Blast Furnaces

'What do you do to prepare for the unexpected? If that is possible at all..

Well, we have around 350 people. One of the most important safety nets – how soft it may be – is discuss everything, the smallest things that can be of importance – openly and with curiosity. People that operate blast furnaces – and I see this everywhere in Europe, the United States, India – are grouped in classic teams. Like family liaisons – rather than very professional, which means system driven, – caring for each other and the processes. Good at the content, bad at procedures. Often careers of many many years are centered around the blast furnace. A blast furnace is a system from around 1910 and the working mentality seems to stem from the same era. Hold each other's hand and be very vigilant not to make mistakes.

What consequences does this have for management of personnel?

You need intelligent people, which is not the same as people that have followed higher education. Intelligent people are people that understand that they have responsibility - for their colleagues, the company, themselves. They are people that are very 'conscious'. Self-selection goes on here in a certain way as well.It is knowledge intense. A lot of what you have to know and do can't be learned at school.'

RISK AWARE 'Constant vigilance is important and I do not regard it as a burden'
Manager blast furnaces

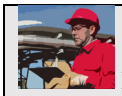
'Constant vigilance is important and I do not regard it as a burden to occupy my time with these kind of things. It's my job. We are not going to fall asleep. My job is like a time machine: I blink two times and two years have passed!'

RISK AWARE 'We do not do our work on a children's playground'
HSE advisor industrial rope access and maintenance

'There is a lot of potential for things to go wrong: the procedures are quite complex, the worker is always at vulnerable positions, there is never an easy way out – whether we are in the ropes or in narrow enclosed spaces, we work with and around dangerous machines and instruments, often with little communication possibilities and at places where it takes a long time before the emergency services arrive. Yes, in this sense effectively there are dangers involved. But we hold in high regard that we are able to safeguard what we do.

Next to this we do not do our work on a children's playground. We are hanging in our ropes at about every high hazard site in the country and often in very exposed places. When we climb in a chimney, for example at a petrochemical site, we do not know if the thing is completely rotten or not, because no one has been there for more than 10 years. Next to that this is exactly the place where the gasses will come out if below there is a problem and suddenly the operator decides he wants to flare.

But on the other hand, if we look at the statistics, working with ropes is one of the most safe activities you can do within the industry.'



RISK AWARE 'Alertness and consciousness are always important'
Emergency response and security manager, chemical industry

Did you regard your previous jobs as dangerous?

The last plant I worked at, dealt with a dangerous substance. This did not mean immediate danger for myself. But if I were to take the wrong decisions, I would put others in danger, so yes. You always have to think three times and do a last minute risk assessment and be sure that you do the right things. But this is a core value of working in the industry. And the same core value goes for driving a car. For sitting behind your desk almost. Alertness and consciousness are always important. Doing things on auto-pilot has risks attached.

3.2.4 Good at thinking through the different scenarios

Some interviewees described how they were trying to think ahead and anticipate future situations by thinking through scenarios, using their vast experience and constantly cross checking with the current state. In other words they try to anticipate uncertainties using what has been called anticipatory thinking. Anticipatory thinking is the process of recognizing and preparing for difficult challenges, many of which may not be clearly understood until they are encountered. It has been defined as a future-orientated form of sense making (Klein et al 2007). This kind of anticipatory thinking requires a high level of experience; it is necessary that a lot of situations have been 'lived through' before large pattern repertoires are built up. With these pattern repertoires effective pattern matching can be conducted leading to problem detection if something is not right. Anticipatory thinking will enable people to get 'ahead of the curve', noticing and extrapolating trends.

THINKING AHEAD SCENARIOS 'Take all changes into account'
Arnaud Guillaume, mountain guide

'It is all about being able to make a picture in your head how the day will develop and prepare yourself. And the very moment that there is a change, you will have to rethink everything. For example: your client is not as fit as he was the day before; the weather is changing; there is another party ahead of you in the route. These changes do not necessarily mean that you will have to stop and go back. But you have to note it and take it into account for the rest of the day. And if there is another change, you also have to take this into account and review you objectives.

…The main thing is that you will have to learn not to shut your eyes or to pretend that something did not happen. Then you are really vigilant.

THINKING AHEAD SCENARIOS 'Like a film in your head'
Lead engineer, industrial rope access and maintenance

'Second - this is something I have developed during all my years of training and working experience - we learn to detect on four dimensions: all different directions but also going forwards in time. During the years you get better and better at this. Certainly with high end clients you are investigating every minor detail in the process. For example: when you are going to work on a platform at sea and will be flown in by helicopter you will have to think through every step in the process:

I am putting my equipment into a container, what is in my equipment (no dangerous goods?), will it be light enough to take out of the container and hand-carry, is it well secured so that it will not immediately fall out of the container when this is opened?

This is something you have to learn, you have to gain experience and you have to be open for it.

It is like a film in your head. The more you can really foresee the things that are going to happen, the more you can prevent or prepare for the risks.'

We also use risk assessment models, such as 'HEEPO - Human, equipment, environment, product and organisation'. This model prevents us from only looking at certain aspects and creating blind spots.

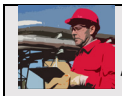
THINKING AHEAD SCENARIOS 'Can you be happy that you have done everything you could?'
Process Safety & Technical Manager, major hazard site.

You are looking at all the different things that can go wrong and then working backwards - if it has gone wrong can you be happy that you have done everything you could, can you live with yourself that you have done what you thought you should have done?

THINKING AHEAD SCENARIOS 'In a structured way you allocate your time to think about it'
Senior company manager HSE (Petro)chemicals

Do you have to constantly generate new scenarios?

Yes of course. We use the bowtie and all these kinds of things. So the strength of all these methods and of QRA is in fact the time that you allocate to think about these things. That is why if you ask a consultant to make your QRA you have missed the goal. But if you do it yourself by working with these probabilities, these consequences, these bowties and the fault tree analysis which is more fault trees than analysis, you can make errors, that is not the problem, it is the fact that in a structured way you allocate your time to think about it. And that is the strength.



THINKING AHEAD SCENARIO'S 'We did not do proper 3D thinking'
Business Unit HSE manager

'The thing we learnt from the Tripod analysis is never to do maintenance using such open systems anymore. And it was clear that we did not do proper 3D thinking for this maintenance problem when we prepared the Permit to Work. What I mean is that we did not consider a worst case scenario and take into account the pipes and cables above the tank. 3D thinking is something that is quite common especially in complex factories with many floors. There has to be a good team manager that has a helicopter view and knows about all the maintenance work that is going on, for example.'

THINKING AHEAD SCENARIOS 'Every situation is more or less specific and it will not always be possible to use your previous experiences'
Arnaud Guillaume, mountain guide

There is the influence of 'the objective' that we have in the mountains. First you are aiming for a certain route or summit and at a certain point the bad weather is coming in. you will say: "Damn! They did not announce this!" But you will turn back and go down - still doubting a little bit. When you are down in the valley, the clouds all disappear. When this happens a number of times, you will be extra focused to proceed – But will it be a good idea to push on? No, not according to me. The probability that something will happen to you is identical to the first time you attempted to go to the summit. Also when you stopped nine times with doubtful weather and nothing happened, and now it is the tenth attempt with the same kind of weather and you decide to go for it the same uncertainty remains. The nine experiences you have had before will not help you in fact to make a good decision!'
(…)
Nothing has been researched formally but when there are accidents it is not the young guides that are part of it. It is not the old guides either. It is middle age-group. We have had guides that had accidents in avalanche situations that had been trainers for avalanche retraining programs.

So these are people who have an enormous experience, are even regarded as experts, but…

They think of something else when they have to make the right decision. They are too much occupied in their minds by "the things of daily life". Their family life for example.

Maybe they want to have a nice powder ride?

No, they are so experienced that they do not search for a thing like that anymore.

There has been an accident a couple of years ago with a very very good guide and a school class. It was about being in the mist during the ascent on fairly flat terrain. He thought an avalanche from the slope above could never reach them and then getting caught with a whole class of schoolchildren behind you…

Damn! It is so difficult. Every situation is different, there are so many traps to fall into. You can never transpose one experience to another situation.'

As shown in the citation above anticipatory thinking and especially pattern matching may however carry important dangers with it: people may wrongly extrapolate the one experienced situation to a new situation, while trusting on their 'experience'. This is one of the reasons why Weick, Sutcliffe and Obstfeld (1999) suggested that mindfulness is important for risk management and decision making under uncertainty. Mindfulness can be described as a state of present-moment awareness. This very much relates to the characteristic of 'real vigilance' as described by various respondents.

As Daniel Kahneman described in Thinking Fast and Slow (Kahneman 2011) many intuitive judgements have to be distrusted because of the functioning of our brain. On the other hand Gary Klein (2003) is very optimistic about the intuitive judgements of experts (he studied for example how firefighters were able to make correct snap shot judgements in crisis situations). Kahneman and Klein have worked together on this subject to see if they could solve their controversy. They agreed that an intuition only can be skilled if

- An environment is sufficiently regular to be predictable;
- There has been an opportunity to learn these regularities through prolonged practice.

In a less regular, or low validity environment, the heuristics of judgements are invoked. And Arnaud Guillaume, mountain guide and risk management teacher at the French National Mountain Guide School, is very aware of this.

3.2.5 Dedicated to getting it right

Anticipating variety and being prepared for the unexpected has, according to several interviewees, a lot to do with focusing on details and getting as much as possible right. By doing this it is said you will have at least the best cards in case the unexpected happens or mistakes are made. The underlying view is that (major) accidents are often a constellation of things going wrong, or in bow-tie terms it is a number of different safety barriers that did not function or were not put in place. The probability of having an accident diminishes when as much as possible is done right. It is not for nothing that combat soldiers are trained to be very disciplined in maintaining their equipment (including themselves) in the best possible state.

This characteristic or attitude has a lot in common with the things that are done in preparing for the expected, but the underlying motivation is focused on the inevitable unexpected.

GET IT RIGHT 'Do not forget any tool'

HSE Advisor, industrial rope access and maintenance

'And people of course do not always oversee all the consequences. If you go on holiday and forget your towel, the consequences are relatively small. Forgetting one of your tools while working at heights may be the difference between coming back alive or not.'

GET IT RIGHT 'they assume nothing will happen'

General Manager, height safety & rescue training company

People leave their rescue kit in their car when they go working at heights at a wind turbine, simply because they assume nothing will happen based on the fact that until now they never have experienced anything that went wrong. But then, if something happens up there and they do need this rescue kit, they will need to go down 100 meters on a kind of ladder – this just doesn't work.

Another example is that people take off their harness while working a day high up in a wind turbine because they find it too hot to keep it on. We try to make them aware of the risks by asking questions.

GET IT RIGHT 'Top level sports'

Manager blast furnaces

'It reminds me of my time as a student and my chess statistics. For example I often replayed the chess-games of a particular grandmaster. I tried to make the right chess moves. Maybe four times it worked well, and the fifth time I made the wrong move and lost the game.

What I mean is that you have to keep your error statistics as low as possible. Me and my colleagues we know that we only get better at managing our processes when we reduce our error statistics. And we know we make many mistakes, every day, because a lot of decisions are taken. So what it is all about at the blast furnace is to reduce the error-statistics without the performance going down too much. And this is top level sports.'

GET IT RIGHT 'It is the little incidents and near misses that help us to prevent worse.'
HSE advisor industrial rope access and maintenance

Many accidents are a constellation of things that went wrong. I often think that if we should have tackled some of these little things upfront, this accident might not have happened. Little things often make the difference.

I will give an example. The moment we hand out safety glasses that are not handy, because there is a rim that blocks part of the field of vision and no one tells us this, we will recognize this problem only after someone has broken his leg because he made a misstep. So I encourage people to report all of these things. And of course it is crucial to follow up everything that has been reported. Otherwise people stop reporting.

At the moment I have a concrete case at hand. It's early summer, temperatures rise and last week one of our people reported: "the work outfit is very multifunctional but it gets very hot inside!" These people work at sea and there is a tendency that they only drink little water during work. This may eventually result in someone being unconscious 20 kilometres outside of the coast. So currently I am checking alternatives.

Another one: someone reported that he had to do a project 3,5 hours driving away from his home. And after 10 hours of hard work for the client he had to drive back. So now we are making a policy for these kind of situations. For example that people may - or have to - sleep in a hotel before or after such a job, to prevent that someone has to work for 18 hours in a row and stay alert all the time, which might end with a crash in some verge.'

GET IT RIGHT 'Little things prevent the big blast'
Manager blast furnaces

'Here all the little things happening will prevent that the big blast will strike. It is like a little child learning to ride a bicycle. He has to get a gash in his knee now and then.

GET IT RIGHT 'It is just statistics'
Arnaud Guillaume, mountain guide

I see all the behaviour that might not be dangerous in the beginning but that becomes problematic as time goes on. Do you understand what I mean?

Please explain.

For instance, it becomes problematic if you do not do certain things systematically. You will have little chance to have an accident if you do not do the same thing many times. But if you do it a lot of times, your incidence will be high. It is just statistics. If you do your thing right systematically, you will have a low risk, but if you do it one time right, one time not like it should be done, then you do it right again and afterwards not right, this will lead to a certain moment when you will not do it right and 'there you are': ping an accident!

So, you always have to make sure to avoid errors and mistakes?

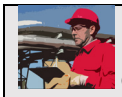
Yes, you shouldn't think: "I can do it faster without that." "This does not serve anything -I will be careful." And you also shouldn't be lazy; for example you made a mistake but do not want to do the task all over again.

GET IT RIGHT 'Do more of these little things right'
Emergency response and security manager, chemical industry

'Does it get safer?

Yes, people are more conscious. In my experience an accident always exists of a compilation of little things that go wrong. It is never just one thing going wrong.

It is like an iceberg. You only see the top of it. Underneath the water there are many things that can go wrong. If you can do more of these little things right, you may prevent an accident. Sometimes you already know something is wrong but still you want to proceed, finish what you are doing. And then an accident happens.'



GET IT RIGHT '…now maybe it's only a small deviation…..'
Process Manager, Petrochemical industry

Now it's maybe only a small deviation, but the underlying behaviour could lead to a major deviation. Somebody leaves a valve open, walks away - and that's not too bad it's only a water stream - but the behaviour is you opened the valve and walked away. If you apply that same behaviour and that same standard to a system which has hydrocarbons I could have a huge fire.

GET IT RIGHT 'Do not forget any tool'
HSE advisor industrial rope access and maintenance
'And people of course do not always oversee all the consequences. If you go on holiday and forget your towel, the consequences are relatively small. Forgetting one of your tools while working at heights may be the difference between coming back alive or not.'

3.3 Learning: "There are not 20 jokers in the game"

3.3.1 The learning issues

Learning addresses the ability to get insight into what has happened, learning the right lessons from experiences resulting in more adequate behaviour than before. These experiences might be failures, near misses or successes. Hollnagel et al (2013) consider that the focus should be on success rather than the avoidance of failure. They call this Safety-II rather than Safety-I:
"Safety-I begins by asking why things go wrong and then tries to find the assumed causes to make sure that it does not happen again …..The alternative is to ask why things go right (or why nothing went wrong), and then try to make sure that this happens again." (Hollnagel et al 2013)

However, in this section it will be explained:

- Why learning from things that go wrong seems to be more effective than learning from 'the positive';
- That in order to learn you should not confuse 'luck' and successful operating;
- That learning from successes might be dangerous (because of certain heuristic traps);
- Why it is essential to be willing to learn - also from small accidents and near misses ('the little things');
- That resilient minds are self-reflective and 'willing to learn'.

3.3.2 Is learning from success or failure?

Hollnagel et al (2013) say that it is more effective to learn from what goes right than from what goes wrong; accidents and catastrophic events do not occur frequently and are too dissimilar to allow generalisations. However in the interviews there is not much support for this in practice. Learning from things that go right instead of things that go wrong was not something that many interviewees could relate to.

LEARNING 'the nine thousand nine hundred and eighty work orders that were done very well today'
Senior company manager HSE (Petro)chemicals

If I talk to you about all those people that were on the roads in this country today and they didn't have an accident you will consider it as a waste of time to talk about. So if I have to go to the operators to talk about all the nine thousand nine hundred and eighty work orders that were done very well today, or this year or last year, they will say that is bullshit.

The majority states that learning from near misses and incidents is the most common *and* the most useful. This also seems to be in synch with popular quotes such as:

'Success is stumbling from failure to failure with no loss of enthusiasm' (Winston Churchill)

Or:

'The formula for success is quite simple: double your rate of failure' (Thomas J. Watson, Chairman & CEO of IBM).

LEARNING 'Through incidents!'
Production assistant at blast furnaces

This learning, how does that work in practice? Do you learn from things that go right or through incidents?

Through incidents! No, if everything goes according to plan, the organisation starts to slumber. It is a pity, but this is how it works. And this goes certainly for these kinds of specific installations and processes. Look, in this country we only make steel in *these two* blast furnaces. So all the knowledge on these processes that we have in this country is gathered here. Unless you look at other countries. A pressure tank you can find at all sorts of places. There is common widespread knowledge concerning design and engineering of these kinds of installations. Our hot air system is very specific. You can only improve by learning from incidents, incidents that we have or that occur in foreign countries. Luckily we have quite good consultation with our foreign peers.'

LEARNING 'Victory is conservative, and failure allows you to progress.'
Lionel Daudet, adventurer

'Which experiences have been more important in building your experiences: successes or (near) misses?

'Le discours que tu tiens, est le fruit de tes actes' (your past experiences are shaping your thinking and reasoning in the present) of course. And strong experiences like accidents have the tendency to shape who you are. Also in my case there have been accidents. And these accidents are all too easy to analyse. There is always this story of a spiral: you have been too slow at a certain point, you have arrived too late somewhere else and you get soaked into a certain situation you feel it gets dangerous, and then the bad weather falls in and 'paff' you will be in this thunderstorm. But, beware, this is all bound to your personal analysis. Your own analysis can be very different than that of someone else. Every alpinist will have a different appreciation of the risk of a certain climb.

And after that there is always a constellation of factors that finally lead to an accident. And afterwards you have always had these alarm lights somewhere in your head that were blinking, but that you did not see or did not want to see.

After an incident has happened, it is always more easy to analyse than when you are in the middle of it. Therefore an incident always has this very constructive value: you learn, you augment your experiences. Victory is conservative, and failure allows you to progress.

This is why I like the anglo-saxon tradition. For us there is the summit or failure. A Brit will say: no, there is also *the attempt*. They recognize the value of an attempt. I like the learning that is involved in trying. That is also why we really are able to progress. We build on the experiences and failures of others as well. And finally: if you never fail, that means that you did not put the bar high enough. Simple as that.'

LEARNING 'we all need a lot of luck in our first years'
Christophe Kern, mountain guide

So your practice has become safer - as for a lot of people because the sport has evolved and grown a lot. But do you still make errors? Do stupid things?

Of course, but less. That depends also on what you call 'stupid things'. Yes, I still climb an easy pitch without belaying myself. But that is something that is inherent to the job of being a guide. You cannot spend all your time on belaying – putting in friends' pitons etc. - when you are in the mountains. Otherwise doing a route will take you three days. You have to be fast as well. So partly this can be regarded as bêtises (stupid, foolish things). It is integrated in the job.

And of course I learned a lot during the years.

The classic scheme is that being an alpinist we all need a lot of luck in our first years. That is different for sports climbing for example because there are less different situations. You can learn step by step what to do in which cases. In alpinism the possibility of making mistakes is enormous. For example judgment of the weather forecast, the path finding, your climbing partner, the quality of the rock, snow or ice. I still take risks (for example when I cross a couloir where there can be rock fall), but I do not have the idea that I still make a lot of mistakes. Where I still make judgment errors is in evaluating the difficulty of the climb or the competences of my clients.

Things that go wrong or nearly wrong seem to be the most engraved in the mind and in the organisation. These are experiences that enhance the understanding of the nature of risk and its consequences, the vigilance and the willingness to do things right; this is learning at a fundamental level.

LEARNING 'It is a pity … people learn the most from incidents'
Business Unit HSE manager chemical industry

'What did these experiences mean for your relationship with 'safety'?

It is a pity, but I have seen that people learn the most from incidents. Many people who are passionate and very aware of 'safety' have encountered incidents somewhere during their career, while they had a line / people responsibility. This responsibility has often only been engraved in their hearts and in their minds when they were involved in incidents involving their employees. That is what I see.

Is it possible for you to give examples of these experiences? You mentioned 'the good, the bad, and the worst'.

The incident that stayed with me for a long time concerns something that happened some 10 years ago. We had extended our production and we had just had the grant opening with a lot of people invited, with family and great festivities.

A day later – everyone luckily had left the site - I was called by a colleague who was on duty and it appeared that there was an emission of a hazardous gas. This meant that a governmental emergency response team had to be flown in. The whole incident made a big impression on me, especially the Tripod analysis. Within Tripod it is always the manager that did something wrong. That made me very aware of my responsibility: "Damn! We are the ones that were responsible for this emission.

LEARNING: 'Things that go (almost) wrong create more intense experiences'
General Manager rope access training company

'One last question: From what kind of situations do your participants learn the most? Things going wrong or things going successfully?

Things that go (almost) wrong create more intense experiences. At least, when people are confronted in the right manner with the consequences by the trainer. But I do want to believe in learning from things that go right!'

LEARNING 'If you don't make errors you don't learn'
Senior company manager HSE (Petro)chemicals

The problem is that it's a very tricky thing, because if you want people to become experienced and knowledgeable they have to make errors. If you don't make errors you don't learn. So they need to make errors but of course we don't want errors. We have return on experience, we send it around we discuss, we talk to the people…

Learning in one case went so far that the person concerned chose another profession for a period in his life, because he considered that his character / state of mind was not compatible with the uncertainties that came with his job surroundings.

LEARNING 'I had to quit what I was doing'
Christophe Kern, mountain guide

'What exact role did the death of your friend play in your decision? (the friend died in an climbing accident, Ed.)

At that moment for me it was a sign that I had to quit what I was doing. I did a lot of highly engaging alpine climbs and it was clear for me that I would die as well if I were to continue. I also had had some very severe accidents myself. Two times I fell down some thirty meters in the Calanques. One time while rappelling and another time on a very easy route with a client. I did not secure myself and then a huge piece of rock broke off. I fell into the water. First I hit the rock and then I plunged into the sea. Those were experiences that were not easy and they told me that maybe at that moment the mountains were too uncertain and unpredictable (aléatoire) for me.

(…) *What exactly changed? (because in the end you chose to become a mountain guide after all.)*

Probably I give myself more time to make decisions. More prudent. More responsible. More and more I take all possible consequences into account, for example when I go and do a heavy route in the Alpes. And also I learned a lot more about several techniques to postpone (*repousser*) errors.'

It thus seems that incidents have an important influence on the attitude / hearts and minds of people. People became aware of the need for other risk management strategies, such as:

- To always have someone or a team of people to challenge assumptions and decisions (use prescribed decision making procedures)
- To have redundancies in place
- Not to count on luck anymore ('better be safe than sorry')
- To keep a larger safety distance (as to avoid coming 'near the edge' or even go beyond)
- To learn from little accidents and near misses.

3.3.3 Do not confuse luck and success

On the other hand several warnings were given by the interviewees with respect to learning from the positive or things that go right. Learning from things that go right involves at least two important risks. First of all things may not have gone right because of good risk management, it may have been due to luck that things were successful. Several interviewees confessed that they had been lucky in the past. And after that they had asked themselves: 'Surely things may have turned out well, but was that due to my own good performance or to luck?' This points at a big willingness to learn and improve.

LEARNING 'Luck does not follow you as you advance'
Arnaud Guillaume, mountain guide

'Do you think that your practice as an alpinist – amateur – has become safer during the years?

Yeaaah. I think so, yes. The more I get older, the more I am afraid of dying. That's for sure. When I look at the climbs I have done, I am more and more convinced that I have been very lucky several times. And my practice as an alpinist – an amateur – should not be built on luck. Luck should not be a part of my risk assessment. Being young, you count on luck. But luck will not follow you if you advance. **There are not 20 jokers in the game.** So I – and this is personal – nowadays prepare my outings without counting on luck. So I put more important security margins on my outings.'

LEARNING 'Protect the new generations'
Emergency response and security manager, chemical industry

'But still there will always be these very experienced people that have been working for 30 years and were just lucky. And others were not so lucky. And we want to protect the new generations from being 'not lucky'.

Do you mean that these very experienced people learnt by mistake and nowadays know exactly what to look for and they can do things quick and dirty without too much problems; Whereas the new generation is less experienced and more in danger?

Exactly. That is why it is always a kind of dilemma. On the one hand we need the experienced people to train the young generation. On the other hand: these certain rituals – things not exactly according to the rules – also are going through. Also here we try to look for the right balance.'

A second warning with respect to learning from success is related to the fact that people might go blind for weak signals when success seems at their side. Or as Weick and Sutcliffe (2001) have stated: "Success narrows perceptions, changes attitudes, reinforces a single way of doing business, breeds overconfidence in the adequacy of current practice, and reduces acceptance of opposing points of view."

LEARNING 'You want to repeat or outclass the previous success'
Manager blast furnaces

'Do you learn from things that work well as well?

We are tempted to exaggerate things that go well. For example: high production records. They taste "more-ish". You want to repeat or outclass the previous success and this will put a barrier up to cutting your losses in time.'

3.3.4 Do not automatically assume that two situations are comparable

Second it has to be pointed out that in the world of variety it is equally difficult to compare situations that were successful as it is to deduce from situations that went wrong. When looking back there is for instance always a risk of an availability heuristic and thus making a decision on unfounded assumptions.

The availability heuristic is one of the famous heuristics proposed by Tversky and Kahneman (1973). It is a mental shortcut that relies on immediate examples that come to mind. The availability heuristic operates on the notion that if something can be recalled, it must be important. Subsequently, people tend to heavily weigh their judgments toward more recent information, making new opinions biased toward that latest news. Further, the availability of consequences associated with an action is positively related to perceptions of the magnitude of the consequences of that action. In other words, the easier it is to recall the consequences of something the greater those consequences are perceived to be. Finally, people not only consider what they recall in making a judgment but also use the ease or difficulty with which that content comes to mind as an additional source of information. Most notably, they only rely on the content of their recall if its implications are not called into question by the difficulty that they experience in bringing the relevant material to mind.

Sometimes the heuristic is beneficial, but the frequencies with which events come to mind are usually not accurate reflections of their actual probability. In the following quote an example of the before mentioned representative misjudgement is in play leading to a deadly accident. The more recent experiences with the weather became more important than the probabilities of the actual forecast.

LEARNING 'Yesterday it went well so today we will be able to do the same'
Arnaud Guillaume, mountain guide

Your risk taking might be influenced by previous experiences when things went well in spite of the risk that was out there?

I know what you mean and I have an interesting example of this. There was this canyoning guide that went canyoning with his clients for some days. Every day the weather forecast was 'sunny with a risk of thunderstorms in the afternoon'. Thus the first day they did something not too long, because of this risk of thunderstorm. In the evening: blue skies. The second day, same kind of weather and he takes the same decision: not go into a long more difficult project. The third day: same situations. However his clients started to put a little pressure on him. For four days this went on and for four days there was no thunderstorm in the evening. The fifth day they forecasted the same kind of weather. The guide decides to go into this long and complex canyon because that was the main objective of his clients for this particular week. And paf: the thunderstorm strikes that day which results in 2 deaths.

Here there is also a phenomenon of 'pression'. But he will have said to himself: it could have been done for four days, the fifth day it will be possible as well.

A same kind of situation can occur when you want to ski snow slopes. You go up on the sunny side and want to go down the north face. Standing above it you have a little doubt and after an evaluation of the situation you decide to ski down. And: great! The next day he has a same situation with a same kind of north facing slope. He might say to himself: "Yesterday it went well so today we will be able to do the same." But no, it is not the same situation! And for sure everyone has this same kind of fault more or less.

3.3.5 Willing to learn and improve: self-reflection

It may sound obvious but to be resilient at the level of the individual mind people have to be willing to look back and learn – also when things turned out right. To challenge their own actions and assumptions, 'not only when things went right but also when goals are attained. Without such a willingness, a lot of opportunities to learn and improve will be missed.

LEARNING 'Learning but 'the risk will never be zero'
Manager blast furnaces

'The situations at which things like this (huge explosions, ed.) can happen are known, but not *all situations.*

The known situations you have to manage with your management system. You have to be constantly alert. You have to constantly check if the measured variables are within margins; your management system has to be correct. What people do has to be in synch with prevention of mixing water with steel. And this is less simple than you think it might be. For example the floors in the oven are cleaned with water. It's a tradition that goes back for many years. It prevents things from getting very dusty. And if water is blown onto liquid steel, you will only get water vapour – no problem. But steel on water, that's uncontrollable, really wrong. And water has the tendency to spread everywhere. So there is for example the possibility that this water is absorbed by a stone and after that liquid steel flows over this stone and there you have your explosion.

So you have to realize that the risk will never be zero. And every time we have an explosion we will analyse what happened, it is a continuous learning process. Every little accident you have to expand discuss, analyse, fill out a 'red line form' etc.

So we try to avoid accidents by influencing the 'human side', but this will give us no guarantees; it will not make things inherently safe.'

LEARNING 'Always feedback'
HSE advisor industrial rope access and maintenance

'How do you as HSE person try to influence this kind of behaviour?

I am very active in gathering all near misses, incidents and accidents. I try to write everything down, to analyse, to give my opinion in the hope that the next time we will prevent things alike happening. That is the material with which I work. And I find it very important to give always feedback to people who report. I want them to stay involved.'

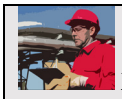
LEARNING 'Look at the mild things'
Arnaud Guillaume, mountain guide

'How is learning from accidents transferred to the guides community?

In case of accidents it can take years before the facts can be analysed within the climbing community. That is because the litigations sometimes take years before coming to an end. The syndicate tries to put in place a 'retour d' experience' based on near misses. Already several interesting cases have been discussed. But many guides are not very willing to share stories like this, even if it is confidential. It is not yet really possible to talk about the errors or faults of a guide. "He was all perfect!" It is not a natural thing for them.

But it is very good to focus on the near misses. Do you know the accident pyramid? The iceberg. Underneath one deathly accident lie two other accidents with severely wounded people. Under that you will have 10 severe incidents, underneath you will have 100 less severe incidents. And so on. So if all the little things are diminished, you will also have less mortal accidents. That's why it is good to talk about small accidents and near misses. Look into a 'normal day' and talk about the things that could have done better, the 'mild things'. Everyone recognizes these things without that it becomes dramatic. When there is a real accident it is easy for people to say "yes, but I would never have done like he did; I never had a deathly incident, this does not apply to me!"

Talking about little incidents that everyone has experienced, this has more impact, according to me.'



LEARNING 'Keep scenario's alive'
Emergency response and security manager

'When it gets safer this will also mean that less things go wrong and that, as a consequence, there are less opportunities to learn.

Yes, this is part of my current challenge: security and emergency response. Keep practicing! Keep scenario's alive. And maybe we should also bring the same philosophy back to our plants, to keep training on scenarios of things that have happened in the past. Probably nowadays there will be barriers, but also these barriers can fail. It is something we do already. On Sunday mornings for example we practice our procedures. Safety risk scenario's we call them.'

The willingness to learn and improve based on reflection of things going right and things going wrong not only makes people resilient but also - what nowadays is called – 'antifragile' (Taleb 2012):

"Some things benefit from shocks; they thrive and grow when exposed to volatility, randomness, disorder, and stressors and love adventure , risk, and uncertainty. Yet, in spite of the ubiquity of the phenomenon, there is no word for the exact opposite of fragile. Let us call it antifragile. Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better. This property is behind everything that has changed with time: evolution, culture, ideas, revolutions, political systems, technological

innovation, cultural and economic success, corporate survival, good recipes (say, chicken soup or steak tartare with a drop of cognac), the rise of cities, cultures, legal systems, equatorial forests, bacterial resistance … even our own existence as a species on this planet".

3.4 Monitoring: "Some people are more switched on than others"

3.4.1 Monitoring issues

Monitoring has been described as the ability to address the critical, to know what to look for and to cover what happens in the environment and in the system itself. It is defined as concerning the actual and the things that are important in the near future (Hollnagel et al., 2011).

The interview respondents were very well able to describe the importance of constant monitoring and gave ample examples of how this works in practice. It also seems that within the high hazard industry already several instruments have been developed to enhance and sustain the monitoring capacity.

This paragraph focuses on:

- The importance of being 'switched on', using all your senses, looking in all directions and concentrate on yourself , 'the other' and the environment;
- The importance of hold points and decision nodes;
- Some important mental traps that can be problematic in relation to awareness.

3.4.2 Being 'Switched on'

There is not a distinct line between the ability to address the actual and near future and the capacity to anticipate as described in section 3.2. Being vigilant and aware of changes in the situation are important mental activities in both monitoring and anticipation. In the monitoring situation we call this being 'switched on'. Being 'switched on' has been described as key characteristic for people working in dangerous environments. It seems equally important to have a 360 degree view of this environment as to have insight into all important factors including the individuals themselves.

SWITCHED ON 'Be in harmony'
Lionel Daudet, adventurer

How do you identify and detect the risks, while you are on the other side of the door, in this unknown world to stay 'safe'?

That is why your attention is completely with your environment. You are part of the environment. There is nothing else than the environment. For example: I do not have a telephone. You are completely and totally in the environment. This concentration will make that you will be at the right moment at the right spot. It is a little bit like playing music. You are making music and you try to be in harmony. And you will feel it when you are in harmony. The harmony can be with the danger, the risk, but also with the extreme difficulties, or maybe even with the weather.

SWITCHED ON 'some people are more switched on than others'
Lead engineer industrial rope access and maintenance

"What factors help you to detect and diagnose?

Well, firstly, some people are more switched on than others. They are more aware of what is going on around them.

One interviewee described that he once was in a situation that nearly cost him his life since he was extremely concentrated on his client that was starting to climb, forgetting about his own safety.

 **SWITCHED ON 'I reckoned myself not as a part of the problem'**
Christophe Kern, mountain guide

'And also it can happen that I take care very well of all my clients but I forget myself. For example when I am climbing a ridge with clients. Because I focus on my clients, I forget my own safety.

That I understood after my second big fall: I was mentally totally with the person that had to start climbing and I reckoned that I myself was not part of 'the problem'. I was not into it.'

The same interviewee describes that it is important to give yourself time to get used to the dangerous environment.

 **SWITCHED ON 'I reckoned myself not as a part of the problem'**
Christophe Kern, mountain guide

I take the best decisions when I am completely in the environment ('when I am swimming in the environment'). When I am dropped into a difficult situation it is much harder to take the right decisions. In the beginning of the winter season for example I start with easy things, very gently, Nordic skiing, ski touring but very flat and so on, because I need to adjust progressively. And equally when someone wants to go to the North face of the Droites in May, the beginning of the summer season, I will say: this is nothing for me. It will be too dangerous, because I am not yet prepared and in shape.

I probably learnt that when I became older. And growing older is not only in a physical way. It is a question of ego too. I have nothing to prove any more.

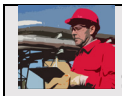
Several people described the importance of using all senses and – within more automated environments – to have measuring systems in place and to have people that are sufficiently switched on as to take immediate action upon little deviations or changes.

 **SWITCHED ON 'I use all my senses'**
Production assistant blast furnaces

'If you make your daily round, what cues are you looking for?

I do not make daily rounds anymore. The job involves a lot of meetings nowadays. But I do talk to a lot of people. And with a process like this, everything should stay inside the installation. Every leakage attracts attention and is researched. And if I am near the furnace I use all my senses. This is something I already learnt from working in the engine room on the commercial ships, I have been sailing. You have to listen to find out if something is wrong, which does not mean that you can perceive everything by sensing by the way.

And I ask people how the daily business is running. This morning I had a nice example at hand. I discussed with a colleague the possibility that a little valve under pressure could cause harm when someone takes it out. Just a small aspect that is related to safety. I do a lot of communicating, talking. And sometimes this means adjusting your own beliefs.'



SWITCHED ON 'A good panel operator does not get any alarms'
Emergency response and security manager, chemical industry

'Nowadays there is this discussion if the 'panel operator' would not be able to do other tasks. For example do things outside the control room, because the ICT allows him to monitor at a distance. But my statement is that a good operator does not get any alarms: he notices everything. The panel operator should be the most experienced man. He knows the system inside out, he notices every little signal and plans the activities that should take place in the coming shifts.'

3.4.3 The importance of 'hold points'

From the interviews it has become clear that being switched on is very important because the environment (including the human himself) is constantly changing, thus implicating variety and uncertainty. If these changes are not perceived and processed in time this might lead to accidents.

HOLD POINTS 'often things are changing gradually and thus almost unperceivably'
HSE advisor industrial rope access and maintenance

'Do you recall situations in which you had to alter your risk mitigation plans?

Certainly this can happen. A lot of times we work at places that are hardly accessible. Sometimes a tank for example only is opened before we start our maintenance project. This means that we try to find out in advance what the situation will look like, but it may be completely different. For example: we can have planned to use a dust mask for the mouth in case there is dust expected. But it could be that we encounter so much dust particles that we need a mask that covers our whole face. If something is really different than foreseen, it is important to stop and rethink the work method. But the first project that goes exactly as been planned has yet to be carried out.

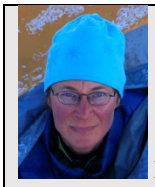
But it is my biggest nightmare that people do not stop in case the situation is changing. Stopping and rethinking the plan asks for discipline. But often things are changing gradually and thus almost unperceivably. Stopping also conflicts with human nature. People often want to finish what they are doing, within the time frame calculated in advance. People want to please. It is often a hassle to stop and come down. First you were already late three hours because the work permit was missing, then it took you an hour to climb up. If at that stage you perceive that something is wrong or strange, it takes courage to come down again and to have a meeting to think through a new approach.'

In dynamic situations, developing scenarios, it is important to have time spaced hold points to allow for data gathering, assessment and balanced decision making. These hold points can be discerned beforehand, while planning an activity, or they can be defined when there is a *novum*: a new - not thought of – situation or change.

HOLD POINTS Discern decision nodes to be less surprised
Arnaud Guillaume, mountain guide

'What I try to teach my students is that they divide their day into logical parts and decision nodes. This means: places and moments where a conscious decision has to be made because there are different options. Decision nodes can be planned ahead - when you prepare your climb. But besides that something unexpected can happen, an external factor that comes in, and this will also evoke a decision node.

If you do this, you will be less surprised by the course of things.'



HOLD POINTS 'That gave me back my certainty and direction'
Katja Staartjes, expedition climber

'We were not acclimatised well, the weather was bad, without a detailed map… then it is not easy to determine the good direction. We doubted what our position was, mainly because our porter did not recognise the area. So we got down for a camping place, not knowing where to go the following day: backwards? Forwards? But once in the tent, after some drink in the sleeping bag, we got clear the situation and we judged we were on the right way. That gave me back my certainty and direction.'

HOLD POINTS 'That's what we're trying to get them to do, to actually stop and ask the question "should I carry on?"?'
Process Safety & Technical Manager, Chemical industry

For the standard procedures we go through every single procedure, identify which steps of that procedure are critical and which are the points of no return and on getting to the point of no return to stop and we encourage them to go back and check through all the critical steps are correct. I think that's quite straightforward because that's routine and it's pretty standard. But for maintenance standards I think that they are generally less routine but we do want them to do these pre job briefings and to actually go and look at the job beforehand, the planning will be in place for what's going to happen and the scheduling. But because it's so infrequent I think the plans are more likely to come up short but when they do come up short that's when you want them to stop and not plough on regardless. That's what we're trying to get them to do, to actually stop and ask the question "should I carry on?". That's when you want them to stop and potentially take it away and have a meeting and decide do we change the plan, is it safe to carry on or do we need to just stop and go back.

HOLD POINTS 'Where are we? What has happened? What is the status?'
Process Manager, Petrochemical industry

So then when really something happens and you say: "hey, now I have a major upset" - part of the plant's down, big unit upset - and you say: "let's call in some support."

Okay, this is a big something, right?

Yeah, something has happened. Then, the first thing that we always try to do is, of course, make sure that we understand the situation and you try to provide structure. So typically when the teams have responded and put the initial units in a safe state of position, then you say, "okay, let's get together," and get the people together from each area of the plant and say, "okay, what is the status of that area?" That is when you start to provide the structure – the status meeting - "Where are we? What has happened? What is the status?"

And based on that, typically that's a roundtable where you have about ten people there, typically, from each area in the plant. Plus from the business teams, plus from the process management – so either me or one of my stand-ins – and you start: "Okay, we have this status. What are the next steps? What do we need to confirm?" This is always still uncertain. "Are we there?" If we don't know, typically a hold point again, within an hour, let's go back, get these confirmations and start working on what do we need for information, or the next steps to be able to start working towards a restart.

HOLD POINTS 'Let's continue when we have those situations clear in our mind'
Shift Manager, Petrochemical industry

It's impossible to know everything therefore it's very important to have team meetings for some minutes, to have hold points, meaning that when we have done something then stop and evaluate. Let's continue when we have those situations clear in our mind; then proceed to the next step.

So a good person knows when a good hold point is?

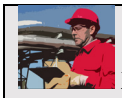
That's also one of our roles during interface meetings when we decide at a certain moment that the coming two or three hours we will do this this and that, and after three hours we will meet again. What are the problems at that moment? Are there unexpected, uncertain things? How do we or will we handle those things? Or does everything turn out as one would wish in that case; after that we will continue to the next step of the process.

3.4.4 Mental biases influencing 'monitoring'

While monitoring the human mind can be susceptible to various mental traps such as:

- Confirmation bias: the tendency to search for, interpret, or prioritize information in a way that confirms one's beliefs or hypotheses;
- Anchoring bias: a cognitive bias that describes the common human tendency to rely too heavily on the first piece of information offered (the "anchor") when making decisions. During decision making, anchoring occurs when individuals use an initial piece of information to make subsequent judgments. Once an anchor is set, other judgments are made by adjusting away from that anchor, and there is a bias toward interpreting other information around the anchor.
- Availability heuristic: a mental shortcut that relies on immediate examples that come to mind. The availability heuristic operates on the notion that if something can be recalled, it must be important.

An example of a severe accident caused by a confirmation bias has been given in one of the interviews (people looked for information that confirmed their hypothesis instead and did not seek information that could falsify their hypothesis):



MENTAL BIAS 'This concentration had always been there'
Business Unit HSE manager

'The reason I am telling this is that I am under the impression that we could have prevented this incident. Earlier that day we had already recognised that there was a very small leakage somewhere in the system. We already had received some kind of signal and –safety first- we had decided to shut down our production line. Our hypothesis was that it might be the sulphuric acid cooler. To check this hypothesis we had taken a sample from the cooling water and indeed, we found SO_4 in the water but we did not verify at that moment whether that concentration of SO_4 was always noticeable in our cooling water. In hindsight it appeared that we could have known that in this cooling water there was always a concentration of SO_4 because we are using water from the port and there is always SO_4 present in this water.

So we thought we had found a deviation! But we were wrong. This you could classify as a mental 'fallacy' and because we had a hypothesis, we measured a concentration not being aware of the fact that this concentration had always been there.'

(…)

We had put up a team to do the analysis for us and they came back with this information that meant an affirmation of our hypothesis. We did not seek nor get other information.

Also in the following quote it is stated that under uncertainty people often look for information that confirms what they want to believe.

MENTAL BIAS 'the decision can be based on other things'
Arnaud Guillaume, mountain guide

'You can make a technical decision based on what you have seen in the environment, but the decision can also be based on other things. You have to be aware of that. By other things I mean for example – and this is a textbook case - you are going to make a cross country ski trip of several days. On the last day you have to cross a col to come back at your car. You leave the last hut and you think by yourself: if I will not make it across the col, I will have to return to this hut and I will 'hit' 500 euros taxi costs. If I cross the col, I will be back home soon, everything will be okay and the slope looks nice as well. Then you arrive at the col and want to make a factual evaluation of the avalanche risk of the slope you want to descend. Already making a good evaluation is difficult in itself by the way. If the situation is very good, it will be easy: you go. If it is very bad, it will also be clear that you will turn back. But in case of intermediate risk – not good, not really bad – you will easily say: it will be fine! Because you do not want to hit those 500 euros taxi costs.

And that is the human factor. In many cases it disturbs our decision making. It has taken a while before we wanted to see this. But after analysing some severe accidents it became clear that there was more to decision making than facts and factual analyses. These were situations where very competent guides took decisions that were influenced by other factors than risk management.'

3.5 Responding: 'Not everyone qualifies for a job in the control room'

3.5.1 Responding issues

Responding has been described as the ability to address the actual: to respond to regular and irregular disruptions and disturbances (Hollnagel et al., 2011).

In this paragraph it will be explained:

- That being experienced is an important characteristic for resilient responding;
- Why adequate responding demands knowing the extent of the room for manoeuvre;
- What role intuition might play;
- That there is a horrible flip side to being experienced: overconfidence, routine, living up to the aura of the expert;
- Why it is therefore very important to be willing to consult others;
- That being 'engaged' is important in order to respond, but to be aware of 'summit fever'.

3.5.2 Experienced

Firstly it can be argued that responding and learning are very much intertwined by 'experience'. Oscar Wilde stated: 'Experience is the name men give to their mistakes.' (from the novel *The Picture of Dorian Grey*).

Many interviewees have stated that experience enhances the ability to respond. Experienced people simply have already encountered many different situations and know on the basis of past experiences how to (re)act on the actual.

Knowing the rules and procedures in combination with training are important aspects of experience. Apparently a certain amount of hours spent practicing in a specific field can make people 'experts' according to Ericsson et al (2007). They say that deliberate practice involves two kinds of learning: improving the skills you already have and extending the reach and range of your skills. This can work in practicing thinking skills as well as actions. "Genuine experts not only practice deliberately but also think deliberately". This is also related to the scenario-thinking described in paragraph 3.2.4.

EXPERIENCED: 'It all depends on the fact of whether people know how to act'
Production assistant blast furnaces

Many things we do know and we manage them in a technical way to have the barriers in place. For example by de-energizing under high pressure, or too low pressure. Some things are covered by human / organisational barriers. These are our weak spots. It all depends on the fact of whether people know how to act. For example, if a torpedo wagon is not filled in the correct manner and it is overfilled there is always a lot of smoke produced. In such a case people always tend to go towards the incident, which is dangerous. So there are instructions how to handle and choose for example a different approach. We try to cover this by the transfer of knowledge, but we do not have something such as a physical fence or a warning sign. It is so human: "Something is happening there. Let's go and see!"

This is one of our huge risks: Our product is liquid iron, at 1500 degrees. And we make iron and slag sand. There is no problem if this is dealt with in a correct manner. But sometimes things might go differently. And then the iron and/or the slag have to be processed differently. Then the product goes into a pothole where it can cool down. And this gives a spectacular sight: as if you are looking at a liquid lava landscape: it is red hot, glowing and bubbling. But, since there can be liquid iron involved and water locked by this hot metal, explosions can occur. Of course this is very dangerous. But inexperienced people are attracted to look at what is going on: it provides a very spectacular sight.

We try to make people conscious of these dangers through our training program. You have to know where the dangers are. But some people have never experienced certain situations and incidents. So they are less alert.

EXPERIENCED: '2000 hours or more'
HSE advisor industrial rope access and maintenance

'And another thing is experience. People that just got their level 1 certification, this appears a weak group. They need extra attention. There is a huge difference between 4 days of training in a training centre and working at a site. There are so many extra factors involved. People that have 2000 hours or more of experience should be able to work about everywhere, but the same does not go for fresh IRATA certified people. This is something we have learned in the past.'

EXPERIENCED: 'Not everyone qualifies for a job in the control room'
Shift manager, Petrochemical industry

'Before you can sit in our control room, you have to have a minimum of four or five years of experience, sometimes 10 years, before you can work inside the control room. You start as a field operator; you learn all those jobs outside in the field, and after that when you're qualified, not everybody is suitable, for a panel job, then after 5,6,7,8 years, sometimes 12 years, you're asked for the panel operator job. Not everyone qualifies for a job in the control room.

EXPERIENCED: 'every single instrument is important'
Senior company manager HSE , (Petro)chemicals

For the operator who sits there eight hours a day operating the plant every single instrument is important. Because he doesn't want a major accident, but you should also realize that with the major accident frequency it is possible that an operator will never experience such a failure, while he will experience many other smaller kinds of failures. So, you can't tell him that from the ten thousand instruments he has on the computer nine thousand nine hundred and twenty are not important and the others are. For him all ten thousand are important. And if there is one failing he will take action, put it in the log book and ask maintenance to repair it.

EXPERIENCED: 'Assertive, self-assertive. Confidence!'
Shift Manager, Petrochemicals

What makes somebody a good operator? Knowing the line-ups. Knowing the situation outside. Knowledge of process and personal risks in such a situation So he has to know his plant by heart and the interfaces between the different plants.

Like a taxi driver knows the streets?

Yes. For example when we have a fire or a spill the knowledge where you have to isolate it in an effective and safe way and how to response . That's important. You don't have a lot of time so you have to be well prepared, dare to be assertive, right and brief communication . Assertive, self-assertive. Confidence!

3.5.3 Knows the bandwidth or extent of the room for manoeuvre

Resilience is the capacity to adapt to changing situations and varieties. In the interviews it has been argued however that it is very important to know the "bandwidth" (safe envelope) or the extent of the room for manoeuvre in order not to turn an adaptation into a failure.

BANDWIDTH: 'Understand the principles'
Production assistant blast furnaces

Strict rules and procedures, how important are they within this field?

Standard work methods are important for standard work, but when things are happening that are not standard and the organisation is only built around these standard procedures, you will lack people that have the possibility to think thoroughly. I think it is more important that the principles are understood really well. With the incident I just mentioned this was the problem. We did not think by the principles to drain all the energy enclosed in the installation.

We tried to stabilize energy with energy instead of taking all the energy away from this part of the installation.

Another example: as supervisor I had the responsibility many times to deliver the blast furnace installation gas-free because blast furnace gas is very toxic. We have standard procedures and checklists for this and if I would give such a checklist to you and give a little bit of extra explanation, you would be able to execute this job. The question is: do you really understand what you are doing? You have to understand the principles and then that the checklist is only a means so as not to forget something.

BANDWIDTH: 'More collateral damage'
Production assistant blast furnaces

The operator who had manage the blown out pipe incident had no previous experience of such a case. He gets signals from his colleagues who are outside the control room and who see it happen. He has a certain image in his head. And it is just how this enters his mind that makes him think: "I have to act immediately" or "I have got five minutes, or ten minutes or a quarter of an hour". This is not good or bad. There is just a little more collateral damage involved, when shutting down is done too quickly. This is the risk of what we are doing.

Operators are not held accountable for something like this?

Certainly not by me. But maybe now and then they will make fun of each other and ask "did you really have to do it like this?" But basically he did the right thing.

BANDWIDTH: 'beware of the bandwidth'
Lead engineer industrial rope access and maintenance

'People also have to be aware of the bandwidth as well. If you switch from screwdriver a to screwdriver b there will not be a problem. But if you go from a disk cutter to a blow torch we do have a problem, because there are different risks attached to each device.'

3.5.4 Intuition as part of expertise

Interviewees also referred to situations in which they had been able to trust their gut feeling or intuition. Intuition could be defined as the synthesis of all previous experiences, knowledge, training etc. It can encompass the ability to know valid solutions to problems and decision making. Klein found that under time pressure, high stakes, and changing parameters, experts used their base of experience to identify similar situations and intuitively choose feasible solutions. Thus intuition is referred to as the pattern-matching process that quickly suggests feasible courses of action (Klein 2003). Others have named this phenomenon 'instinct'.

INTUITION: 'This feeling only comes when the risk is very high'
Katja Staartjes, expedition climber

What drives you to take this decision to turn around – even when it is so difficult to take?

I think for me it comes down to intuition. But also other people in the team can be a decisive factor.

At my last adventure it has been the first time that Henk and the Sherpa Chhiree wanted to turn back before me. Usually – in the Alps - it is the other way around. Then I want to turn around before Henk does– because technically I am the lesser climber or I do not want to put up with the risk and anxiety that comes with it. On expeditions usually we felt the same about these kind of decisions, but not this last time.

How do you know you can trust your intuition?

It is hard to explain. But I do know that when I am in the mountains I am more into contact with my intuition.

It is an overall feeling that it is not okay and you have to turn back to survive. This feeling only comes up when the risk is very high. There is never an instinct that tells me to go ahead. When it is okay, you just go on.

Nevertheless it is impossible to know a posteriori if this feeling was right. And I can go on and on in my mind about the question whether or not it was the right decision. But that is me: I always want to do things perfectly and want to learn.

INTUITION: 'Find the right answers for situations that are extremely difficult'
Lionel Daudet, adventurer

'All these things you are telling me right now, how did you learn them, or have you always known them?

Life is permanent learning. You develop a certain intuition, which is fruit of your experiences. Intuition means that your experience will guide you to certain decisions that are not per se rational. For example if you are searching for the right way to go, you may chose a line according to your intuition. And during the years you will gain experience that will make you feel at home at places where man does not belong. But thanks to your experience you will have the right reflexes and will act in a way in which you will find the right answer for situations that are extremely difficult.'

However beware: trusting on your intuition might be a good idea to find a way out or to turn back in front of dangerous situations, it will be treacherous to trust your intuition when the summit is nearby and you want to push on. In such cases 'summit fever' might come into play.

3.5.5 The 'flip side of experience'

Important warnings however were also given to something that could be called 'the flip side of experience'. This flip side has three important problem area's (cf. also Hertz 2013):

- The overconfidence effect: this is a well-established bias in which someone's subjective confidence in their judgments is reliably greater than their objective accuracy, especially when confidence is relatively high. (Pallier et al 2002)
- Routine: experience can also induce 'routine'. Interviewees stated that, due to this routine, vigilance declines and being switched on/awareness diminishes. See also Weick and Sutcliffe 2007 on this aspect.

ROUTINE AS A PROBLEM: 'We would become sloppy'
Lead engineer industrial rope access and maintenance

Because we always do difficult work at difficult places we can claim more time and money. This characteristic will also keep us awake and alert. I think that we could become 'sloppy' if we would always do the same, for example washing the windows of the same high building every month, year after year.

It is to our advantage that we always have new and different projects. This is also part of our law: repetitive work should not be done by rope access workers. For these kind of jobs permanent technical measures should be taken. But unfortunately there are very few architects that want a window washing machine on their building…

ROUTINE AS A PROBLEM: Vigilance versus routine
Arnaud Guillaume, mountain guide

'The main thing is that you will have to learn not to shut your eyes, pretend that something did not happen. Then you are really vigilant.

It is here where routine becomes really dangerous. There are guides that do the same course over and over again. Each week the Dome des Ecrins or Mont Blanc. And then they do not have the same vigilance anymore. They pass underneath the seracs every day and they get used to the danger, they do not pay special attention anymore and in their decision making they forget about it instead of taking a little distance and think through the consequences.'

- Living up to the 'aura of The Expert': when regarded as an expert, others may not question decisions anymore and 'the expert' in question may feel obliged to always come up with a decision, even if for some reason he or she is not the most capable in a specific case (see also McCammon 2002).

THE AURA OF THE EXPERT: 'also the guy in front can make an erroneous decision'
Arnaud Guillaume, mountain guide

'Talking about this, there are interesting situations when you are breaking the trail on a ski tour (with a group of guides). In many cases the other guides will follow you and not think for themselves. "The guy in front is a guide!" they will think. And only if you stop they might look around and evaluate the situation for themselves. However, the problem is that also the guy in front can make an erroneous decision!

And the guy in front will say to himself: "the other guides are following me so probably it is still safe."

We even say: there is no worse climbing team, than a climbing team existing of guides.'

THE AURA OF THE EXPERT: 'my well experienced colleague'
Production assistant blast furnaces

(talking about a severe accident) 'We were two people and we were both entangled in the same kind of erroneous thinking. We were focused on preventing something from moving. And we were not thinking: let us take out all of the energy. We did not pay any attention to other solutions. One person draws the other, or the other way around. We do not have standard solutions for this. But what might be done is that people mirror new solutions with other people and we ask for critical opinions. Other perspectives. Different angles.

And there is the risk of having the halo of the expert. That if you – with 20 years of experience – say something, then it must be true.

Oh yes, without doubt this can happen. Certainly with for example my well experienced colleague this can be a risk. But I do not know how we can solve such things.

These problem areas related to experience even led one respondent to strongly distrust the positive effect of experience on the total of risk suffered (in the case of mountain guides). He refers to risk accumulation.

EXPERIENCED AND RISK ACCUMULATION: 'The more we are in the mountains, the more the risk will augment'
Arnaud Guillaume, mountain guide

'Does experience also have a positive effect with respect to risk?

That is a big dilemma. Before we thought: when the number of days in the mountains augments, our experience augments. When our experience augments our knowledge augments. When our knowledge augments, we will be able to better manage the risk and be less at risk. Because we know the environment better, we will deal with it better.

Nowadays we see that the more we are in the mountains, the more the risk will augment. It is like Russian roulette. One time it goes okay, the second time it goes less okay, the third time… It is statistics.

At a certain time I thought that the experiences would balance the number of hours of risk taking. But no, I came to the conclusion that the more time we spent in this environment, the higher the chance that we will have an accident.'

In the interviews people have however also pointed at the possibilities to mitigate the dangers mentioned in

relation to experience, for example through consultation of others. This will be explored more into depth in the next chapter.

3.5.6 Engaged – beware of summit fever

Resilient people are dedicated to success. This could be called 'being engaged'. However various interviewees have also pointed at the dangers of being too engaged. Something that has been called 'summit fever' e.g. getting the production going or finishing what you are doing 'at all costs'

SUMMIT FEVER: 'People want to please'
HSE advisor industrial rope access and maintenance

People often want to finish what they are doing, within the time frame calculated in advance. People want to please. It is often a hassle to stop and come down. First you were already late three hours because the work permit was missing, then it took you an hour to climb up. If at that stage you perceive that something is wrong or strange, it takes courage to come down again and to have a meeting to think through a new approach.'

SUMMIT FEVER: 'Stick to the plan'
Lead engineer industrial rope access and maintenance

'This is very related to the cognitive biases that we want to talk about. For example there is this bias that if you have already invested a lot to come at a certain point, it is very hard to quit, even if you know that the costs of pushing on will be very high. What strategies do you use to protect yourself against this?

Open up communication is the only way. Talk about it! Make it part of your procedures to communicate, repeat it. Make it clear to everybody that risk will go up if we do not stick to the plan. Our risk analysis is based on the procedures as foreseen. If we are going to do things differently, we will have to go back to the drawing board. Everybody has to understand this.

(…)

This is not always easy, I must admit. Myself, I was recently offshore for a take in of work (job assessment) and I wanted to loosen a bolt to look at the state of the wire underneath it. And I caught myself in the act of collecting all kinds of sub-optimal tools to try to get the job done. I was about to start without the appropriate equipment, without proper planning and assessing all the risks. There was no direct danger, but there was a lot that could go wrong. I was there together with an operational manager from another contractor, and I said: "Dude!, we do not want to do this. We really want to finish it, but this is not okay". We were already considering even more drastic measures. We had to step back. It was not according to plan, we were not prepared and we did not have the right equipment.

So I had to admit to myself. "Hey buddy, you think you are the big guy that knows everything, but here you are trying to get the job done, unprepared and with the wrong set of tools creating a potentially dangerous situation." That is not something to be proud of and you rather want to forget about it; but rather than make it disappear I talked about this incident with my colleagues and I even mentioned it in a formal inspection round on this platform so that we can learn from this.'

SUMMIT FEVER: 'We don't want to get to that last layer of protection'
Process Safety & Technical Manager, Chemical industry

They almost got caught in summit fever while they were waiting for the fan to get repaired - "Give it another half an hour; it will be repaired in half an hour"- until it got to the point where they ended up lifting a relief valve. It's really easy in hindsight but they should have stopped a long time before then and sort of just accepted the fact and brought the plant down, got it repaired and then brought it back up. As soon as they popped the relief valve they did bring the plant down but that was too late really. We don't want to get to that last layer of protection.

SUMMIT FEVER: 'Sometimes it's the natural/basic reaction of people to act immediately'
Shift Manager, petrochemical industry

And we're trained. (Cardinal rules). Never bring yourself into danger or another (never enter a vapour cloud etc). But sometimes it's the natural/basic reaction of people to act immediately in such a situation. When somebody falls down the first reaction is to go to this person and help him, but not wondering yourself what the reason is that your colleague collapsed.

People do that in enclosed spaces, one person goes in…

… and then a second, third. Yes, yes.

Is it difficult to prevent?

Well, we are trained for that. We talk about it; don't do that. Then they expect that you don't do it. (These are the cardinal rules, repeated many times during training days).

3.6 Resilient minds, a round-up

In this chapter several characteristics of resilient minds have been described. Next to this the most important pitfalls as discussed within the interviews have been explained. Figure 4 summarises the characteristics and the pitfalls. In the next chapter it will be described what can be done within the organisational context to support and enhance human resilient intervention. This will be done within the context of organisational teams and organisational processes.

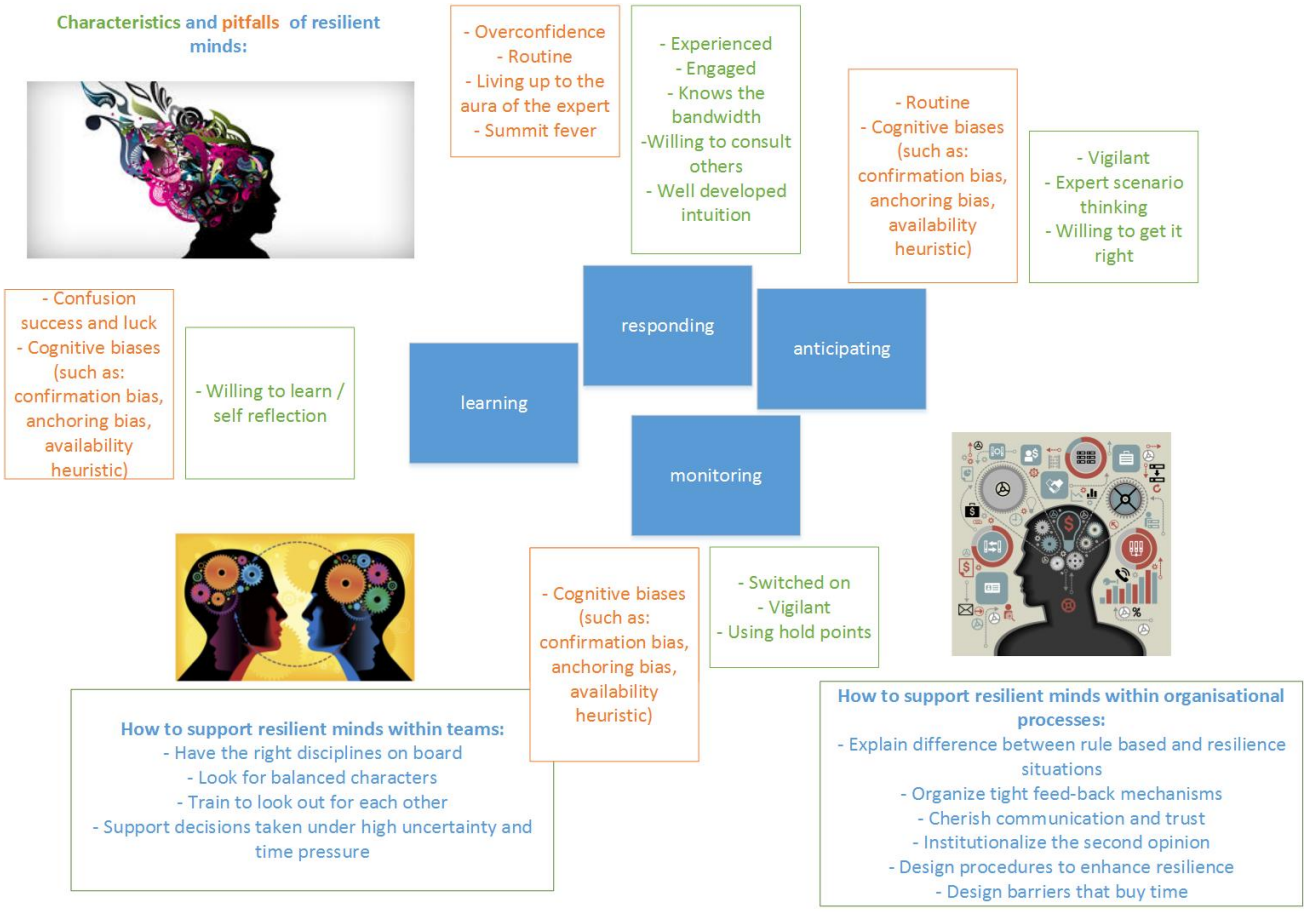


FIGURE 4 CHARACTERISTICS AND PITFALLS OF RESILIENT MINDS

4 RESILIENT MINDS WITHIN THE ORGANISATION

This chapter explores how resilient minds fit into the wider organisational framework. How can teamwork and organisational processes enhance resilience within the organisation? Also in this chapter some mitigating actions for problems mentioned in chapter 4 in relation to resilient minds are proposed.

4.1 Resilient minds within teams

In this section the focus will be on resilience within teams. A team can be put together for a specific situation (e.g. a project team) or be a more or less fixed institution (e.g. a shift).

It is explained that:

- The quality of thinking and deciding under uncertainty will be higher when the right disciplines are on board;
- Certain traps like summit fever could be avoided by balancing team members
- It can be advantageous when team members are able to watch out for each other in high hazard situations;
- Leaders should back-up their team members when they have to take difficult decisions under high uncertainty, no matter whether the decision turns out to be optimal or sub optimal.

TEAMS: 'make the organisation stronger, the people stronger, and more profitable'
Process Manager Petrochemical industry

What aspects of your job do you like?

Well what I like is - I think over the years it has changed of course - the role. As you progress through the career, from a large portion being technique and engineering, now it is more about enabling an organisation to be successful. So it's more about, "How do you set up teams? How do you motivate people? How do you set up the organisation?" And that's an element that I really appreciate: how to work with the teams and with the people, and how to facilitate that the teams can go off and run and then make the organisation stronger, the people stronger, and more profitable.

4.1.1 Have the right disciplines thinking and deciding together

Having the right disciplines is important for decision making under uncertainty. As the interviewees state, more disciplines will broaden the scope and enhance - amongst others - the awareness (monitoring) from different perspectives and the ability to think through different scenarios (anticipation).

THINKING TOGETHER: 'People have different competences'
HSE advisor industrial rope access and maintenance

What role does the team composition play?

People have different competences and experiences, so we try to adapt the team to the job and the specific site. It can be very useful to have someone that knows the site already in the team for example.

THINKING TOGETHER: 'they did not make the link with our working situation'
HSE advisor industrial rope access and response

Did you ever encounter situations in which you did not foresee the risks involved?

Yes, of course. One example is about an incident that happened while two IRATA workers were dismantling a pipeline: The client had assured us that there wasn't any product left in this pipe; it was on both sides decoupled. So the guys started to use their stonecutter. But suddenly they discovered that the pipe was combusted and that there was still some product left in the pipe. It was a pyrophoric product to be exact. And the stonecutter could have been a potential ignition source. From now on we will always ask our client a written statement that a pipe is empty, because apparently decoupling is not enough.

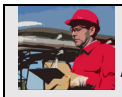
There is always the problem that we do not know the plant at which we work. The client is always very curious about our working methods, with our ropes and so on. So they ask a lot of questions about this. They regard our job as dangerous. For us it is the other way around: we are not aware of the daily functioning of a plant and this may lead to problems, because we might miss something in our preparation.

I will give an example of an experience I had at an oil platform at sea. The moment such a platform trips everything is shut off immediately. The alarm goes off, emergency procedures come into force. What happened was that we had worked all morning under the platform and we just had finished and returned to the deck. The platform trips, the systems are shut down and immediately also the automated fire extinguisher is started up, that is a pump that sucks in water automatically and the water that is not needed is being discharged. And yes, that was directly above where we had been working all morning. We might not have died there, but it would have been a critical situation.

The guys from the platform did not make the link with our working situation, when we were planning the project and made the work method statement.

I have got a similar example of us being next to a chimney that was flaring. For them it might be the best solution, but we are in the danger zone.

From this we all gained experience. A lot of things we have learned the hard way. And of course luck was on our side.



THINKING TOGETHER: 'more powerful than the individual approach'
Shift Manager Petrochemicals

When you have a problem, you try to solve it. That's also a mental process, you don't do it alone. And when there's a huge problem, more people are involved normally to solve that problem. And the strength of the group I believe in, you have common interests, that's more powerful than the individual approach. I suppose that you are not easily taking the wrong decisions because the strength of it is the group/team process itself.

4.1.2 Look for balanced characters

A resilient team will not only embody different skills, a team can also contain carefully selected different character types that will balance each other. For example: people that are very risk aware and cautious next to people that are engaged to keep the production high; people that know and follow procedures next to people that are intuitive and creative. A team with balanced character types will more easily avoid – according to our interviewees - certain mental traps such as summit fever.

BALANCED CHARACTERS: 'balance in the team is very important'
Manager blast furnaces

In a plant in which process safety plays a role these are difficult things. Especially because it is not as controllable as in the petrochemical industry where everything is already so developed that things have to break down before there are real problems. We have to depend on human behaviour.

(…)

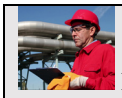
Yes, that is why it is very important to keep talking about these things. And to have a mixture of people: people that want to produce and people that are conservative. Balance in the team is very important. And discussion. Many of the phenomena that we manage in the blast furnace we do not fully understand. That makes it difficult to steer and manage. There is a lack of knowledge which means that we manage a black box. So we have to keep monitoring and communicating, continuously. We do not have a computer that does this for us. We only have opinions. And within this group of opinions we have to find the right path through, on the safe side, that is our job!

BALANCED CHARACTERS: 'pushers'
Lead engineer industrial rope access and response

´Do you have the right mix of people?'

'And risk evaluation models like Fine and Kinney that help us define the appropriate mitigating measures.

This is very handy in practice. It gives you a broad perspective on the project. For example the factor 'human'. Do you have the right mix of people in your team to end the project safe and successful? For example when there are three 'pushers' ('duwers') on the project, there will be a chance that they will be keen on finishing rather than on safety and finish it in the right way. When I say 'pushers' I mean guys that really want to finish the job: let's go, we're almost there, go on, go on! – this is okay, you need these kind of people, but if you have three of them on the same project, you will lack other qualities. People that will say: are we within our procedures? Are we still working according to plan? We were planning to use this and this equipment, but now we are working with something else which is more dangerous, is this really a smart thing to do?'



BALANCED CHARACTERS: ´Invite introvert people´
Business Unit HSE manager chemical industry

´Did you learn other things about decision making in the face of uncertainty?

Another strategy that I was already using early on in my career: in each team there are introvert and extravert people. The extravert people are always expressing their opinion, which might mean that the whole team takes a left turn, even if that is not the way to go. What I did in my "operational meetings" each morning was that I invited the introvert people explicitly to give their view. Not everybody liked that by the way but it resulted in more nuanced decision making.

4.1.3 Train to look out for each other

It is known that in the high hazard industry (as in other domains such as industrial rope access) the governmental first response organisations will in some cases not be able to come to the rescue in time in case of a threat or in case of emergency. Think of wind mills and oil-platforms and the industrial accident at the Dutch Amercentrale at which 8 people died when the scaffolds collapsed. Within certain disciplines and for certain tasks it even might not at all be possible to be rescued. In these situations it will be necessary that people are able to look out for each other: the so called 'buddy system'. This will make the team more able to respond adequately to uncertainties.

LOOK OUT FOR EACHOTHER: 'Make sure we can rescue ourselves'
Lead engineer industrial rope access and maintenance

"We always will make rescue plans. What if the light falls out? How do we get away in case there are toxic substances released? Do we need gas masks?"

"For us it is important to make sure that we can rescue ourselves. We cannot rely on the fire brigades for example even if they would prefer to come and rescue us because formally it is their job. They do not know our business and procedures. In practice it just won't work. Rope access work is maybe something they only train once every two years. And it will take a long time before they will get to us. "

It is not that I do not want to work with them – they are better at first aid for example, but I do not want to rely on them.

We have the buddy system in place in case of emergency.

4.1.4 Support decisions taken under high time pressure and uncertainty

Several leaders explained that it was crucial to support team members - for example operators - also when in hindsight they had not taken the most optimal decision. Only then they would act resiliently and with a certain confidence a next time when it could be necessary. Recognizing the (time) pressure under which sometimes difficult decisions have to be taken is essential.

SUPPORT DECISIONS UNDER UNCERTAINTY 'Stand by your people'
Business Unit HSE manager chemical industry

"*What role did time and production pressure play?*

This is something that played an important role at this particular site. The site had a large absolute daily contribution margin[2]. Also, shutting down this site means that the site can only restart very slowly and each time an operator takes the decision to close down the plant it costs some hundred thousand euros of margin per day. This is a big amount. The economic impact of this plant is relevant at company level, and the same goes for the safety impact.

So the operators have a heavy job to do, because they are probably very much aware of the impact of their decisions. How do you as a manager facilitate their decision making?

Leave the responsibility to act in line with procedures to them, but also back them up when – as it might appear – they have unnecessarily taken the whole plant out of service. Sometimes this is very difficult. Stand by your people; praise them for the fact that they have taken this decision. If you do not do this as a leader they might not want to take the same decision later on – when it is really necessary.

We learned from this incident. For example, we trained all our shift supervisors to work with a decision making matrix. They now know which systems they can block in within which time frame."

4.2 Resilient processes

It is not possible to capture everything in procedures because of uncertainty and the variability. However it is possible to design organisational processes such as communication, knowledge management and the management of deviations in such a way as to enhance the human resilient intervention.

Within the interviews examples have been given of how this could be done.

This paragraph will explain:

- The importance of discerning between situations in which one should be resilient and situations in which obeying rules is crucial;
- That tight feedback mechanisms are important;
- That communication and trust are essential to encourage human resilient intervention;
- That within this environment of trust it is crucial to organise an 'institutionalized' second opinion;
- How procedures can actually help human intervention;
- How also classical built in technical barriers can improve human resilient intervention.

4.2.1 Explain the difference between 'rule based' and 'resilience based' situations

Resilient teams acknowledge that to handle uncertainty it is necessary that people from various disciplines and with different character types take their share in monitoring, responding, learning and anticipating. From this it follows that the people in the team must feel free to express their knowledge, opinions, etc. Hierarchy

[2] The marginal profit per unit sale

is not leading in such discussions. Next to this however there will also be situations in which obeying rules is of great importance. Clear guidance and finding the right balance is an important organisational challenge.

We will always stop, think, make a procedure and then do. And again, there will always be exceptions. Start an activity without a procedure in place, we would never do it.

So the basic principle is that when you find yourself in that situation of uncertainty you stop and you think it out.

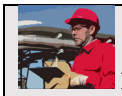
Yeah, you stop, you call your boss and you think about what we can do. You put people around the table, you make a procedure and you make a plan. That is how it works. I would be very surprised if people do it differently.

DIFFERENCE: RULE BASED AND RESILIENCE SITUATION: 'obeying, that is difficult in our culture'
Manager blast furnaces

"And now we come to another aspect that is necessary in the culture around a blast furnace: sometimes people just have to obey and follow rules – because I have commissioned them. And I have commissioned them after discussion and with good reason, even if they are able to make very difficult decisions by themselves. Obeying, that is difficult in our culture.

And this is also a tension field: we want people to be creative and think for themselves 90% of their time, and they need to obey and follow rules 10% of their time.

I manage this by trying to separate my roles: "now I am discussing the content with you to look for the best solution, and now we are back in the hierarchical situation." I am very conscientious in this."

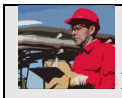


DIFFERENCE: RULE BASED AND RESILIENCE SITUATION: 'Start an activity without a procedure in place, we would never do it'
Senior Manager HSE, (Petro)chemical industry

We will always stop, think, make a procedure and then do. And again, there will always be exceptions. Start an activity without a procedure in place, we would never do it.

So the basic principle is that when you find yourself in that situation of uncertainty you stop and you think it out.

Yeah, you stop, you call your boss and you think about what we can do. You put people around the table, you make a procedure and you make a plan. That is how it works. I would be very surprised if people do it differently.

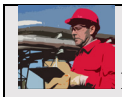


DIFFERENCE: RULE BASED AND RESILIENCE SITUATION: 'So we agree that we do it differently'
Plant supervisor on duty, chemical industry

So if we have a fixed procedure, then it needs to be followed and so we do that.
(…)
It may also be that for our standard procedures, when we are halfway through one, the situation changes. Well, then I always get a call and typically I go down to the workplace and and we can just verbally agree that now this is not completely according the procedure because it's a little different; we may agree depending on how serious it is. So we agree that we do it differently, perhaps also without making any written instructions about it.

So you could, in principle, …deviate from the procedure if there is a justification ?

Yes, we may be forced to … and it is also, depending on the situation, something I will decide, or it may be something I should have my boss's opinion on, or the engineers' .



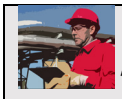
DIFFERENCE: RULE BASED AND RESILIENCE SITUATION: 'you can only proceduralise it so far'
Process Safety & Technical Manager, Chemical industry

"…if you don't follow the procedures as they are written then you are having unforeseen consequences. So the day-to-day stuff, we want the operators to do it in the same way. But that doesn't apply when things go wrong. That's where you need the experience. At that point you can only proceduralise it so far. I always remember Piper Alpha where the people who died were the ones who followed the procedures exactly. So my sort of take on it is the day-to-day stuff you want to proceduralise and you want it as consistent as you can get it. But when things go wrong you want to give them the options where you can but you have also got to rely on people knowing the time to use the experience to do the right thing."

4.2.2 Organise tight feedback mechanisms

In paragraph 3.4, examples have been given on how individuals are able to monitor, for example by 'using all their senses'. To create being 'switched on' on a wider scale the organisation has to first have an extensive and fast communication network. Data have to be collected and examined on a regular basis. To enhance these tight feedback mechanisms the following can be done:

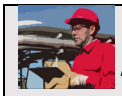
- Provide information to the right level
- Analyze near misses, deviations, faults for potentially more serious cases
- Install a low reporting threshold e.g. even of deviations that were solved on the spot
- Think of proactive indicators
- Reward the reporting, not the lack of incidents.



TIGHT FEEDBACK: 'a constant feedback loop'
Group EHS Manager, Chemical industry

What have you learnt? What have you learnt about learning?

You have to be very close to the operation. And you need a constant feedback loop in place, and I think we've done that pretty successfully.



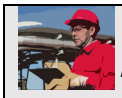
TIGHT FEEDBACK: 'It's a culture'
Shift Manager, Petrochemicals

If you call it a near miss, then you don't try to prevent it?

Our loss prevention system (LPS) requires that from all kinds of near misses and incidents (in LPS we call it Near Loss incidents or Loss Incidents) we have to make a report. And those reports are generated by the people who recognized or have seen the near miss/incident. The essence of this is to have lessons learned from it so that your group has knowledge of what has happened, preventing for the future that it will happen again.

And how do you get such participation from the people and such feedback in the learning process?

It's a culture. It's promoted; you will be rewarded if you're very active in those kinds of things.



TIGHT FEEDBACK: 'they feel more appreciated to have to actually give you that feedback'
Process Safety & Technical Manager, Chemicals

I think they're more willing to be critical and I think they feel more involved so if you give them something you're much more likely to get feedback than you were before. Before you could send things out into a void and never hear of it again. Now they would be a lot more willing to actually give you the feedback. I think they're more confident to give it and they feel more appreciated to have to actually give you that feedback as well.

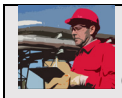
4.2.3 Cherish communication and trust

Communication and trust are essential in the management process (this contributes to the data sharing and the feedback and to the sensitivity of people to signals).

COMMUNICATION & TRUST: 'a basis of trust'
Business Unit HSE manager

For teams to function at their best there has to be a basis of trust. And the next step is that it should be possible to have discussions. This all enhances safety a lot.[3]

[3] The interviewee made a reference to Lencioni, P., 2002. *The five dysfunctions of a team.*



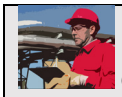
COMMUNICATION & TRUST: 'we sat together with our competitors'
Business Unit HSE manager

At the time of this emission did you have the opportunity to consult with someone from outside the plant, an expert at your level?

That could have been possible. Actually this is something we currently do when we do a HAZOP study. In such a case we ask someone from outside the plant to join in. This hazard study leader is normally more interested in the quality of the hazard study than with the speed of getting results or with production targets.

Is it possible to talk with peers about safety issues?

Yes, we are at the forefront of a European peer group and when I worked for the second high hazard plant, once a year we sat together with our competitors to share safety incidents. These are precarious sessions. The first part we are always talking about code of conduct and we sign a secrecy agreement and after that we are sharing incidents and this helps learning a great deal.'



COMMUNICATION & TRUST: 'they need to be able to rely on each other'
Process Manager, Petrochemical industry.

If somebody purposefully disarms safety systems and doesn't report it, I'm done with that person. Somebody makes an honest mistake, reports it, that's different.

Why might somebody disable a safety system and not report it?

They thought it was a nice joke. That ends their career…. that's not the kind of people – with my responsibility that I have – that I can work with. And not just me. That same suggestion came from the colleagues, the crew, that they lost trust in that guy.

Right, so trust is really important?

If you think about, I mean, that's what those guys understand as well. They work with small shift teams together in certain areas; they need to be able to rely on each other. There's a lot of potential things that can go wrong, they need to be able to rely on somebody, someone who says, "yeah, I'm going to take care of this," and it's going to be taken care of. If the shit really hits the fan they need to be able to rely on that.

So the feeling in the team that they <u>are</u> a team and they can rely on each other is an important thing, then?

Yes.

4.2.4 Institutionalize the second opinion

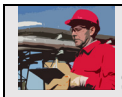
Many respondents regard it as crucial to organise consultation before taking important decisions. Getting a second opinion helps to improve the detection of missed scenarios or weak signals and to mitigate mental biases.

SECOND OPINION: 'Since that day I will always take a moment for real consultation'
Christophe Kern, mountain guide

There is this interesting story I can tell you. Once I was guiding a big group of maybe 20 people together with two colleagues during a day ski touring. One at the bottom, one in the middle and me at the front.

Being at the front I saw the big possible avalanche slab. It was a long time ago… I looked at the most experienced guide and waved at him signing non-verbally "what shall I do?" He made a sign "thumbs up: go ahead!" So I did. And afterwards the guide told me I was crazy to go in this dangerous terrain. And I said: "I asked you!" Apparently he thought that I asked him "are you doing okay?", and he had responded "I am fine, go ahead!"

Since that day I will always take a moment for real consultation and even if there is only one guide who has doubt we will not continue.



SECOND OPINION: 'Challenge decisions'
BU HSE manager chemical industry

Did you learn other things about decision making in the face of uncertainty?

To always have someone within your team to challenge information that comes in or to challenge decisions. And to take the worst case scenario more into account.

Furthermore we were taught to use the Kepner-Tregoe[4] problem solving & decision making strategies. This taught us for example to improve our analysis methods: gather more information before you make a decision, for example by getting reference information from other plants. It taught us to make multiple hypotheses and to only reject any one of these hypotheses when several concrete facts have been gathered that proved that this hypothesis was false. This prevents you from getting tunnel vision.'

SECOND OPINION: 'By discussing things with someone else things will become more real'
Lead engineer industrial rope access and maintenance

All plans we produce will be challenged by a colleague: do you really think that this will only take an hour? This is not meant to 'bully someone'. By discussing things with someone else things will become more real than if you only write it down.

[4] Kepner, C. H., & Tregoe, B. B. (2005). The new rational manager (rev. ed.). New York, NY: Kepner-Tregoe. In summary, their method of problem analysis includes: (1) problem identification, (2) definition of what the problem is and is not, (3) prioritizing the problem, and (4) testing for cause-effect relationships

SECOND OPINION: 'Do I make the right analyses?'
Manager blast furnaces

And in situations where you measure high temperatures - I can show you the figures on my computer- you have to discuss this. How should we interpret this?

This is not something you can do on your own. Higher management has to be informed: this is happening. Ask second opinions, peer reviews, ask within your own team: do I make the right analyses? Talk with physics people, etc. I am managing this process to get the right knowledge around the table. They have the facts and the knowledge to make a decision. I am never taking decisions on my own any more. I will prepare a decision with my team and after that I will go to my boss, explain the decision I want to take and ask him if he is okay with it. And I regard it as my task to explain all the implications of the decision to him, that it introduces an economic risk.

SECOND OPINION: 'I challenge people and ask them if it is really worth the risk?'
Production assistant blast furnaces

Do you have examples where you had to choose between safety and production?

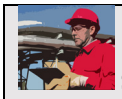
No, for me things are always quite clear with respect to that. Another related thing is that I do challenge people. When they choose for a quick and dirty solution. We are all human. This is something we all do. Take shortcuts because it is easier. We all have this tendency. But I challenge people and ask them if it is really worth the risk? If it is necessary to shut down the installation, do it!

But myself I have never been in the situation that I had to choose for production instead of safety. Still I can imagine the temptations to take short cuts. This is something you have to face on a daily basis almost.

Can you give an example?

Yes, I am responsible for the water purification and attached to that the sludge processing. And sometimes blocked pipelines are unblocked without bringing the installation properly to a halt.. they use a valve, or a high pressure hose, or a pole and they get it working again. Because bringing the installation to a halt is time consuming, involves a lot of extra work or can lead to another disruption in the system. So they go for this quick and dirty solution. And yes, they know that they shouldn't do a thing like this, climb on a fence and work on an installation that is in operation. But still they do it.

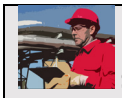
Some organisations regard asking a second opinion of such importance that they institutionalize it in their procedures.



SECOND OPINION: 'provide a cold eye'
Process manager Petrochemicals

And I provide a cold eye to teams as well. As the team is running say: "Have you seen this? Have you thought about this? Have you looked at it from this angle? Have you spoken to these guys?" I mean, that's the kind of thing that you try to do here, and sometimes you challenge people as well.

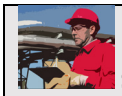
What I do a lot is ask people: "How could this escalate?" If they have a situation and say, "we've managed this," I say, "okay, have you thought about how this could escalate?"



SECOND OPINION: 'I will ask questions how do you mitigate it in the case where the situation is different or changes'
Shift Manager Petrochemicals

Can you give an example of the cold eyes thinking? How does that actually work?

Let me think… At the moment that a safety critical device, it may be a safety valve, a logic system, doesn't function there are possibilities to bypass that. That isn't allowed; there are so-called "defeat of critical equipment" procedures for that. But then it is necessary to have the right mitigating precautions and know what the impact is in running the plant without these critical devices. And at the moment when a first line supervisor has the idea/is convinced that it is possible to bypass this safety critical device, then I will ask questions how do you mitigate it in the case where the situation is different or changes, so that the plant can be shut down safely or operate safely without this device available? These will be my cold-eyes questions I ask with regards to the restarting of a piece of equipment or keeping it in operation without the critical devices in place.



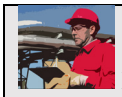
SECOND OPINION: 'I knew exactly the people I would want'
Process safety & technical manager, chemical industry

I think anywhere you very quickly find out the sort of the people are going to give you good feedback I know when I was at YYY I knew exactly the people I would want. You don't want the ones who are just going to say yes that's fine. You can put it in and it's going be wrong. You don't want people who are going to be belligerent and tell you everything is wrong because they have had a bad day. You want the ones who are really critically going to assess it.

4.2.5 Design meta procedures to enhance resilience

In the interviews we came across organisations that try to enhance human resilient intervention by designing special procedures or guidelines for situations when such intervention is needed. They have procedures for deviating from procedures or for situations when there are no procedures at all. Of course this all starts with the recognition that:

- Not every possible situation is knowable and foreseeable;
- There will be moments when strict procedures cannot be applied because of unacceptable consequences.;
- There will be human errors.



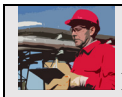
RESILIENCE ENHANCING PROCEDURES: Procedure for how to deviate from a procedure
Process manager, petrochemical industry

How important are very strict procedures and standardization? How much strictness and flexibility is there.

You need both. That's the answer, you need both. So you need to have processes, you have procedures. The basis is you follow procedures but we have a procedure for how to deviate from procedures, because you need to have both. If I am dogmatic, you will follow the procedure then become like a lemming and you will run off the cliff. So you need to have both. The standard is you follow procedure, but there is procedure on how to deviate from procedure. And depending on what kind of level of deviation it is, what the risk that's involved with that deviation, it escalates up to me. If it is a low risk deviation then the first line supervisor can approve that, but that's part of the procedure on how to deviate from procedures.

4.2.6 Design barriers to buffer and buy time

Automation can replace tasks humans would otherwise have to perform and can create buffering capacity (absorbing disruptions), signal when the system is close to the safety boundary and buy time. Humans are good at problem solving when they have enough time. Automatics can be valuable for online control when the human needs time to think and work out what is happening, having been freed from that requirement. When there is insufficient time this can mean a switch from knowledge based thinking to reflex reaction so buying time can be important for monitoring what is happening and deciding what to do. However, the down side is that when humans do not interact manually with a system, skills can be lost Bainbridge (1983). Fitts (1951), whose famous list distinguishes between the properties of man and machine had already identified this problem (de Winter & Dodou 2011), arguing also that activity in any task is conducive to alertness, and helps to ensure that the human will keep abreast of the situation.



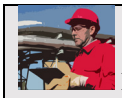
BUY TIME: 'Get it closed off'
Plant manager, chemical industry

If something unexpected happens to them, they try to close off at the next nearest place they can get to, and then we, both the supervisor on duty and I, we will be contacted subsequently by the control room with information about the event, and then we go out to the incident location, and help them, and then we make a plan for how we handle the situation afterwards.

If something unexpected happens, how do you deal with that?

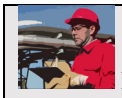
Well, if an incident happened that I had not expected, e.g. that we've had an unintentional release of some gas from a reactor, the first thing I think about are the people that are nearby, plus to limit the spill as soon as possible. It's the first thing I think of. So safety of the people that are there, and equipment afterwards. Get it closed off, and it may well be that there is some equipment that gets damaged, but there is nothing to do about that, we will deal with that later…

Redundancy of equipment can buy time:



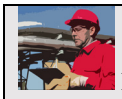
BUY TIME: 'Normally you have redundant/spare equipment'
Shift manager, Petrochemical industry

For 99 percent our process computer controls the process. We have special applications with running targets But when it reaches its alarm limits, then the operator has to analyse the situation and bring it back between the alarm settings; normally the computer applications will prevent those situations (before the alarms ring). But when you have an upset because of a pump failure or something like that, then it is common action, the outside operator has to switch the spare pump in the field to bring it back into normal service and the console operator has to restore the upset by taking e.g. a valve off computer control and giving it temporarily a manual setting to restore the normal process execution as soon as possible. Normally you have redundant/spare equipment, but not in all cases. Normally when a piece of equipment fails it takes some time to get the whole process control back to the normal situation, but that's our job and we are trained for these situations (simulator training).



BUY TIME: 'That sort of layer of protection is sitting round the plant'
Process Safety & Technical Manager, Chemical industry

What we like to think is you've got your extents, your limits, and if it goes outside of that in any parameter and it is going to have a significant safety implication, then the plant will trip. That sort of layer of protection is sitting around the plant but then from a quality point of view it's left much more in the hands of the operators to respond how they want to according to their experience. So the products going out of spec then there could be 50 reasons why; for that one we are relying on their experience. But if it's getting dangerous we like to think from our LOPA studies and hazard studies that we will have trips in place that will trip it to a safe state.

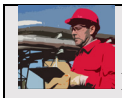


BUY TIME: 'part of the plant's down, big unit upset - and you say: "let's call in some support." '
Process Manager, Petrochemical industry

So then when really something happens and you say: "hey, now I have a major upset" - part of the plant's down, big unit upset - and you say: "let's call in some support." (…)

Then, the first thing that we always try to do is, of course, make sure that we understand the situation and you try to provide structure. So typically when the teams have responded and put the initial units in a safe state of position, then you say, "okay, let's get together," and get the people together from each area of the plant and say, "okay, what is the status of that area?"

People are often triggered to react when it would be better if they had thinking time:



BUY TIME: 'he smelled gas so he had to close the valve'
Senior safety manager HSE, (Petro)chemical industry

Recently there was a guy who shut down the valve and above the valve there is a panel saying "Never touch the valve", in red, and he manually shut the valve. What happened is that while he was working he thought he smelled gas so he thought there was a leak and his immediate reaction was I have to close that valve. So he didn't even look at the panel he just closed the valve and afterwards he of course realized he did something wrong. But that is what I say, people are not working in uncertainty they are working in certainty, meaning he smelled gas so he had to close the valve. (…)

You might ask that if you should never touch the valve why it is made possible that you can touch it, if you see what I mean?

But then you go to design. That is true, if we don't want people to close the valve we shouldn't place a panel we should make it impossible.

4.2.7 Resilient minds within the organisation, a round up

Kahneman concludes his book Thinking, Fast and Slow (2012) with the following statement:

'Organisations are better than individuals when it comes to avoiding errors, because they naturally think more slowly and have the power to impose orderly procedures. Organisations can institute and enforce the

application of useful checkliststst (…). At least in part by providing a distinctive vocabulary, organisations can also encourage a culture in which people watch out for one another as they approach (cognitive ed.) minefields.' (pp.417/418)

To round-up this chapter it will be interesting to look back at the different strategies to mitigate risk as discussed in chapter 2.

In the next figure the link between these different strategies and the things the organisation can do to enhance resilience will be made clear:

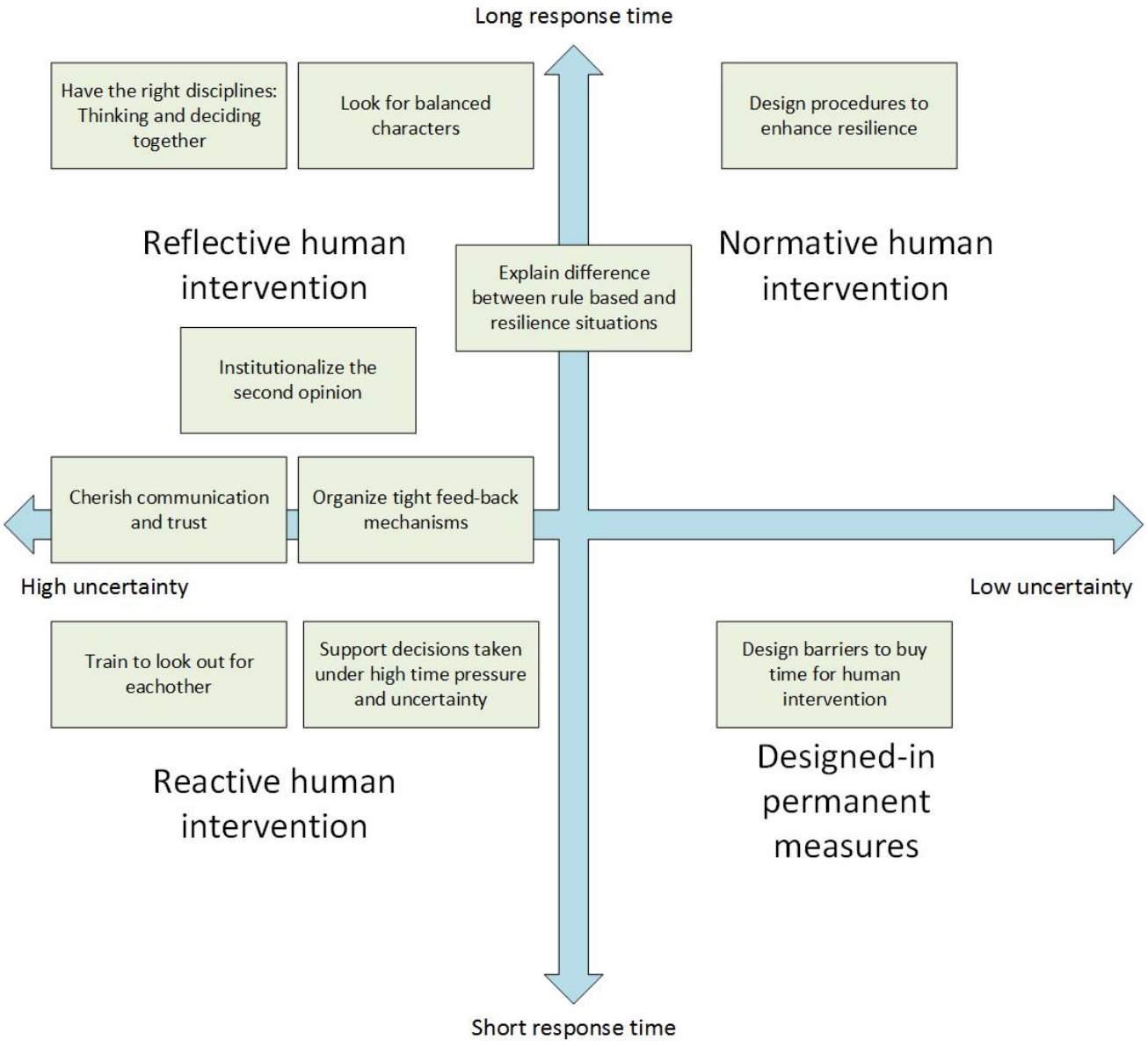


FIGURE 5 ENHANCING RESILIENT INTERVENTION WITHIN THE ORGANISATIONAL CONTEXT

5 IMPROVING VIGILANCE AND MITIGATING BIASED REASONING

Based on the interviews two specific field of problems can been detected concerning human resilient intervention:

- Low accident rates lead to less vigilance
- Human reasoning involves biased reasoning

In the next paragraphs some strategies are suggested to deal with these two fields of problems based on the interviews and scientific literature. However the authors are aware that more fundamental research is needed to verify the effectiveness of the strategies.

5.1 Keeping vigilance high

5.1.1 The problem of low signal rates

From a resilience point of view it is crucial to have the possibility to learn from mistakes in order to improve the learning and adaptive capacities of the human, the team and the wider organisation. It also seems that characteristics like vigilance, awareness and anticipatory thinking may disappear when the risk is not perceptible anymore and when for some time an organisation is 'accident free'.

In this age there is a tendency to move to more and more automated environments thinking that more automation leads to more control, less variation and less incidents. In the risk society errors and accidents (even small) are more and more regarded as unacceptable (Beck 1992). In line with this tendency 'to be accident free' is an important goal for many multinational strategies (often with reward systems in place to arrive at this desired state).

However our interviewees have argued - that (as seen in the previous chapters and especially 4.3), mistakes, near misses and incidents are necessary to become and stay vigilant, to learn and improve and to adjust. In the interviews warnings have been given of the risks that are attached to this automated organisation with low accident rates. People need to stay engaged.

For example the risk that previous learning vanishes from the organisational memory:

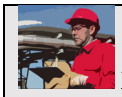
LOW ACCIDENT RATES: 'The potential high hazards are drifting out of sight'
Production assistant blast furnaces

'So, as I said before, you can try to catch everything in procedures and standards but it is more important to understand the way it works.

Look, when I started off working here in 1992 there was this contingent of very experienced people who were 25 years and more at the blast furnace. And then they all retired with a special arrangement for people that were 55 years and older. And between 1995 and 2004-5 there was this whole bunch of people that had less experience. When I came in 1992 the experienced operators told me: "you will never learn how to make steel properly anymore". And they listed a couple of situations that would never occur again, like liquid iron that runs across the floor. And I said: "Luckily, I do not want to experience such things". Through the years we have this learning curve and that is how it should be. Nowadays we have other problems, but they are less severe than before.

But the danger is that maybe nowadays we are paying attention to little things and that we have forgotten the 'principles' of the really important things. The potential high hazards are drifting out of sight while we are paying attention to marginal things.'

Next to this to set 'zero- accidents' as a goal in a punishment and reward system seems to have its drawbacks, because this will lead to underreporting:



LOW ACCIDENT RATES: 'if you blow the whistle for everything, we will not have a game anymore' Emergency Response and Security Manager, chemical industry

'Stay open for change. People sometimes have the tendency to say 'why change things when we do not have many accidents'? But it might be that they were just lucky. And I see a problem here in relation to punishing mistakes. It might mean that people are less willing to report near misses! With the lifesaving rules I do think there is a risk that communication stops if too many things are punished. It is like a soccer match; if you blow the whistle for everything, we will not have a game anymore. On the other side of the spectrum, do not reward people for the wrong reasons. A couple of years ago we had this policy that three years without an accident and everybody would get an I-pad. This is killing for your reporting! After such a thing you hear nothing because no one wants to be the person that kept 200 colleagues from getting an I-Pad because he cut his finger.

Hereunder several strategies are defined to keep vigilance high, even when the accident rate is low. These strategies can be summarized as follows:

- To embrace modest failures because they are essential to resilience;
- To also learn systematically from mistakes that others have already made;
- To keep the organisational memory alive;
- To use simulators;
- To make the risk perceptible through design;
- To organise sensible job- and task-rotation.

5.1.2 Embrace modest failures

Regular, modest failures are essential to many forms of resilience: they allow release and reorganisation of resources.

Or as Zolli (2012) has put it: 'More broadly, resilient systems fail gracefully – they employ strategies for avoiding dangerous circumstances, detecting intrusions, minimizing and isolating component damage, diversifying the resources they consume, operating in a reduced state if necessary, and self-organizing to heal in the wake of a breach.' 'resilience is, like life itself, messy, imperfect, and inefficient. But it survives.'

In every organisation a constant dialogue is needed in which near misses and smaller accidents are discussed extensively. This strategy also has been described by several interviewees. The idea is that by discussing near misses and smaller accidents and by understanding their potential impact and learning from them, it will be possible to improve and exclude or postpone serious accidents. A very open (safety) culture is needed here; without the menace of punishments or disciplinary measures. Companies that have set up a strict punishment system in relation to for example lifesaving rules may ask themselves to what extent these rules are impeding an open culture around near misses, faults, ignoring procedures etc.

5.1.3 Learn from accidents that have taken place elsewhere

This is a method that is of course already broadly used in industry. International high hazard companies which have plants in many locations can use learning opportunities within their own organisations. Within-company learning has been mentioned by several of the interviewees. It implies that incidents are communicated as soon as possible with a broader public – often in a personal way (the people involved tell

their story: what went wrong, the impact of the accident for them and the environment, what they have learnt etc). In some sectors companies also share accidents and near misses with their peers.

5.1.4 Keep organisational memory alive

Modern high hazard organisations learn from incidents. There is often an extensive follow up and learning is implemented in the organisation. However there are also indications that in the long term (when decennia have past) this learning has eroded. Design philosophy is gone. Up to date information is missing.

Strategies to keep the organisational memory alive could involve visualization of past incidents. For instance develop a gallery or a book that aims to sustain learning. But also updating procedures to match the situation and incorporate the learning history. .

FIGURE 6 NOT FORGETTING: A VIEW OF DELFT AFTER THE EXPLOSION OF 1654

FIGURE 7 NOT FORGETTING: CAREL LODEWIJK HANSEN - RAPENBURG, LEIDEN 1807 AFTER THE EXPLOSION OF A GUNPOWDER SHIP ON 12 JANUARY 1807, WITH LOUIS NAPOLEAN BONAPARTE INSPECTING THE DAMAGE ON THE LEFT (*RIJKSMUSEUM*)..

FIGURE 8 NOT FORGETTING: DSM GELEEN 1975

5.1.5 Use simulators

Of course in certain domains 'simulators' are very common as a way to learn from near misses and mistakes without having to bear the consequences (aviation, military / law enforcement, driving). It has been mentioned in two of the interviews that a simulator for operators managing high hazard processes is used. Although quite costly at the moment, simulators might be a way to keep vigilance high and learn from errors in the future.

5.1.6 Keep the risk perceivable through design

If stimulating human vigilance would be part of the design criteria probably some installations would have a different 'look and feel'. However in many modern installations the risk is not really perceivable anymore- as described by the interviewees. The rope access workers described that they had little problems with staying vigilant, because when hanging on their ropes it was very clear what could happen when falling down (and next to this they are legally not allowed to do routine work like washing windows every week).

Ecological Interface Design (EID) is an approach to interface design that was introduced specifically for complex sociotechnical, real-time, and dynamic systems.The goal of EID is to make constraints and complex relationships in the work environment perceptually evident (e.g. visible, audible) to the user. This allows more of users' cognitive resources to be devoted to higher cognitive processes such as problem solving and decision making.

5.1.7 Moderate task rotation

It has been mentioned in the interviews that people that are new on certain high hazard jobs are more vigilant and do not yet take certain risks and procedures for granted. It has therefore been suggested that moderate task rotation has a positive effect on vigilance.

TASK ROTATION: 'prevent blindspots'
Emergency response and security manager, chemical industry

How do you prevent people from working on automatic pilot?'

Toolboxes are invented for this to keep people alert with accidents that happened elsewhere. And as a manager be on the shop floor, talk with people, discuss why people do things like they do. And prevent routine by changing tasks. It is not good when it is always the same person that takes measures for example. To change tasks is good for many things, also for the ergonomics for example.

This will prevent blind spots. I try to keep my people multifunctional in their functionality.

5.2 Mitigate cognitive biases

Mental biases are often at the basis of erroneous human intervention. For example in the interviews a phenomenon that could be called 'summit fever' has very often been mentioned as weakening proper decision making in high risk situations – not only by climbers, but also by people working in the high hazard industry. It is the phenomenon that when certain desired goals are almost achieved or very near at hand, people find it difficult to think through and take into account all consequences that might be involved in gaining the last meters to the top (Roberto 2002).

The confirmation bias is also a mental trap that is often mentioned by the interviewees. It describes the phenomenon that people have a tendency to seek out only that information that supports one's preconceptions, and to discount that which does not.

A large body of evidence has established that a defining characteristic of cognitive biases is that they manifest automatically and unconsciously over a wide range of human reasoning. This makes bias mitigation a difficult objective. Some strategies however can be suggested to deal better with cognitive biases in decision making processes under uncertainty.

Bias mitigation can be undertaken from three angles:

1. Using prescribed decision making procedures;
2. 'Train as you fight';
3. Deepen the knowledge about the self.

5.2.1 Use prescribed decision making procedures

To avoid all kinds of mental traps that are likely to occur when dealing with decision making under risk and uncertainty , several aspects of 'prescribed decision making procedures' have been mentioned by the interviewees and are described in scientific literature concerning mental bias mitigation. Hereunder these procedures are mentioned and explained:

Ask an outsider view: This strategy has been discussed in the previous chapter and is already used in many high hazard companies. Of course it refers to the institutionalized second opinion as described in the previous chapter.

Consider the opposite: To mitigate several kinds of biases this might be a good strategy when for example there are no outsiders available to provide a 'cold eyes look'. Considering the opposite might have been a useful mitigating strategy in the case described below.

MENTAL BIAS: 'In hindsight I say we just have been stupid'
Production assistant blast furnaces

'Sometimes you can have surprises at hand, that suddenly it appears that for a certain part of the installation there is not yet a good safeguarding procedure. Then you have to develop something, talk with people about the best way to block in a certain part of the installation to create a safe working environment. This is something you do not do alone. But even then you can make mistakes.

How come?

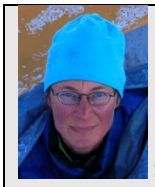
It is always a question of applying enough critical thought. Last March we had a very severe accident. Someone was trapped for one and half hours and it was me that drew up the procedure to create a safe working environment, together with someone from technical management. And still, together we overlooked something which resulted in the fact that this guy got trapped. Things like this are very nasty. We try to avoid risk, but still things like this happen. In hindsight I say we just have been stupid. But we were two people together looking at this specific problem and didn't caught the mistake in creating a safe working environment.

I ask myself: Do we have to look with three people? At that time of the incident we could not safeguard this part of the installation mechanically. Nowadays we do have this possibility by the way, because 'you close the stable door after the horse has bolted'. Human/ organisational barriers are weak as I said before.

You can even look at such a problem with four people, when everybody makes the same reasoning error…..

In situations that are not normal you have to start really thinking clearly and you do your best but it is not possible to prevent everything, unfortunately.'

Set strict rules beforehand to keep margins: Research has shown that people make less impulsive, less suboptimal decisions in many domains when they make choices further in advance of their consequences (see Milkman, Rogers and Bazerman, 2009). Therefore it is sensible to set strict rules beforehand to keep margins. An example could be when climbing Everest to always turn around at two o'clock (as to separate the important decision from the heat of the night). Or to always shut down an installation when the temperature rises above xx degrees.



SET STRICT RULES BEFOREHAND 'I have not invested 40.000 dollars to turn around at 50 meters under the top'
Katja Staartjes, expedition climber

'A lot of research has been done about cognitive biases (explanation by interviewer). For example the sunk cost fallacy: if you have invested a lot into a certain goal, you are more likely to go on, even if the costs of going on can be very high, even higher than the benefits of attaining your goal.

At my expedition on Everest someone died because of this. One of our team members was too late to summit. When I was going down one of the guides behind me told him to go down. But he answered: I have not invested 40.000 dollars to turn around at 50 meters under the top. When I think of it, it was even less: around 30 meters under the top. This means around 45 minutes or longer at that altitude. Your notion of time and your capacities gets blurred when you are up there. He summited but died going down.

Is it possible to take counter measurements against this phenomenon?

At high altitude this is impossible or at least very difficult. People will get very angry and unreasonable. But yes, you have to talk about this up front and make very clear arrangements. That is your only chance.

SET STRICT RULES BEFOREHAND: 'I really do not like to renounce'
Arnaud Guillaume, mountain guide

Look, one of my big faults is that I really do not like to give up. It is bad, but it is like that. Well, I am not a psychopath of course, but it is difficult for me. And especially in winter I always work on the preparation side. I make sure that I plan a tour which will be possible, even when the conditions are worse than announced. For example I chose a slope with a faint gradient to be practically sure that I will arrive on the top.

I will not choose a slope that will be doable, but of which the last 100 metres are uncertain. Because when I arrive at that height, I want to summit!

It is one of my weaknesses and I am aware of it and I try to avoid situations in which it can bring me in trouble.

Learn to use facts and figures in a structured manner: This is for example done in within a method called reference class forecasting introduced by Kahneman[5] and in Kepner Tregoe decision making procedures.

[5] One approach to mitigation originally suggested by Daniel Kahneman and Amos Tversky, expanded upon by others, and applied in real-life situations, is Reference class forecasting. This approach involves three steps: with a specific project in mind, identify a number of past projects that share a large number of elements with the project under scrutiny; for this group of projects, establish a probability distribution of the parameter that is being forecast and compare the specific project with the group of similar projects in order to establish the most likely value of the selected parameter for the specific project. This simply stated method masks potential complexity regarding application to real-life projects: few projects are characterised by a single parameter; multiple parameters exponentially complicates the process; gathering sufficient data on which to build robust probability distributions is problematic and project outcomes are rarely unambiguous and their reporting is often skewed by stakeholders' interests. Nonetheless, this approach has merit as part of a Cognitive Bias Mitigation protocol when the process is applied with a maximum of diligence, in situations where good data are available and all stakeholders can be expected to cooperate.

Use bias-checklists: Kahneman, Lovallo, and Sibony (2011) have proposed a Decision Quality Control Checklist involving three phases of assessment. Each phase will check for certain biases that are likely to occur, such as the Self-interested Biases (overoptimistic), the Affect Heuristic (in love with the solution), the Confirmation Bias (credible alternatives), the Anchoring Bias (where did the numbers come from) and the Optimistic Biases (game it).

5.2.2 Train as you fight – fight as you train

It is important to notice that especially using the first strategies - prescribed decision making procedures - requires the availability of a certain amount of time to respond. As argued in section 2.2.1 there is not always sufficient response time available and the human resilient reaction then comes down to intuition, experience, and skill. In these situations situational training will be more appropriate. Intensive situational training seems to provide individuals with what appears to be cognitive bias mitigation in decision making. 'Train as you fight' as it is called in the military and in firefighting departments amounts to realistic training and a strategy of selecting an adequate response to recognized situations regardless of the 'noise' in the environment. This is especially helpful in situations with little time left to respond (the bottom left corner in Figure 5 Enhancing resilient intervention within the organisational context). Since this bottom left corner also represents 'high uncertainty' there certainly will be no guarantees for success.

TRAIN AS YOU FIGHT: It is very important to train on location
General manager rope access training company

'Knowing the risks and knowing the ways to mitigate these risks is of course very important. However it does not guarantee that in practice people will always do the right things. For example there can be so much pressure to get a job done that people chose to take more risk than they have learnt in training programs. Is it possible to train on this aspect?

That's why I think it is very important to train on location and not only in a training centre. For example on the ground people can perfectly simulate a rescue. But what if they are at a height of 50 meters?'

5.2.3 Deepen self-knowledge and promote mindfulness

Enhancing self-knowledge and promoting mindfulness are mentioned several times as strategies to enhance risk management and mitigate mental biases.

Weick and Sutcliffe (2007) also mention mindfulness as a way to counteract simplifications of the mind, and as a way detect small failures that foreshadow larger problems:

"Formally we define mindfulness as 'a rich awareness of discriminatory detail.' By that we mean that when people act, they are aware of context, of ways in which details differ (in other words they discriminate among details), and of deviations from their expectations. Mindful people have the 'big picture', but it is a big picture of the moment. (…) Mindfulness is about the quality of attention. High Reliability Organisations become more vulnerable to error when their attention ins distracted, unstable, and dominated by abstractions. All three of these predispose people to misestimate, misunderstand and misspecify what they think they face. Distractions often take the form of associative thinking ('That reminds me of the time when…'). Which draws attention away from the present and from an awareness of change and substitutes abstract ideas for concrete details." (Weick and Sutcliffe 2007, pp. 32-33)

"Trouble starts small and is signalled by weak symptoms that are easy to miss, especially when expectations are strong and mindfulness is weak."

"Systematic reflection" has been addressed by Ellis et al (2014) as a tool for learning from experience and for counteracting biases. This is a learning procedure during which learners comprehensively analyze their behavior and evaluate the contribution of its components to performance outcomes. For example data verification can be prompted by asking if a different approach could have been taken and what could have happened if it was, or by comparing and contrasting personal actions with similar actions played out in other (more or less successful) situations.

Meditation and arts that improve balance, the mind-body connection and concentration such as yoga and martial arts are suggested to enhance mindfulness and self-knowledge and to have beneficial effects on concentration and awareness. Georgetown University Professor Elizabeth Stanley developed a mind fitness training program to use with service-members before their deployment to combat, to improve their operational performance and reduce the likelihood of psychological injury afterwards. Mindfulness-based Mind Fitness Training (MMFT, pronounced M-fit) is specifically designed for individuals operating in high stress environments. It blends (1) mindfulness skills training with (2) stress resilience skills training and (3) concrete applications for the operational environment. It cultivates mindfulness skills with specific exercises to build attentional control and concentration. Yoga and meditation techniques are part of this training program. [6]

SELF-KNOWLEDGE: 'I try to assess my 'feeling' in the morning when I wake up'
Christophe Kern, mountain guide

This is also important for organisations, because it is clear that people cannot take good decisions for example when they have had a fight with their wife the evening before.

And how do you know if you are not in the right mood or position to take decision? Do you check it every morning when you go out there?

Well, for around the last ten years I try to assess my 'feeling' in the morning when I wake up.

It started back when I was very serious with rock climbing and every morning I did stretching. 'Are you angry, are you tense, are you tired? Happy, energetic?' for me all this is very important to know. I do not necessarily ask myself the question 'why'. The fact to know the state I am in is already important. And depending on my goal I might try to adapt myself for the program. For example when I have a client that unnerves me, I will try to play with this fact instead of going against him. This self-knowledge is crucial for me. I am not someone who always will be positive "I am all right, everything goes well".

[6] http://explore.georgetown.edu/researchprojects/index.cfm?Action=View&DocumentID=47644

SELF-KNOWLEDGE: 'emotions attached to this game'
Manager blast furnaces

So there is a cultural aspect that drives people to carry on, whereas it would be better to cut your losses in time.

This is a game that is related to the blast furnaces. And there are also certain emotions attached to this game. such as proudness if you are able to play the game well, if you are able to deliver high performance of the furnace. Shame if you make mistakes, if you went too far. But there is also an aspect of daring. All kinds of biological processes and feelings are triggered. Ego is important as well.

In a plant in which process safety plays a role these are difficult things. Especially because it is not as controllable as in the petrochemical industry where everything is already so developed that things have to break down before there are real problems. We have to depend on human behaviour.

SELF-KNOWLEDGE: 'They evaluate what they have experienced'
Manager blast furnaces

How do you make sure that your people can react in the right way?

We have a knowledge intensive department. You would not guess this, by the way, if you look at the pile of rust outside of this office. But under this pile of rust there are processes hidden that are managed at a qualitatively very high standard. It is top-level sport. We do not work with IT driven artificial intelligence operating systems, but with people. These people have a very long and intensive training program. It takes many, many years before you are given the responsibility to operate a blast furnace and during these years a lot of talking is done. They discuss what they encounter, they evaluate what they have experienced when the rabbit crossed the road, and every time they try to learn lessons from this.

There are no guarantees that you will do things right the next time. That is why some people are afraid of a blast furnace. They lose confidence and search for another job. It is difficult, with no overview, and there is a lot at stake.

And if something strange happens which you do not understand, the adage is: shut down the furnace and think through the situation. But this is not something that people do easily, because we also want to make production. So there is a field of tension.

SELF-KNOWLEDGE: 'Why we do the things the way we do them'
Emergency response and security manager, chemical industry

Once I had a team of supervisors and they were not at all acting as a team. They were not really working together, sharing information, there was no comprehension of 'the other' etc. All these people had already followed the regular multinational chemical company X course program, just like me. This is the theory and I wanted to let them experience it for real. So we went on a leadership journey - a long weekend Portugal. We explained to each other why we do the things the way we do them. It was impressive, grown men opening up. Since then we understand each other much more. We understand why someone takes a certain risk for example and someone else doesn't.

So when this specific colleague does not have had a proper night's sleep he will not come to work and, because he has explained why, we all accept this. We all make decisions based on our own experiences. Why is someone quickly emotional? Why does someone not like to do certain jobs? It might be related to accidents that have happened. Between the shifts there can be resentment like "oh, again they have not finished what they were doing". Or "we are the best shift". But since the training this has changed miraculously. They are now a very strong team.

5.2.4 Improving vigilance and mitigating biased reasoning, a round-up

In this chapter two key problem areas of resilient minds have been discussed: decreasing vigilance due to automation and incident numbers and biased reasoning. Strategies to deal with these problem areas have been suggested. All techniques aim to improve vigilance, mindfulness and 'being switched on', which seem to be key characteristics of the resilient mind and organisation. Figure 9 summarises this. Note that further research is needed to validate the effectiveness of each of these techniques.

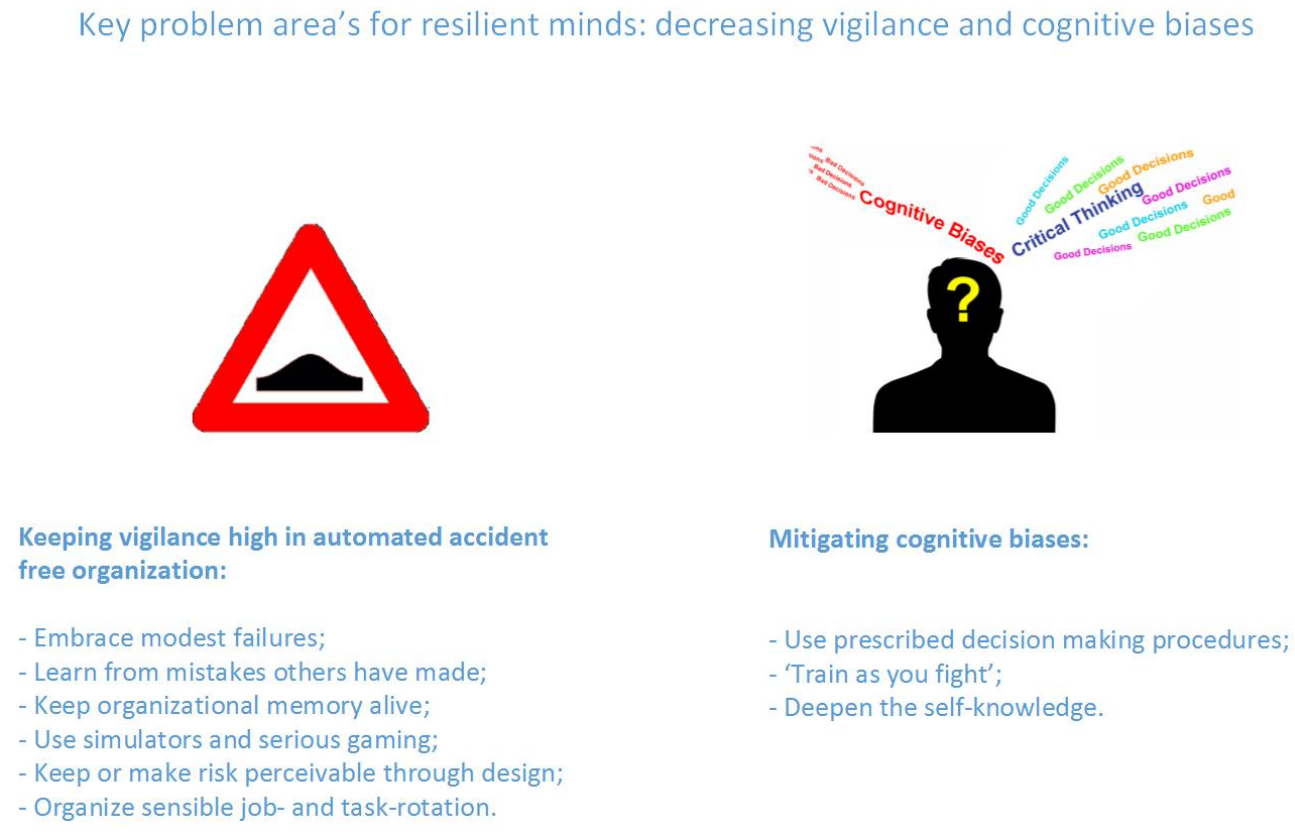


FIGURE 9 KEY PROBLEM AREAS AND STRATGEIES

6 CONCLUSIONS

6.1 Towards a common understanding of strengths and traps related to human intervention

Resilience might be regarded as a recovery system but one of regeneration and renewal rather than simply recovery. Resilience is also about going along with change, handling it, learning from it, moving on, a constant learning to live with 'snakes'. Amongst these snakes are not only the uncertainties and unforeseen hazards of the environment but also the adaptation of the mind to the real world experiences - through routine for example or through repeated successes in environments which nonetheless could have led to failure on another day.

Resilience is needed when the situation is complex. Complexity makes it impossible to predict all futures and requires the system to have resources for adaptation to possible futures. Complexity is a property of certain sorts of systems. Funtowicz & Ravetz (n.d.) specify two key properties of complex systems: the presence of significant and irreducible uncertainties of various sorts in any analysis and the multiplicity of legitimate perspectives on any problem. They give an example of a group of people gazing at a hillside each seeing different things (forest, archaeological site, potential suburb, planning problem), reflecting not only those cognitive and social structures which condition their perceptions but also the complexity of the hillside itself. In a similar vein the current research has aimed to investigate the perspectives of different people in different sectors managing high risk complex situations. The "hillside" in that respect becomes a metaphor for the hazardous systems and the perspectives are given by people who work in those systems.

This research has investigated, through interviews, the mental models of people delivering success in handling uncertainty and complexity and builds on what is learnt from this. In the current research case studies turned out to provide inspiring examples of human thinking in the face of risk[7]. They gave insight into people's minds with respect to the management of risk, the unexpected and resilience in handling it. These stories taken from 'the professional worker'[8] can be used as signposts to guide the way in becoming more resilient as a person and as an organisation. There is however no ready-made recipe for enhancing resilience because every person, situation and organisation is different and complex risk-environments do not have simple risk management solutions. In addition even professional people overestimate their own capacities and underestimate the risks as some of the interviewees have pointed out.

The question might be asked as to why resilience does not also apply to situations giving rise to apparently simple accidents (Jørgensen 2014), such as slips, trips and falls accidents for example. There is no reason why coping with variability in the environments surrounding such so called simple cases could not be addressed with a resilient approach, anticipating deviations at a deeper level which give rise to deviant conditions such as an unexpected spill or sudden icy conditions for example and developing the ability to respond quickly to such changes.

The researchers consider that this study can provide the basis for a shared understanding and vocabulary in which the strengths and traps of human intervention can be discussed and managed, starting from the mental frameworks of people that handle risks. For example: the characteristics of the resilient human mind could

[7] Interviews were held based on a Resilience Questionnaire developed in the study see ANNEX A: Case Study Method and Questionnaire

[8] This stands for a person who is identified as one of the very best at doing the job in a safe way. (S)he will be the person that others could learn from and the person who can help make the workplace resilient.

be used in selection, training and coaching of people that have to deal with unforeseen risks within companies and communities.

6.2 Characteristics of resilient minds

The four cornerstones of resilience were used as a basic framework to analyse the characteristics of the mind in relation to human resilient intervention.

The most important findings are:

Anticipation

The main points are:

- Interviewees have described how they experience uncertainty in their jobs e.g. "the danger is not binary but like a snake".
- Resilient people say they are risk aware and vigilant, but not afraid;
- That it is important to be good at thinking through the different scenarios;
- That it is even more important to be dedicated to "getting it right".

Most of the interviewees fully acknowledge and in certain ways also appreciate the variety and the danger of their working environment. Being 'switched on' to the now and what it means, what could also be called being aware and vigilant (constant watch for signals) are important for dealing with unforeseen risk-situations. For some that sort of demand draws them to this kind of work or experience.

A resilient mind is occupied with scenario-thinking. Scenario thinking helps to prepare for the unknown.

The people that have been interviewed stressed the importance of 'getting it right', i.e. to make sure that in the planning and preparation phase as well as 'in the act' as much as possible has to be done right so as to avoid an accumulation of small flaws and errors which could facilitate a big accident.

Learning

The main points deducted from the interviews were:

- Learning from things that go wrong seems to be more effective than learning from 'the positive';
- In order to learn you should not confuse 'luck' and successful operating;
- It is very important to also learn from small things that go wrong or from near-misses;
- Learning from successes might be dangerous (because of certain heuristic traps);
- Resilient minds are self-reflective and 'willing to learn' , also from small accidents and near misses ('the little things');

Despite what some resilience thinkers may say, it remains very important to be preoccupied with failure instead of success. As one of the interviewees stated 'success tastes *moreish'*. Success seduces people into becoming overconfident; it narrows perceptions and evokes dangerous biases such as 'summit fever' which can apply to goal seeking in any task. Failure on the other hand is more engraving in the mind of individuals and of the organisation; it makes people realise the importance of getting it right and their role in risk management. In order to learn from failure it is important not to confuse luck and successful operating. Next to this it is crucial that people are willing to learn and are self-reflective and are also prepared to learn from little things that did not go well and near misses.

Having this said, this study is an example of sharing best-practices and focuses on how people manage risks successfully on a day to day basis and therefor might be a perfect example of 'looking at things that go right'.

Having learning and experience is good for resilience and so to make use of this in the organisation means having available multidisciplinary knowledge and experience, balancing characters like devils advocates as well as people who want to push forward, applied to both preventive and regenerative tasks.

Monitoring

The main points that came up in the interviews points:

- The importance of being 'switched on', using all your senses, looking in all directions and concentrating on yourself , 'the other' and the environment;
- The importance of hold points and decision nodes;
- Awareness-limiting mental traps like confirmation bias

Being 'switched on' is a key characteristic when it comes to monitoring in a complex high hazard environment. This stands for using all your senses, looking in all directions and concentrate on yourself, the others and the environment. The emphasis is on the detection of change or difference. This is about watching out for every little thing that could signal a change in the risk situation as well as finding out everything that has changed in the situation.

It also has become clear that monitoring can be influenced by mental traps which narrow or distort awareness. To enhance and facilitate monitoring, the importance of hold points and decision nodes has been stressed and to make best use of the competences, individual characteristics and multi-disciplines in thinking together and collecting the right information.

Responding

The main points were

- Being knowledgeable and experienced are important characteristics for resilient responding;
- Adequate responding requires knowing the extent of the room for manoeuvre;
- Intuition can play a role;
- That there is a horrible flip side to being experienced: overconfidence, routine, living up to the aura of the expert;
- The need for a willingness to consult others;
- Being 'engaged' is important in order to respond but to be aware of 'summit fever'.

To be able to respond it is important to understand (have knowledge of) how an installation/system/process behaves as this supports thinking in unforeseen situations and knowing the bandwidth of safe operation; to understand the principles. Good responding requires experienced people – where experience can mean very many hours or years of experience. Experience is a guide which can come into play as instinct or intuition. Experience guides to certain decisions that are not per se rational.

A very important finding though is that it seems to be that experience is not an antidote to every risk. Although experience may be beneficial in finding the right solution in risk problems, our and other research (e.g. Weick and Sutcliffe 2007 and McCammon 2002) also shows that there are important flip sides to experience, notably overconfidence, routine and living up to the aura of the expert. It seems that every stage of experience has its own pitfalls.

It also became clear that being 'engaged' is important in order to respond adequately, but that one should be aware of 'summit fever'.

To avoid traps and pitfalls interviewees have pointed at the possible advantages of thinking and deciding together. This will be elaborated in the next paragraph.

Teams

In high hazard industry people often work in teams. Teams have the advantage that the quality of thinking and deciding can be improved by taking the right multidiscipline on board. When there is time available then making decisions under high uncertainty when a lot is at stake should not be taken alone.

Besides this interviewees have mentioned that certain traps like summit fever could be avoided when team members have balancing characters.

The uncertainty and complexity of processes sometimes forces people to make difficult decisions under high time pressure, for example to shut down an installation. The only way to encourage people to keep on making such decisions is to support them, also when the outcome of the decision turned out to be less favourable (for economical or even safety reasons). Leaders should back-up their team members when it comes to decision making under uncertainty and time pressure.

6.3 Organisational processes

In order to make organisations in the high hazard industry more resilient it is not only necessary that employees have the mental abilities to act resiliently when necessary but also the organisation itself should be organised in certain ways so as to facilitate resilient human intervention. This leads to the following point for reflection and recommendations:

- The organisation should help people to understand the differences between situations in which one should be resilient and situations in which obeying rules is crucial;
- The organisation should enable tight information & communication feedback mechanisms;
- The organisation should promote a culture in which communication and trust are at a high level;
- Within this culture of trust it is crucial to organise an 'institutionalised' second opinion;
- Also meta procedures for deviating from standard procedures can help human intervention;
- Technical barriers such as automated trips can actually improve human resilient intervention, because these measures can buy time to monitor and reflect before acting.

6.4 Dealing with traps related to resilient intervention

In this study two key problem areas of the resilient mind have also been discussed. The first problem is that resilience-enhancing characteristics of the mind such as awareness, vigilance and 'being switched on' are felt to decrease in automated environments with little accidents. Strategies have been selected from the interviews and literature that might mitigate this problem. For example to embrace modest failure, use simulators and make and keep the risk perceivable through design. High Reliability Organisations (HRO's) are said to be preoccupied with failure: "HRO's encourage reporting of errors, they elaborate experiences of a near miss for what can be learned, and they are wary of the potential liabilities of success, including complacency, the temptation to reduce margins of safety, and the drift into automatic processing. They also make a continuing effort to articulate mistakes they don't want to make and assess the likelihood that strategies increase the risks of triggering these mistakes." (Weick and Sutcliffe 2007, p.9)
The next problem area lies in the fact that cognitive biases weaken decision making under uncertainty and time pressure. In the interviews various examples have been given such as summit fever and confirmation bias. Not many remedies have been proposed by the interviewees apart from using prescribed decision making procedures, such as always to seek a second opinion. Some have used training in awareness of mental biases. Next to this 'Train as you fight' (realistic training) and striving to deepen the self-knowledge and mindfulness could be useful in mitigating the effects of cognitive biases.

6.5 Suggestions for further research

This report was based on 18 interviews across 4 different sectors. This study has researched the resilient minds of the professional worker (i.e. people that are experienced, recognized by their peers as very accomplished) working in high hazard environments. It also would be interesting to learn more about the minds and mental models of other groups of people such as leaders as well as people with less experience or people that are not regarded as 'super professionals'. A study into the influence of company values and leadership on resilient minds and resilient teams could provide insight into ways to promote resilient human intervention and to mitigate traps that are related to human resilient intervention.

Based on the interviews and on literature study some strategies to mitigate possible pitfalls in relation to human interventions have been mentioned. It will however be useful to further explore these mitigating strategies in professional (high) risk settings and to gather more information on useful resources that can be made freely available.

7 REFERENCES

Bainbridge, L., 1983. Ironies of automation. Automatica 19 (6) 775-779
https://www.ise.ncsu.edu/nsf_itr/794B/papers/Bainbridge_1983_Automatica.pdf

Bellamy, L.J., Mud, M., Manuel, H.J., Oh, J.I.H., 2013. Analysis of underlying causes of investigated loss of containment incidents in Dutch Seveso plants using the storybuilder method. Journal of Loss Prevention in the Process Industries 26 (2013) 1039-1059.

Beck, Risk Society: Towards a New Modernity. New Delhi: Sage. 1992 (Translated from German: Risikogesellschaft, 1986).

Colas, A., 1994. A New Stage in Improving the Operating Safety and Performance of Edf´s Nuclear Power Plants by Enhancing Professionalism and Developing the Safety Quality Culture, Tech. Report,Version 4.: EDF Nuclear Power Plant Organisation- Human Factor Group.

Davies DR & Parasuraman R., 1982. The psychology of vigilance. London: Academic Press.

De Winter, J.C.F., & Dodou, D. 2014. Why the Fitts list has persisted throughout the history of function allocation. Cognition, Technology & Work (2014) 16:1–11
http://link.springer.com/article/10.1007%2Fs10111-011-0188-1

Edwards, C., 2009. Resilient nation. London, Demos.

Ellis, S., Carette, B., Anseel, F., & Lievens, F., 2014. Systematic reflection: Implications for learning from successes and failures. Current Directions in Psychological Science, 23 (1), 67-72.
http://users.ugent.be/~flievens/Ellis.pdf

Ericsson, K.A., Prietula, M.J. & Cokely, E.T., 2007. The Making of an Expert, in: Harvard Business Review, July-August 2007.

Fitts P.M. (ed), 1951. Human engineering for an effective air navigation and traffic control system. National Research Council, Washington, DC.

Flyvbjerg, B., 2006. Five Misunderstandings about Case-Study Research. Qualitative Inquiry, vol. 12, no. 2, April 2006, pp. 219-245.

Funtowicz, S.O. & Ravetz, J.R., 1990. Uncertainty and Quality in Science for Policy. Kluwer academic publishers.

Funtowicz and Ravetz (n.d.) Post-Normal Science - Environmental Policy under Conditions of Complexity.
http://www.nusap.net/sections.php?op=viewarticle&artid=13

Hale et al 1997 Modelling of safety management systems. Safety Science 26 121-140.

Hayes, J., 2013 Operational Decision-making in High-hazard Organisations Drawing a Line in the Sand. Ashgate Publishing.

Hertz, N., Eyes wide open, how to make smart decisions in a confusing world, 2013.

Hollnagel, E., Nemeth, Ch., Dekker, S, 2008. Resilience Engineering Perspectives, Volume 1 Remaining Sensitive to the Possibility of Failure, Ashgate 2008.

Hollnagel, E., 2011. Epilogue: RAG – The resilience analysis grid. In Hollnagel, E., Paries, J., Woods, D.D. & Weathall, J. Resilience engineering in practice: A guidebook. Ashgate, 2011.

Hollnagel, E., Paries, J., Woods, D.D. & Weathall, J., 2011. Resilience engineering in practice: A guidebook. Ashgate.

Hollnagel, E., Leonhardt,J., Licu, T., Shorrock, S. 2013. From Safety-I to Safety-II: A White Paper.

Jørgensen, K., 2014. Prevention of "simple accidents" with major consequences. DTU, Denmark (accepted for publication in Safety Science in 2015).
http://orbit.dtu.dk/files/103299675/Prevention_of_simple_accidents_with_major_consequences_power_points_final.pdf

Kahneman, Daniel, Heuristics and Biases: The Psychology of Intuitive Judgment, Cambridge University Press, Cambridge, 2002, "Representativeness Revisited: Attribute Substitution in Intuitive Judgment", p. 51–52.

Kahneman, D. 2011. Thinking , fast and slow. N.Y. Farrah Straus & Giroux (2011)/ London: Penguin books (2012).

Kahneman, Lovallo, and Sibony, The Big Idea: Before You Make That Big Decision… in: *Harvard Business Review* June 2011.

Klein, G., Sources of Power, How people make decisions, Cambridge, MA: MIT Press 1999.

Klein, G., *Intuition At Work*. Random House, NY, NY. January, 2003.

Klein, G., Snowden, D & Pin, C.L. (2007) Anticipatory thinking . Asilomar Conference Grounds, Pacific Grove, CA.: NDM8 - the Eighth International Conference on Naturalistic Decision Making.
http://www.ara.com/CognitiveSolutions/documents/KleinSnowdenChew_2007.pdf

Kurtz, C. F., & Snowden, D. J. (2003). The new dynamics of strategy: Sensemaking in a complex and complicated world. *e-Business Management, 42*(3). [Cited by Klein et al 2007].

McCammon, I., Evidence of heuristic traps in recreational avalanche accidents, presented at the International Snow Science Workshop, Penticton, British Columbia, Sept. 30 – Oct 4, 2002.

Milkman, Rogers and Bazerman, How can decision making be improved? In: *Perspectives on Psychological Science*, Volume 4, number 4 2009.

Pallier, G., Wilkinson, R., Danthiir, V., Kleitman, S., Knezevic, G., Stankov, L., Roberts R.D., 2002. The role of individual differences in the accuracy of confidence judgments. The Journal of General Psychology 2002, 129 (3) 257-299.

Pariès, J., 2011 Resilience and the ability to respond, in: Resilience engineering in Practice, a guidebook, Hollnagel e.a., 2011

Perrow, Ch., Normal Accidents: Living With High-risk Technologies. Princeton University Press, Princeton, NJ, 1999.

Petersen A.C., Janssen P.H.M., van der Sluijs J.P., Risbey J.S., Ravetz J.R., Wardekker J.A., Martinson Hughes H. , 2013. Guidance for Uncertainty Assessment and Communication, , 2nd Edition, PBL, 2013. Developed for the Environmental Assessment Agency, The Netherlands.
http://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2013_Guidance-for-uncertainty-assessment-and-communication_712.pdf

Rasmussen, J. & Svedung, I., 2000. Proactive Risk Management in a Dynamic Society. Sweden: Räddningsverket. Swedish Rescue Services Agency.
https://www.msb.se/ribdata/filer/pdf/16252.pdf

Resilience Success Consortium 2014. Success in the face of uncertainty: human resilience and the accident risk bow-tie. **http://safera.industrialsafety-tp.org/filehandler.ashx?file=13344**

Roberto, M. A., 2002. "Lessons from Everest: The Interaction of Cognitive Bias, Psychological, Safety and System Complexity." California Management Review (2002) 45(1): 136–158.

Taleb, NN., Antifragile: Things That Gain From Disorder, 2012.

Tversky, A. & Kahneman, D., 1973. Availability: A heuristic for judging frequency and probability. Cognitive Psychology, 5, 207-232.

Tversky A & Kahneman D, 1974. Judgment under uncertainty: Heuristics and biases. Science 185: 1124–1131.

Weick KE, Sutcliffe KM, Obstfeld D. Organizing for high reliability: Processes of collective mindfulness. Research in Organisational Behavior. 1999;21:81-123.

Weick, KE. Sutcliffe, KM., Managing the Unexpected, Resilient Performance in an Age of Uncertainty, 2007 (second edition).

Zolli, A. and Healy, A.M., 2012 Resilience. Headline Publishing Group, London.

ANNEX A: CASE STUDY METHOD AND QUESTIONNAIRE

A.1 The use of case studies

The research can be placed within the case study tradition of social science inquiry of which the work by Hayes (2013) on operational decision making in high hazard organisations is a prime example. The stories that are collected aim to improve our understanding of the mental models of people while they are making decisions in their working environment where risk and uncertainty are 'part of the game'. Next to this the stories provide insight into the organisation which coordinates and controls the actions of its members and provides resources for the successful completion of their tasks.

Citations taken from the interviews are used throughout this report. Such stories are an important vehicle to learn from the experiences of others. They help people build additional patterns of thinking and responding and govern responses to future events. Narrative is an important mechanism for explain situations and making sense of events also referred to as 'meaning making' (Kurtz and Snowden 2003). Flyvbjerg (2006) responds to criticisms and misunderstandings that may arise from case-study research as follows:

1. Predictive theories and universals cannot be found in the study of human affairs. Concrete, context-dependent knowledge is therefore more valuable than the vain search for predictive theories and universals.

2. One can often generalize on the basis of a single case, and the case study may be central to scientific development via generalization as supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas 'the force of example' is underestimated.

3. The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone.

4. The case study contains no greater bias toward verification of the researcher's preconceived notions than other methods of inquiry. On the contrary, experience indicates that the case study contains a greater bias toward falsification of preconceived notions than toward verification.

5. It is correct that summarizing case studies is often difficult, especially as concerns case process. It is less correct as regards case outcomes. The problems in summarizing case studies, however, are due more often to the properties of the reality studied than to the case study as a research method. Often it is not desirable to summarize and generalize case studies. Good studies should be read as narratives in their entirety.

A.2 Interviews and storytelling

Interviews were designed around a questionnaire (Annex A.3) that was developed in detail from the Resilience Analysis Grid (RAG) framework (Hollnagel 2011). Interviews were carried out in the Netherlands, France, Belgium, Denmark and the UK. Interviews were with three types of people:

- Mountaineers (also called alpinists) who are directly confronting natural hazards;
- Rope Access Workers carrying out dangerous maintenance on man-made structures;
- HS&E Managers and Operations Managers of high hazard chemical, petrochemical and steel plants.

After conducting an initial set of semi-structured interviews with the mountaineers, there was a progression to rope access workers doing dangerous maintenance to get a picture of how people operating close to danger think and act. The questionnaire was then refined by making it a more specific set of questions and more focused on major hazard safety, major hazards being fire, explosions or toxic releases from chemical installations. This approach is illustrated in Figure 10 The questionnaire addresses the way people successfully deal with uncertainty and variability. From the interviews, examples and stories about resilience in practice

were identified, especially focussing on the commonalities between people in different and similar sectors and roles.

FIGURE 10 INTERVIEWING APPROACH: START WITH MOUNTAINEERS AND PROGRESS TO HAZARDOUS INSTALLATIONS

A.3 Resilience questionnaire

The questionnaire was used as a 'guideline' during the interviews rather than rigid question and answer sessions. It was not aimed at assessing the individual or the organisation but rather to focus on how high risks are identified, understood and managed from the perspective of the individual mind. The questions were used to evoke an open dialogue and narratives and to cover the fields of interest of this study.

The Resilience Analysis Grid (RAG) framework (Hollnagel 2011) upon which the questionnaire was designed is also called 'the four cornerstones of resilience' which are:

- Anticipation – Finding out and knowing what to expect
- Response – Knowing what to do and being able to do it
- Monitoring – Knowing what to look for
- Learning – Knowing what has happened

The questionnaire has a section on cognitive biases, the concept originating from Tversky & Kahneman (1974), also sometimes referred to as cognitive illusions (Pohl 2012). The main feature of cognitive biases is that they are mental short cuts (heuristics) used in judgement & decision making in uncertain conditions which can lead to errors. These biases are unconscious, automatic influences. For example, confirmation bias is the tendency of people to favour information that confirms their beliefs or hypotheses rather than looking for evidence that falsifies them.

The questionnaire also addresses the (mental) strategies the interviewees use to try to prevent or mitigate these biases.

A.4 Interview logistics and interviewees

From April 2014 – October 2014 people working in various high risk environments were interviewed. These people have to deal with high risk control problems on a daily basis such as mountain climbing, management of major hazard (petro)chemical installations, making steel and dangerous maintenance tasks.

In total 18 interviews were conducted. Each interview took approximately one and a half to two hours. Where preferred, interviewees were sent the questionnaire up front so that they could consider their answers

beforehand. Each interview was digitally recorded and reported as literally as possible. The interview reports were then sent to the respondents for verification. **www.resiliencesuccessconsortium.com** has the interviews as a set of showcases to enhance individual and inter-sectoral learning.

A.4 From interviews to characteristics of resilience

The characteristics described in *Chapter 4 Resilient minds within the organisation* and *Chapter 5 Improving vigilance and mitigating biased reasoning* are defined by studying the interview data and pulling common threads from them. The interviews were held with people at various organisational levels. They ranged from very experienced operators to people responsible for the health and safety or production process of an important division or site of international companies as well as from people that climbed ambitious new routes in remote mountain areas solo to people who are responsible for clients in alpine terrain.

Hence some interviews provide insight into the individual minds of people at the frontline and some interviews produce useful information on the organisational level.

TABLE 1 INTERVIEWEES

Nr.	Name and / or current job role	Date	Sector
1.	Christophe Kern, mountain guide and trainer	1 April 2014	Mountain climbing
2.	Katja Staartjes, expedition climber and interim manager	8 May 2014	Mountain climbing
3.	Lead engineer, manager	13 May 2014	Industrial rope access maintenance
4.	Lionel Daudet, mountain guide	16 May 2014	Mountain climbing, adventuring
5.	Manager blast furnaces	3 June 2014	Steel industry
6.	Production assistant blast furnaces	3 June 2014	Steel industry
7.	General manager height safety and rescue training company	4 June 2014	Training rope access solutions
8.	Business Unit HSE manager	14 June 2014	Chemical industry
9.	HSE advisor	1 July 2014	Industrial rope access and maintenance work
10.	Emergency response and security manager	22 June 2014	Chemical industry
11.	Process Safety & Technical Manager	7 August 2014	Chemical industry
12.	Senior company manager HSE	14 August 2014	Petrochemical & Chemical industry
13.	Arnaud Guillaume, mountain guide	16 August 2014	Mountain climbing, training
14.	Process Manager	4 September 2014	Petrochemical industry
15.	Shift Manager	4 September 2014	Petrochemical industry
16.	Group Environmental Health & Safety Compliance Manager, Healthcare	5 September 2014	Health care chemicals
17.	Plant Manager	1 October 2014	Chemical industry
18.	Plant supervisor on duty	9 October 2014	Chemical industry

A.5 Resilience Questionnaire

Resilience has been defined as: *the ability of a system to adjust its functioning prior to, during or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions (Hollnagel)*

This questionnaire is based on the following four dimensions of resilience:

- Anticipation – Finding out and knowing what to expect
- Response – Knowing what to do and being able to do it
- Monitoring – Knowing what to look for
- Learning – Knowing what has happened

Consideration should be given to daily routine as well as special projects or tasks that are unique or irregular.

1. Can you tell something about your career until now? For example: What education did you follow? What was your first job? Which aspects of your job do you like / not like?

2. Do you regard your job as dangerous?

3. How much (range of) uncertainty (variability) is there:

    a. In how the plant will behave on a particular day - because of the inherent variability in the process parameters, external conditions or the people who operate the plant?
    b. In how the plant will behave on a particular day - because of knowledge limitations or limits in what can be measured?

4. What is a typical daily routine for you?

    a. What do you look out for?
    b. What communications do you have with other people?
    c. What planning might be required?
    d. What sort of decisions do you have to make?

5. Can you tell something about your feelings about/responses to the following change situations (give some concrete examples that you have experienced). E.g. How do you adapt to:

    a. Changing situations in your team/people
    b. Changes in the installation/process/new technology
    c. Changes in methods/standards/requirements
    d. Changes in the environment/situation

6. What is the trade-off between being efficient and being thorough given that there are always resource limitations? Can you give one or two examples where you have had to make such a trade-offs?
   Note: Resources can be time, materials, money, human capacities and limitations (workload, fatigue, competence), manpower, information, tools etc.

7. How important are strict procedures and standardisation. E.g.

    a. In planning an activity?
    b. In responding to unexpected events?

8. What is the trade-off between rigid requirements and the need for flexibility? E.g.

    a. Was it ever necessary to change plans once a job has been started?
    b. Was it ever necessary to change or adapt a standard procedure
    c. Was it ever necessary to communicate with people outside your team?

9. How do you keep in touch with what is going on:

    a. Directly in monitoring the safety of the plant and the behaviour of people in relation to managing the risks
    b. What is happening in other parts of the organisation

10. Given inherent uncertainties, how easy is it to spot signals that something is not right (with the installation, process, and people)? What are you personally looking for to know if there are dangerous situations?

    a. Weak signals
    b. Slow degradation
    c. Not according to expected
    d. Indications of increased risk
    e. Instinctive/gut feelings

11. Did you ever encounter situations you did not anticipate? Can you give examples of how you have had to deal with unexpected events that might arise from the uncertainties talked about earlier?

    a. Handling doubt
    b. Golden rules/rules of thumb.
    c. Common sense
    d. Drawing a criterion line that should not be crossed
    e. Getting other opinions/using expertise of others (how easy is that?)
    f. Using buffers or redundancies e.g. to buy time with decision making
    g. Clear risk criteria about what is acceptable or not.

12. What have you learnt here since starting here about managing risks and uncertainties e.g.

    a. Common successes (how to do things right)
    b. Special training to handle risks and uncertainties in your job
    c. Follow-up when things go wrong
    d. Things you have learnt from personal experience – what goes right as well as what goes wrong
    e. Things you have learnt from others inside and outside the organisation (how easily/quickly do you hear)
    f. Information available from membership of a forum or special subject group or professional affiliation
    g. Other sources of information e.g. lessons learnt from accidents on other plants
    h. Are you learning all the time or does it tend to be event driven?

13. Have changes come about as a result of learning?

14. How do you anticipate the future in what you are doing now in terms of possible future scenarios?

    a. To what extent are there scenarios provided that you are expected to consider?

b. Are new scenarios being added such as new ones for existing situations or new ones as a result of change? (How often)
c. To what extent do you dream up new scenarios?
d. Do you discuss possible scenarios with your colleagues?
e. Do you think about scenarios that are hardly possible?
f. Is the speed at which things might develop considered?
g. Are scenarios considered in relation to risk criteria – what is acceptable or not.

15. How much preparation do you put into dealing with these possible futures?

    a. Do you always have a plan?
    b. Do you have the knowledge and expertise to adapt to these possible futures
    c. How fast could you respond to the unexpected?
    d. How do you maintain your alertness and readiness to respond (and not get sucked into the daily routine for example)

16. In handling risks and uncertainty, when dealing with rare and unexpected events and even regular events all sorts of "heuristic traps and cognitive biases" in decision making have been identified [explanation/examples]
    a. Which traps/biases are the most difficult traps for you to handle?
    b. What advice/solutions do you have for dealing with them?

    <u>Examples.</u>

    Confirmation bias: The tendency of people to favour information that confirms their beliefs or hypotheses.

    Optimism bias: The tendency to be over-optimistic, overestimating favourable and pleasing outcomes.

    Overconfidence effect: Subjective confidence in one's judgments is reliably greater than the objective accuracy, especially when confidence is relatively high and in answering more difficult questions.

    Sunk cost fallacy: The phenomenon where people justify increased investment in a decision, based on the cumulative prior investment, despite new evidence suggesting that the cost of continuing the decision outweighs the expected benefit.

ANNEX B: EXAMPLE INTERVIEW TRANSCRIPT

RESILIENCE
SUCCESS CONSORTIUM

INTERVIEW

13 May 2014

Lead engineer industrial rope access and maintenance

Interviewer & Author: Anne van Galen

Can you tell something about your function and your background?

Of course. I started studying mechanical engineering at Eindhoven University. At the same time I started climbing. I finished my study but I decided that I could not work behind a desk. For that I did not have enough tranquillity in my mind. Therefore I started working for an outdoor agency. At first I worked for Dutch companies but gradually I wanted to have a better education and certification. Via my canyoning training I started working for an Austrian mountain guide. I worked as a climbing instructor, did maintenance and construction work. At a certain moment I was finished with outdoor construction work and I wanted to combine technical work with my love for ropes. At first I did that next to my job as a Subsidy Consultant. So during weekdays I worked in a suit and during the weekends I got this job on the side, working with ropes. At a certain moment I quit my job and started for myself. This was the way to go for me. Because I had more capacities than the average rope man I quickly started doing project management and my company grew fast. At a certain moment we were bought by another company. That was okay for me because at that time I was working day and night. So I went from rope access worker to supervisor, project manager, lead engineer and at the moment I am also interim manager of our department. This means that I deal with all the difficult technical things, product and process innovation and for the moment I also manage the department.

For difficult projects I still go outside to make an analysis of the problem, identify solutions and design the implementation process.

At first we were only asked to take our ropes and do the job. Nowadays we are more and more asked to think with the client what the best way is to do the job. That has to do with safety, lead time, maintenance costs, flexibility, costs short term and long term. I also studied business administration and in these projects all aspects come together.
Besides this I am still certified as an IRATA (industrial rope access trade association) level three.

What is ROPE ACCESS?

IRATA International's rope access system is a safe method of working at height where ropes and associated equipment are used to gain access to and from the work place, and to be supported there.

The advantage of using rope access methods mainly lies in the safety and speed with which workers can get to or from difficult locations and then carry out their work, often with minimal impact on other operations and the nearby area. Another major benefit is that the combination of the total man-hours and the level of risk for a particular task (man-at-risk hours) is often reduced when compared with other means of access and their associated risks and costs.

The primary objective when using rope access methods is to plan, manage and carry out the work with minimal accidents, incidents or dangerous occurrences, i.e. to ensure a safe system of work is maintained at all times, and with no damage to property or harm to the environment.

The three technical grades are:

Level 1

This is a rope access technician who is able to perform a specified range of rope access tasks under the supervision of a Level 3.

Level 2

This is an experienced rope access technician who has Level 1 skills plus more complex rigging, rescue

and rope access skills, under the supervision of a Level 3.

Level 3

This is a rope access technician who is capable of complete responsibility for rope access safety in work projects; is able to demonstrate the skills and knowledge required of Levels 1 and 2; is conversant with relevant work techniques and legislation; has an extensive knowledge of advanced rigging and rescue techniques; holds an appropriate and current first aid certificate and has knowledge of the IRATA International certification scheme.

My team consists of one operations manager, three project managers, back-office staff, several IRATA level three workers and a large number of freelance IRATA workers.

Talking about rope access workers that are certified and those that are not:

This morning I talked with someone from a peer company that works just like us on the site of a major chemical company. He told me this company had hired people to do rope access work that were not at all IRATA certified. For us that means false competition; it is against their own very strict rules. This is not because they do not know about their own rules, they just do not want to ask too many questions if they are offered a price that is very cheap and then they do not ask any further questions.

10 years ago rope access work was pretty new for many companies. Before we could start we really had to explain and demonstrate to the safety experts and site manager what we were going to do and if this really was safe. Now we are more and more regarded as a commodity, business as usual, and this means that at the start clients do not have the right attention for the project.

Sometimes this leads to conflicts. The client just wants us to hang out our ropes and we stick to our very strict procedures.

A client told us, for example, that we just had to put a piece of plastic around our ropes and get started working at some tank with potential sulphide residue (highly corrosive to ropes). That is not the way we operate.

This certainly has to do with the pressure on costs and the current economic situation. It is easier to look for savings on the side of contractors.

And also sometimes there is a lack of knowledge. This leads to deficient planning and finally to panic measures (like the access to the tank without 100% assurance for the absence of corrosive chemicals) and this leads to quick fixes with regard to safety.

This does not match with our approach to safety because we only want to work after meticulous preparation. If things go wrong the consequences are enormous.

To be honest, I do not think that our work as rope access workers is dangerous, although there are certainly risks involved. There are very few accidents in our field. The statistics are with us. The feedback is always very clear. You do your job well, you come back safely on the ground. You make a mistake, you fall down. It is one-zero.

Look, someone who builds a scaffold and who does not have his fall protection does not necessarily have a problem. In our work it is much clearer - if you don't hang onto something, you fall down.

With rope access work it is easy to manage the risks. You only have to do the right things, all the time.

Can you explain why you say that the risks are easy to manage in your field?

This is related to three things:

First, there always is clear feedback. The risk is very evident. Everyone understands this.

Second, and maybe this is the most important, there is a very strong safety culture. Everyone has safety first, his own safety and also the safety of his buddy (as well as the people around us). When they work people are very conscientious of their safety. It becomes part of yourself.

Third, we have very strict rules. Even if it is only one hour of work, we will always make a plan, a TRA, a description of the scope. We will never do something 'quick and dirty'.

And of course sometimes this means a conflict with the client. Procedures force us to take time to think. We never start a project before we have a plan written down (method statement), a JSA/TRA (Job Safety Analyses/ Task Risk Assessment), a kick off meeting with the client and third parties. Every day we will organise a daily operational meeting: Did something change in the environment? What did we learn yesterday? All these aspects will be spoken through. This is something we do very seriously, everyone has to sign up to this.

What is new is that we have to do a Last Minute Risk Assessment (LMRA); this is something you do at the workplace, just before starting. This is another moment that you could discover that something is different than expected. For example, there are other maintenance projects going on that you did not know of, someone is working nearby with high temperatures (hot work)[9], there is more wind than expected, a plant nearby has an exhaust of dangerous gases and your job means that you will be there on some high tower in the middle of these chemical substances.

For us the LMRA is a little bit a double check because we also have the start-up meeting (daily operational meeting), but it is mandatory and for the whole company it is a reinforcement.

Furthermore we have lifesaving rules, a time out card, target zero (the company's overall safety system). Sometimes, to be honest, it can be difficult to take everything seriously, because we are already so strict on safety and things start to feel like double measures.

How do you detect and diagnose after you have started the job?

Within the IRATA system there is a strict requirement for the supervisor to make sure the job is performed safely and according to plan. Also we have the buddy check. When we have put on our working equipment we will always ask our partner to check us. Also me as a supervisor, I will ask a fresh man to check me. I am also just a human.

What makes it possible for you to be able to detect and diagnose?

Well, firstly, some people are more switched on than others. They are more aware of what is going on around them.

Second - this is something I have developed during all my years of training and working experience - we learn to detect on four dimensions: all different directions but also going forwards in time. During the years you get better and better at this. Certainly with high end clients you are investigating every minor detail in the

[9] This is dangerous because the ropes can melt.

process. For example: when you are going to work on a platform at sea and will be flown in by helicopter you will have to think through every step in the process:

I am putting my equipment into a container, what is in my equipment (no dangerous goods?), will it be light enough to take out of the container and hand-carry, is it well secured so that it will not immediately fall out of the container when this is opened?

This is something you have to learn, you have to gain experience and you have to be open for that.

It is like a film in your head. The more you can really foresee the things that are going to happen, the more you can prevent or prepare for the risks.

We also use risk assessment models, such as 'MUOPO': Mens, uitrusting, omgeving, product en organisatie[10]. This model prevents us from only looking at certain aspects and creating blind spots; and risk evaluation models like Fine and Kinney that help us define the appropriate mitigating measures.

This is very handy in practice. It gives you a broad perspective on the project. For example the factor 'human'. Do you have the right mix of people in your team to end the project safely and successfully? For example when there are three 'pushers' on the project, there will be a chance that they will be keen on finishing rather than on safety and finishing it in the right way. When I say 'pushers' I mean guys that really want to finish the job: let's go, we're almost there, go on, go on! – this is okay, you need these kind of people, but if you have three of them on the same project, you will lack other qualities. People that will say: are we within our procedures? Are we still working according to plan? We were planning to use this and this equipment, but now we are working with something else which is more dangerous, is this really a smart thing to do?

I can imagine that it will not always be easy to change things such as the people on a team. How does this work in practice?

Well, you have to be 'hard' at these moments but also always positive: "It is really great that you want to push on and finish the job in time, but we have to stop right here and go back to the drawing board."

Drawback of this stringent approach is that it could be used to halt progress and stall the job, also known as "slacking". That is not how we are working; but neither must we go too far and stretch safety measures and be over-creative and make something that is not doable.

That is a very precarious and difficult moment, for everybody. We have engaged (stand-by) boats, helicopters, you name it, and at that very moment it appears that we have to go back to the drawing board. This is the hardest aspect of the job. If you ask everybody individually, people are very aware of the dangers of the situation, but in the group it might not be possible to speak up.

This is very relevant to the cognitive biases that we want to talk about. For example there is this bias that if you have already invested a lot to come at a certain point, it is very hard to quit, even if you know that the costs of pushing on will be very high. What strategies do you use to protect yourself against this?

Open up communication is the only way. Talk about it! Make it part of your procedures to communicate, repeat it. Make it clear to everybody that risk will go up if we do not stick to the plan. Our risk analysis is based on the procedures as foreseen. If we are going to do things differently, we will have to go back to the drawing board. Everybody has to understand this.

[10] HEEPO - Human, equipment, environment, product and organization

People also have to be aware of the band width as well. If you switch from screwdriver 'a' to screwdriver 'b' there will not be a problem. But if you go from a disk cutter to a blow torch we do have a problem, because there are different risks attached to each device.

This is not always easy, I must admit. Myself, I was recently offshore for a take in of work (job assessment) and I wanted to loosen a bolt to look at the state of the wire underneath it. And I caught myself in the act of collecting all kinds of sub-optimal tools to try to get the job done. I was about to start without the appropriate equipment, without proper planning and assessing all the risks. There was no direct danger, but there was a lot that could go wrong. I was there together with an operational manager from another contractor, and I said: "Dude!, we do not want to do this. We really want to finish it, but this is not okay". We were already considering even more drastic measures. We had to step back. It was not according to plan, we were not prepared and we did not have the right equipment.

So I had to admit to myself. Merijn, you think you are the big guy that knows everything, but here you are trying to get the job done, unprepared and with the wrong set of tools creating a potentially dangerous situation. That is not something to be proud of and you rather want to forget about it; but rather than make it disappear I talked about this incident with my colleagues and I even mentioned it in a formal inspection round on this platform so that we can learn from this.

There are companies where you could get fired…

Yes, maybe you are right. But I think that some companies are more and more hypocritical in their approach. They say that safety is their goal but in the mean time they are just punishing people. Yes, of course, when for the third time someone does not want to wear his safety equipment, the consequences have to be clear. But sometimes they go way too far with their stringent punishment procedures.

These same companies can be rather creative with their safety rules when it is convenient for management or profits.

Especially when there are KPIs[11] attached to so called safety targets, strange things are happening. Things are 'swept under the carpet'. In incident analysis they are trying to blame third parties instead of looking at their own share. The safety statistics are becoming a target on their own instead of a way to monitor and to analyse what is going on.

Example: people that have an accident while performing their main job get another task at a desk– so that they do not have to use their injured leg for example – with the sole purpose to avoid a Lost Time Injury that would be bad for the safety statistics.

But back to the platform and our cognitive traps

Rules and procedures, training programs, external audits, meetings with all parties involved to think through the whole process, detailed approach description (method statements), risk analysis and mitigation, each morning kick off, LMRA, daily operational meeting, all these things reduce the risk of over optimism and easily made judgemental errors as 'oh, it will be fine'.

Also organising a second opinion - all plans we produce will be challenged by a colleague: do you really think that this will only take an hour? This is not meant to 'bully someone'. By discussing things with someone else things will become more real than if you only write it down.

[11] KPIs = Key Performance Indicators

If everything goes well – you have little incidents as you state – doesn't that mean that you will be pushed to do things more effectively? Thinking: The last time it went well, so it will be alright next time….

Yes, that is possible. And we are trying to work as efficiently as possible. Nonetheless, we always work in places that are very difficult to access. We don't know exactly what we will find. We have to and can claim a margin because of this. Or we can do an inspection beforehand, and make a detailed plan on basis of what we have found.

Because we always do difficult work at difficult places we can claim more margin. This characteristic will also keep us awake and alert. I think that we could become 'sloppy' if we would always do the same, for example washing the windows of the same high building every month, year after year.

It is in our advantage that we always have new and different projects. This is also part of the law: repetitive work should not be done by rope access workers. For these kinds of jobs permanent technical measures should be taken. But unfortunately there are very few architects that want a window washing machine on their building…

If you do things too often you will get blind to the risks.

How could we relate this to normal factories in which people do their risky job 5 days a week?

People that are the most in danger are the ones that are absolute beginners – they are overwhelmed, they do not know what they are doing and they do not know the risks (they are 'unconscious', 'unable'). On the other hand there are the people who feel very comfortable with the risk; they stop seeing the risk. Routine is a huge danger. I think for that kind of danger it will be important to change tasks now and then. Change tasks and teams to prevent people starting to dream and work on auto pilot. But it should not be institutionalised! Then it becomes crazy. It becomes a goal in itself and the perspective of safety is forgotten.

I see parallels here with the implementation of the lifesaving rules. If people want to steer and judge on these kinds of things, they lose their functionality. It is no longer the safety of human that counts but the statistics.

As an example: yes, we do have little incidents in our team, but since 2005 never one single LTI[12]; but still we have to do the same number of workplace inspections as other teams within this company even though those other teams do not have such favourable safety statistics.

Can you influence the rules and procedures with which you work?

Yes, I definitely can. Together with my colleagues we are regarded as an authority in the field. It helps that we have all followed higher education / university and that we have gained a lot of experience in practice. We know what we are talking about.

And do you get a lot of signals from your colleagues in the field?

Yes, glad to say yes. It is not always easy. You can imagine there is also this aspect of a blame culture. And sometimes it is annoying to hear that someone dropped something, or a life jacket was blown up because they were playing around. But it is very important to know as much as possible about near misses and I try always to be positive and thank people for coming to me. Open communication is so extremely important.

You will lose people if you bash them. And you will also lose them if they give feedback and you do not take them seriously, if you do not follow up on their remarks.

[12] LTI = Lost Time Injury

You must motivate them, stay positive and take everything seriously.

It is the same when you go to the police to report that your bike has been stolen. If you do not hear anything afterwards you will never bother to do it again – and yes, it will look like there is no problem there. But if you hear that they have used your information, if you are reported back to, you will also come for the next time.

Do you think your practice has become safer over the years?

Hmmmm. Yes in certain ways yes. We will do things differently and better than some years ago. And also we have optimized our procedures. We are more prepared. Our procedures are more detailed.

We have to have more things written down because the distance gets larger. I mean our team is getting bigger and bigger, so it becomes more difficult to know everybody, their weaknesses and their strengths.

But there is this thin line on which we are balancing. If our procedures are becoming too extensive, people will not read them anymore; then it is much better to have comprehensive checklists on a few sheets..

Often I work with teams of engineers or advisors. The things they come up with, just crazy! Then I will ask them: do you have any practical experience in using these proposed tools in this situation? Most of the time this is not the case. Often people do not want to admit that they do not have the right knowledge and experience. But to be successful you really will have to work together. Really communicate.

Do you make use of alternative plans?

We always will make rescue plans. What if the light goes down? How do we get away in case there are toxic substances released? Do we need gas masks?

For us it is important to make sure that we can rescue ourselves. We cannot rely on the fire brigades for example even if they would rather come and rescue us because formally it is their job. They do not know our business and procedures. In practice it just won't work. Rope access work is maybe something they only train for once every two years. And it will take a long time before they will get to us.

It is not that I do not want to work with them – they are better at first aid for example, but I do not want to rely on them.

We have the buddy system in place in case of emergency.

Not to be arrogant but I am convinced that we can share a lot of our knowledge with the average HSE officer. We come to so many different sites with different situations and scopes. We have so much experience in practice.

Do you still get into situations that you really did not foresee or expect?

I have to think back. Yes, I recall a situation in which I trusted the client's safety measures.

I was working on a tower during a maintenance project and one of the safety measures that had been arranged was that no one would work beneath or above us. The client also provided safety wardens who were given instructions. At a sudden moment I noticed that melted iron was flying all around me. Apparently some decks above me someone was using a cutting torch while I was hanging in my ropes. I first had to get down from my ropes and then had to kick the guy that was working above me. Well it appeared to be some bloke from Eastern Europe that just got this assignment and was not at all conscious of the other things that were happening on other decks. He just had started and was also not able to communicate in a language I could understand. I was able to communicate with my colleague / buddy but not with the client.

Another near miss:

Once a colleague of mine had to clean a column, a funnel at a cokes carburettor. There was this thick layer of ashes. My colleague was in this funnel and I was his buddy standing outside. When he had taken away the ashes it appeared that underneath there was this enormous heat covered up that now materialised. The guy immediately got heat stroke. The bad thing was that to get out of this funnel you first had to climb through this small pipe of one and half meter long, 60 centimetres diameter. I just got him out in time. It was a narrow escape.

This same day one of my other colleagues had the same sort of issue at a different site. He also had to climb out of a tank through a very narrow man hole. He didn't feel good about it at all. That evening we talked on the phone and decided that we would stop immediately and go back and do some training on these kind of problems first. So we built some mock-ups[13] to gain experience. We built 'man holes' and started training.

This colleague that had the heat stroke, how did you detect something was wrong?

Well, luckily I heard him talking through the radio: "argh, hot" and I reacted immediately. I could pull him out and luckily he also was able to help a little with his legs.

And your colleague had the same problem on the same day?

He did not have an incident, but he had a very bad feeling about the whole situation. There was this kettle and several colleagues had to work in there while there was only this narrow manhole. It was not me that put the project on hold. My colleague himself had this nasty feeling and took the consequences of this. These are difficult decisions. Later on that day we decided together on the phone that we had to set up a simulation training.

First you have to admit to yourself that you have made a miscalculation in your judgement/assessment of the situation. Second you have to disappoint the people around you, because the job will not be done in the time foreseen.

People would rather go forth on the same chosen path than stop and pull back, admit they could be wrong and reconsider the whole thing. It is really, really difficult. Of course I can pull the safety card on my clients and colleagues, but then I first have to admit to myself that I was wrong!

What do you need to be able to do this?

You have to learn this, you need the culture for this and, very important, the back-up from your superiors. If you do not take people seriously you will lose them because the moment that people start to talk about these things they can also be punished for not having taken the right measures, for example.

How important is ego?

Oh yes, ego, I know exactly what you mean. To admit that you have made a judgement error means that you have to put aside your ego. And this is difficult because many progressive achievements are also gained because of ego.

What to do?

Well, at least you can try to avoid an offense of the ego. For example to refer to laws and rules, to make it more general and to give opportunities to *not t*ake things personally. Now we are already touching on the field of group dynamics, inter human communications.

[13] A mock up is a model or replica built for experimental purposes.

Other strategies for bias mitigation?...

..Planning fallacy, optimism bias?

Do test runs

..Hot hand fallacy (live up to the expectations that you are a winner)?

Do evaluations, standard procedures, stick to the plan

..In general?

Be process oriented. This makes it easier for people to do all the necessary things and not forget anything, like using a checklist.

..Sunk cost fallacy?

Culture and investing in being trusted by your client

..Confirmation bias?

Always have a second opinion

What role does the way a contract is constructed play?

Lump sum contracting brings in the risk that you will start doing crazy things, quick and dirty.

So at the start you have to make better arrangements in which you can go back to the client when things are different than expected. But there is always this thin blue line: they like the quality of our work or they think I am very irritating when I come bothering them again with safety risks. On the other hand: we also choose our clients. For certain people we decided we did not want to work with them anymore.

This is a risk, but we really want to be within our safety thresholds. And taking one hour more up front to do things right is always cheaper than an accident.