1

Safety Culture Concepts

1.0 Introduction

Summer blockbuster movies always have some huge disaster as a major part of the plot. These events include events like airplanes crashing, volcanoes erupting, explosions, ships sinking, fires, tornadoes, earthquakes, railroad trains crashing, or alien invasions. In the movies all the bloodshed is fake. In reality, these types of disastrous events cause real people to die, to become severely injured and destroy families' homes and businesses. Events like tornadoes, earthquakes, and volcanoes can't be prevented. However, airplanes crashing, industrial explosions, ships sinking, trains crashing, and fires can be prevented. Alien invasions, well we don't know yet (or maybe we do).

Safety and health professionals dedicate their lives trying to prevent people from being killed or injured and to prevent property damage. Safety and health professionals include:

- Safety engineers
- Industrial hygienists
- Fire inspectors
- Fire fighters
- Health physicist
- Radiation safety officers
- Ergonomists
- Risk analysts
- Human factors practitioners

In addition to:

- Professional engineers of all types
- Chemists
- Biologists

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- Ecologists
- Physicists
- Medical professionals
- Police and Military

It is quite a list of professionals who work to keep us safe. Some of these professionals are dedicated to designing safe products, some to ensuring safe working conditions, some working to ensure we live healthy lives, and some ensuring our physical security.

I wrote this book because of my passion about safety and helping people come home safe every day from work. The case studies in this book represent a broad range of events that have happened and could happen tomorrow, if precautions are not taken. Safety culture is the focus of the book because disastrous events can be prevented if the safety culture of organizations is improved.

The book is organized into 10 chapters. Chapter 1 discusses the concepts of safety culture; Chapter 2 discusses aspects of the evolution of safety and safety culture through the centuries and decades, Chapters 3–9 discuss a wide range of accident case studies and the associated safety culture attributes. Chapter 10 discusses methods of assessing safety culture.

The case studies presented in the book should inspire employers to ensure their facilities and processes are engineered and maintained to be safe, employees are properly trained, and organizations place a high value on the lives of their employees.

I want to thank the investigators form the Chemical Safety Board (CSB), National Transpiration Safety Board (NTBS), Canadian Transportation Safety Board (CTBS), Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and local fire and police departments for their integrity in performing the detailed accident investigations that I have used in this book.

1.1 Culture

The American Heritage Dictionary defines culture as "The totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought characteristic of a community or population." A culture is comprised of behavioral norms, patterns of perceptions, language/speech, and even building design features that make the culture what it is. It is difficult to understand a culture in total, but it is possible to study and understand individual norms. A social norm is defined as an unspoken rule of behavior that, if not followed, will result in sanctions. In an organization, a norm might be that managers must business attire.

In this organization, a manager who arrives at a meeting in casual clothes might be teased or reprimanded. If he or she consistently failed to wear the appropriate clothing, might be considered unprofessional, not reflecting the company image, and face severe sanctions, including loss of his or her position.

Every organization, as does every country, has a culture. Even within a country, cultures vary widely. The cultures within the United States vary greatly. We all know how different the culture in a northeast state varies from the deep South. Consider also that a city culture varies from a culture just outside a city. We recently watched a movie entitled "Into the White." The movie was based on a true story about a German and a British air crew stranded in the high Norwegian plateau during World War II after shooting each other down. The interesting part about this movie to me is when they were out of food and starving a British and a German airman went hunting for food. They shot a rabbit and brought it back to their cabin and all five looked at the dead rabbit and had no clue how to prepare it to eat. I grew up in the mountains of the west and I was hunting at 12 and cleaning what I killed. These airmen had been denied that skill because of the cultures they grew up in.

Cultures vary widely in countries and areas within countries. Consider the languages in the small country of Dagestan. The country is only about 20,000 mi^2 (about 50,000 km^2) and has only 3.1 million residents. There are more than 30 ethnic groups and 81 nationalities. There are 14 official languages, and 12 ethnic groups constituting more than 1% of its total population. In addition, there are over 40 languages (Charles Rivers 2019). So, how did all these cultures come about? Dagestan borders the Caspian Sea and is in the Caucasus Mountains. It was at a crossroads during ancient times and many villages were high in the mountains. Adjacent villages were separated enough that distinct dialects developed. Also, the invasions by various groups brought languages and customs to Dagestan as well.

So, what is the point of this? It is that within companies and organizations safety cultures vary widely, just as cultures range widely in cities, counties, states, and countries.

A safety culture is composed of safety norms within a company or an organization. A safety norm can be positive or negative (Ostrom, Wilhelmsen, and Kaplan 1993). A positive norm is that a lab worker always dons their safety glasses and a fire-resistant lab coat every time they enter a lab. A negative norm is when an electrician fails to use proper lock and tag procedures when working on electrical circuits. The case studies will present the results of numerous case studies involving negative safety norms.

Pidgeon (1991) writings from 1991 are still true today. He wrote that a "good" safety culture is hard to define. Part of the reason for this is that each organization's culture is somewhat unique. Culture can be influenced by the nation or region, by the technologies and tools it uses, and by the history of success and

failure the company/organization has achieved. Safety culture of an organization may be influenced by the marketplace and regulatory setting in which it operates. Safety culture may be influenced by the vision, values, and beliefs of its leaders as well. All these influences make it difficult to say what a "good" safety culture will look like in a particular setting. Despite differences, good safety cultures do have things in common:

- Good safety cultures have employees with particular patterns of attitudes toward safety practice.
- Because it is impractical to establish formal, explicit rules for all foreseeable hazards, norms within the organization are required to provide guidance in particular circumstances.
- In a "good" safety culture employees might be alert for unexpected changes and ask for help when they encounter an unfamiliar hazard.
- They would seek and use available information that would improve safety performance. In a "good" safety culture, the organization rewards individuals who call attention to safety problems and who are innovative in finding ways to locate and assess workplace hazards.
- All groups in the organization participate in defining and addressing safety concerns, and one group does not impose safety on another in a punitive manner.
- Organizations with a "good" safety culture are reflexive on safety practices.
- They have mechanisms in place to gather safety-related information, measure safety performance, and bring people together to learn how to work more safely.
- They use these mechanisms not only to support solving immediate safety problems but also to learn how to better identify and address those problems on a day-to-day basis.
- What is acceptable in a company regarding safety must be defined and practiced if a corporate culture that values safety is to be created. Ideally, employees should know all the risks associated with their jobs, what is required for safety, and take responsibility for themselves. In other words, develop a norm in which employees are aware of all the risks in their workplace or are continually on the lookout for risks.

  The result is an overall positive attitude toward safety.

1.2 Safety and Health Pioneers

People have been trying to understand and control the factors that lead to occupational illnesses and accidents for two millennia. Some of the first leaders in occupational safety and health were Hippocrates, Pliny the Elder, Galen, Agricola, and Bernardino Ramazzini. The Greek physician Hippocrates identified lead as

a hazardous material in the mining industry in about 400 BCE (BC). He helped develop rules for working in mines. The Roman Pliny the Elder in about 100 CE (AD) identified zinc fumes and sulfur vapors as hazardous. He developed a face mask made from animal bladders to help protect chemical workers. Galen was another Greek physician who characterized the pathology of lead poisoning and the hazards of working copper miners who were exposed to acid mists. Agricola was a German scholar and a very early industrial hygienist and described the diseases of miners. He also developed preventative measures to avoid diseases associated with mining.

Bernardino Ramazzini made a huge impact on safety and health. Most safety and health professionals consider him to be the founder of occupational medicine. Those of us who work also in ergonomics consider him to have been a pioneer in the study of musculoskeletal injuries.

He was born on October 4, 1633, in the small town of Capri. This town is located in the duchy of Modula, Italy. In his lifetime he established the field of occupational medicine. In 1682 Duke Francesco II of Modena assigned him to establish a medical department at the University of Modena. His title was professor "Medicinae Theoricae."

He was appointed chair of practical medicine in Padua, Republic of Venice, in 1700. This was the premier medical faculty in Italy. That same year he wrote the seminal book on occupational diseases and industrial hygiene, De Morbis Artificum Diatriba (Diseases of Workers).

He is best known for his work on exposure to toxic materials. His pioneering effort in musculoskeletal illnesses included linking occupations to specific disorders (Franco and Fusetti 2004). Ramazzini was one of the first to observe that common musculoskeletal illnesses could develop due to common stresses associated with poor ergonomics, for instance, prolonged stationary postures or of unnatural postures. Just as today, people working in awkward postures like bakers, scribes, weavers, or washer women could develop illnesses. People in professions that required prolonged static postures like workers who stand or are required to sit for long periods of time can develop problems as well. In addition, workers who are required to perform tasks that require heavy muscular performance are at risk of injury.

1.3 The Evolution of Accident Causation Models

The next step in the evolution of safety was the development of accident causation models. Accident causation models have been evolving for about 100 years. Heinrich's Domino Theory developed in the 1930s was based on the premise that a social environment conducive to accidents was the first of five dominos to fall

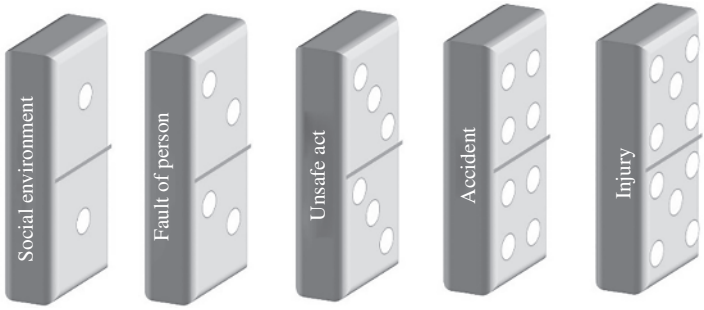

Figure 1.1 Heinrich's theory of accident causation. Source: Redrawn by Ostrom (2022).

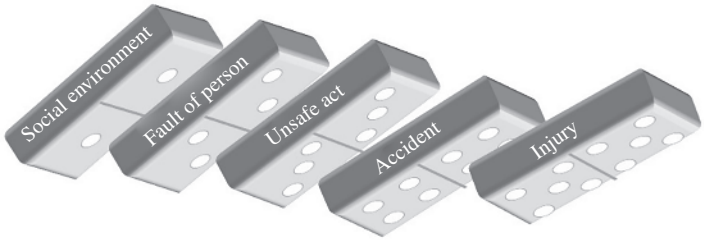

Figure 1.2 Heinrich's theory of an accident sequence. Source: Redrawn by Ostrom (2022).

in an accident sequence (Figures 1.1 and 1.2) (Heinrich 1931; Heinrich, Peterson, and Roos 1980). The social environment in this case is associated with the culture the worker grew up in. Included in this were what Heinrich called, ancestry traits, like stubbornness, greed, and recklessness. The other four dominos in sequence were fault of person (personal traits), unsafe acts/mechanical issues/facility, accident, and injury/property damage. If a domino is removed, then the accident sequence is stopped. This theory is now 90-plus years old and focuses on the inherent traits of the person, instead of all the other cultural influences on safety, within an organization. However, his theory does support the concept that accidents occur because of a sequence of events (Figure 1.3).

Heinrich's accident process is:

1. The environment is where and how a person was raised and educated, therefore the culture of his upbringing.
2. Faults of persons are inherited or acquired because of their social environment or acquired by ancestry.
3. Personal and mechanical hazards exist only through the fault of careless persons or poorly designed or improperly maintained equipment.
4. An accident occurs only because of a personal or mechanical hazards.
5. A personal injury (the final domino) occurs only because of an accident.

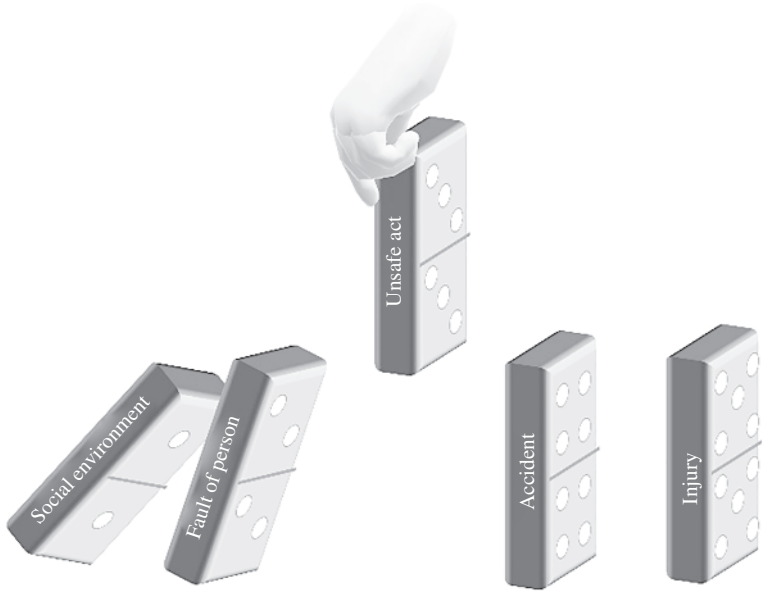

Figure 1.3 Removing a domino in the sequence. Source: Redrawn by Ostrom (2022).

Heinrich believed that the unsafe act or mechanical/physical hazard should be examined and corrected first to be able to prevent accidents.

A major development in the accident causation process by Heinrich is that an accident is any unplanned, uncontrolled event that could result in personal injury or property damage. For example, if a person gets their hand caught in a piece of equipment an accident has occurred even if no injury resulted. Heinrich developed the initial accident hierarchy triangle (Figure 1.4). This triangle shows his idea of how many near miss accidents there were (300) to minor injury accidents (29) to major injury accidents/deaths (1).

Frank Bird (Bird and Germain 1996) modified the dominos to reflect his theory of accident causation in the late 1960s and early 1970s (Figure 1.5). His ratio of near miss accidents to incidents to serious incidents to accidents is shown in Figure 1.6.

Bird's theory was that accidents occur because of:

1. Lack of management control or oversight
   The items he felt management should control are planning, organizing, directing, controlling, and coordinating, job analysis, personal communication, selection and training, "standards" in each work activity identified measuring performance by standards and correcting performance by improving the existing program.

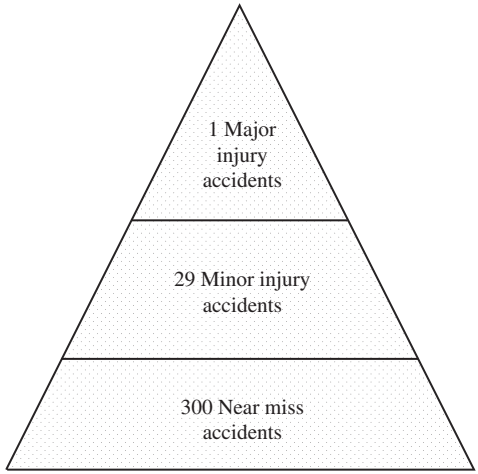

Figure 1.4 Heinrich's triangle. Source: Redrawn by Ostrom (2022).

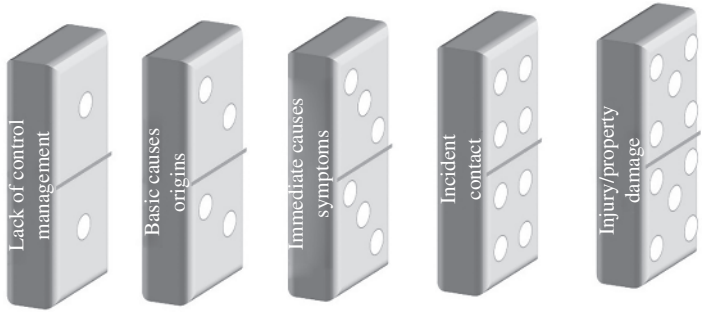

Figure 1.5 Frank Bird's theory of accident causation. Source: Ostrom (2022).

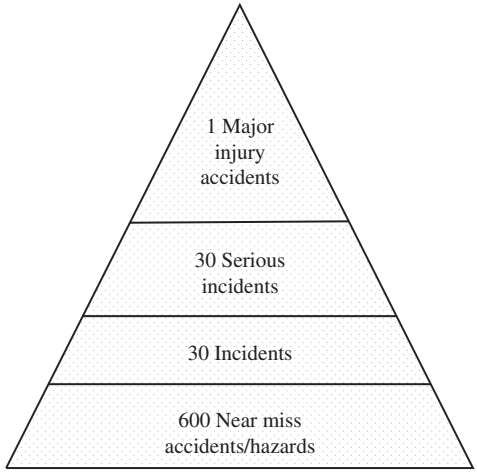

Figure 1.6 Frank Bird's accident triangle. Source: Redrawn by Ostrom (2022).

2. Origins or basic causes
   The origins fall into two categories:
   Personal factors include lack of knowledge or skill, improper motivation and physical or mental problems.
   Job factors include inadequate work standards, design, maintenance, purchasing standards, abnormal usage, and others.
   These basic causes and conditions and failure to identify them permit the second domino to fall. This initiates the possibility of further chain reaction.
3. Immediate causes
   Immediate causes are only symptoms of the underlying problems in an organization. These underlying conditions manifest in unsafe acts and unsafe conditions.
4. Accident
   The accident results because of the unsafe acts or conditions. There are ways to mitigate the results of unsafe acts and conditions using personal protective equipment, for example.
5. Injury/damage
   Injury is the most important item of loss and second, comes property damage.

The Swiss cheese model of accident causation was developed by James Reason (1990, 1997). Figure 1.7 shows a depiction of the model.

In the Swiss cheese model defenses, barriers, and safeguards are integral to ensuring the safety of a system. Modern complex systems have many defensive layers. These include engineered components like alarms, physical barriers, automatic shutdowns, and interlocks. Other controls rely on the human. These are the key operating personnel in the system and include operators, pilots, medical personnel, and maintenance personnel. Procedures and other administrative control are also an important component of safety.

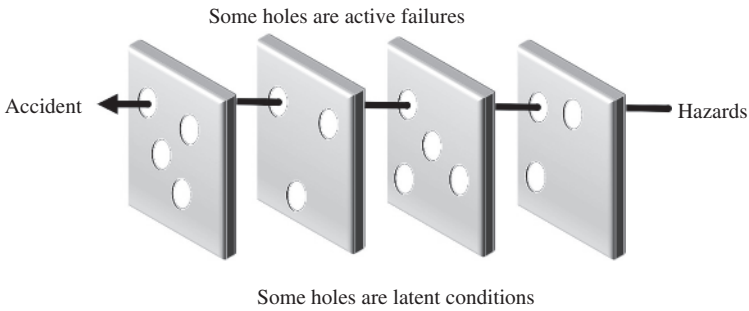

Figure 1.7 James Reason's Swiss cheese model. Source: Redrawn by Ostrom (2022).

As Reason explains; "In an ideal world each defensive layer would be intact. However, they are more like slices of Swiss cheese, having many holes – though unlike in the cheese, these holes are continually opening, shutting, and shifting their location. The presence of holes in anyone "slice" does not normally cause a bad outcome. Usually, this can happen only when the holes in many layers momentarily line up to permit a trajectory of accident opportunity, bringing hazards into damaging contact with victims."

The holes in the defenses, according to Reason, come about for two reasons: active failures and latent conditions. Adverse events involve a combination of these two sets of factors.

Active failures are the unsafe acts committed by people. Unsafe acts include slips, lapses, fumbles, mistakes, and procedural violations. These types of failures have their influence on defenses for a short period of time.

Latent conditions are those that, as the name implies, are hidden in a system until a set of conditions occur that triggers this type of failure to manifest itself. These types of conditions are, for example, faulty protection systems, untested interlocks that are faulty, or faulty design or construction. The fall of the Champlain Tower collapse in June of 2021 was probably due to unrepaired structural damage, or latent failures. They can also be personnel issues like overworked important employees, time pressure, or inadequate equipment. The COVID-19 epidemic has caused health care workers to experience great amounts of stress that could lead to being a latent condition.

The point of this model is that there are holes in the defenses all the time and if the conditions line up an accident can happen.

The accident causation models discussed earlier are considered Simple Linear or Complex Linear (Safeopedia 2017). That is that accidents are a culmination of a series of events or circumstances. There is a sequential interaction of events. An event occurs and his leads to the next event. Heinrich's Domino Theory (1931) is the classic example. As shown earlier, the sequence is broken by removing one of the events the disaster will be avoided.

Complex Linear presumes that accidents are the result of a combination of latent hazards and unsafe acts that continue to happen in a sequential way. The model considers a variety of factors that include the environmental as well as organizational effects. The application of the model enables the set-up of safety barriers and defenses along the timeline of the events (contributing factors). The Swiss cheese model is considered Complex Linear (Reason 1990, 1997).

Complex non-linear accidents are the results of a combination of mutually interacting variables occurring in real world environments (Safeopedia 2017). These models seek to understand the interactions through careful analysis. A systemic model focuses on interactions and functions of the system rather than just individual events. Accidents are regarded as emergent rather than resultant phenomena.

Hollangel and Örjan (2004) and Hollangel (2012) FRAM (Functional Resonance Accident Model) is an example of a complex non-linear accident causation model. This is a very complex model. Hollangel's idea is that in a system there are numerous interactions between components and systems. Instead of being a linear sequence of events, one activity/event can influence one or more of the other activities/events. A path can lead to success or failure depending on the variability in the activities/events. An accident can be caused by the variability in the system. The variability is a result of the variable and different conditions, group interactions, resources allocation, time available, control functions, and many more possibilities. Hollangel describes resonance of a system as a function of an activity/events' variability. This means that if its variability is unusually high then there could be consequences spreading dynamically to the other functions of the system through not necessarily identifiable couplings. FRAM enables a better understanding of a socio-technical system, by avoiding decomposing the system into smaller components and characteristics. The process itself forces questioning rather than finding straight clear answers, as it does not include the typical cause-effect models. The process is time consuming and requires the accident analyst to do "what-iffing" to develop the best model of an accident. Figures 1.8 and 1.9 show the basic unit of the FRAM model and an example of a possible connection.

Risk assessment techniques can also be used to develop accident sequence models as well. Please consult Ostrom and Wilhelmsen (2019) for further information.

We developed a risk model of aircraft inspection, factoring in the safety culture of the maintenance and inspection organization. The complete article is found at Ostrom and Wilhelmsen (2015). This work was performed as part of a NASA sponsored study on the risk factors associated with aircraft inspection. The basic inspection model is represented in Figure 1.10. DVI is detailed visual inspection and GVI is general visual inspection. As the names imply, a DVI is a much more detailed examination of an aircraft part and a GVI is more of a walk by examination of an aircraft.

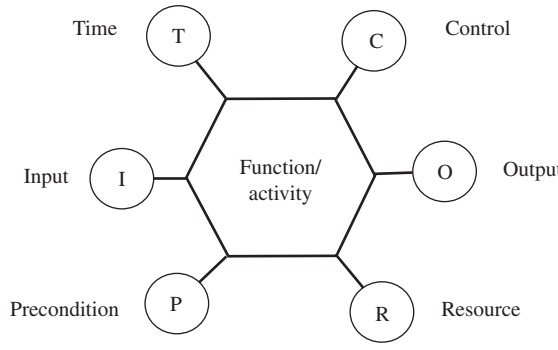

Figure 1.8 Basic unit of the FRAM model. Source: Redrawn by Ostrom (2022).

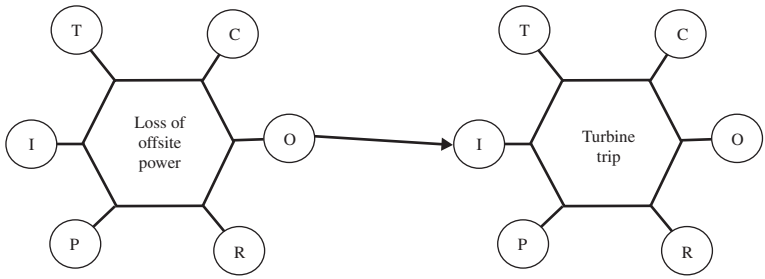

Figure 1.9 Example connection in a FRAM model. Source: Redrawn by Ostrom (2022).

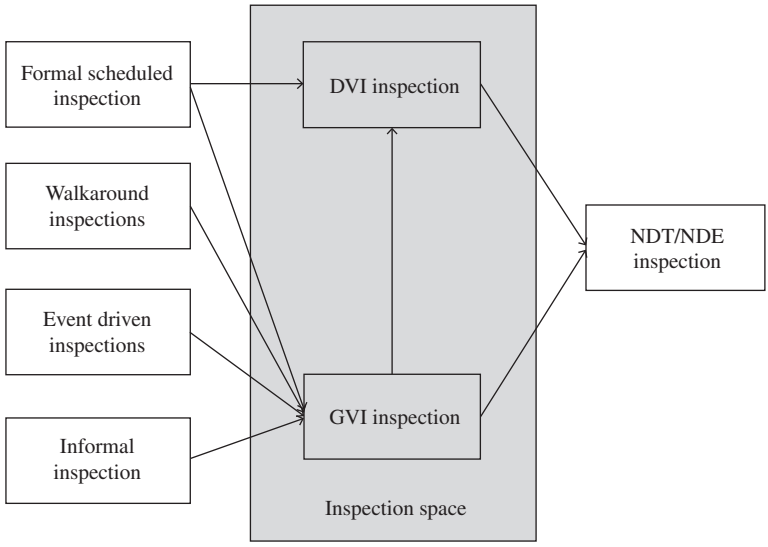

Figure 1.10 Representation of the aircraft inspection process. Source: Ostrom and Wilhelmsen (2015).

Depending on the results of a GVI or DVI a non-destructive examination (NDE) technique will be used to determine if an anomaly in an aircraft part is truly damage. Many factors contribute to the success of failure of the inspection process.

These factors reside in the physical condition of the inspector, conditions of the inspection event, nature of the anomalies, process parameters, and organizational system. These factors are normally called performance shaping factors (PSFs) in the risk assessment and human factors domains.

During the study we developed a risk framework of the inspection process. A risk framework is basically the context in which safety/risk is considered for a system and/or organization. Several different alternatives for depicting the risk

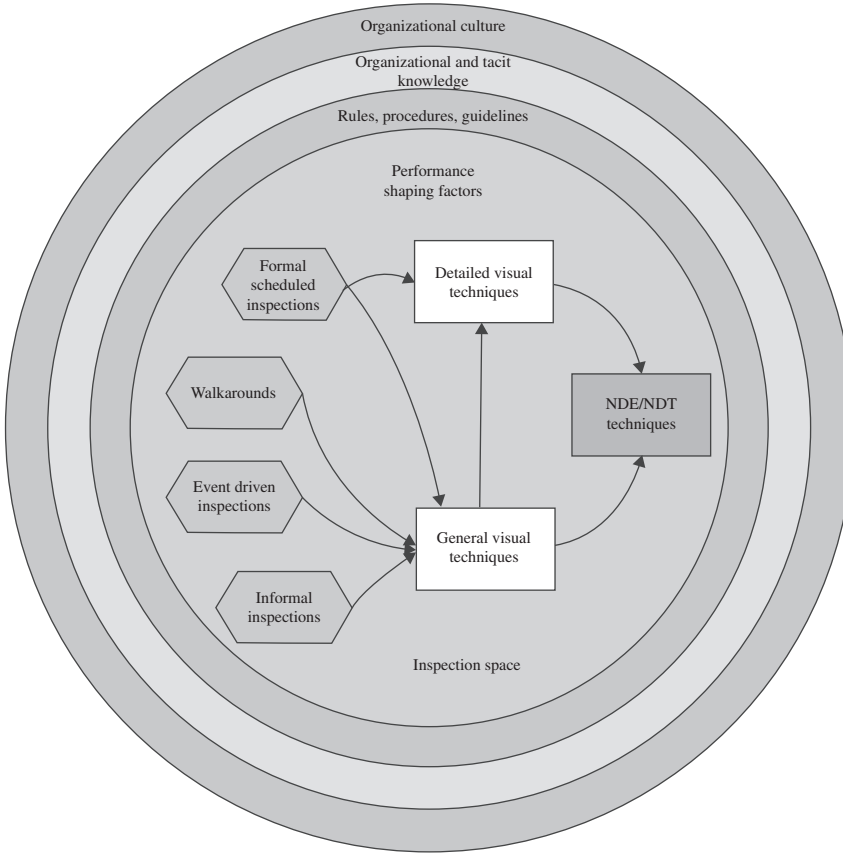

Figure 1.11 Inspection risk framework. Source: Ostrom and Wilhelmsen (2015).

framework for visual inspection were considered. Figure 1.11 shows our final depiction.

The overarching factor in this depiction is the organizational culture. In this framework, there are four generalized entry points into the visual inspection space. These include the following: formal scheduled inspections, walk-around inspections, event driven inspections, and informal inspections. As the graphic depicts, we found that the organizational factors were the overriding contributor to success or failure of the inspection process.

1.4 Safety and Common Sense

I recently was required to take safety training so I can have easier access to the Center for Advanced Energy Studies (CAES) building, which is absolutely a

great policy. However, a term that was used was that certain aspects of safety were "Common Sense." I don't believe safety is common sense. In fact, I don't believe in the concept of common sense at all. As discussed in the Section 1.1 in the first few pages of this chapter, I brought up the fact that preparing a rabbit for eating if someone hasn't done it before, is an alien concept. It isn't common sense. As Mark Woodward says in his podcast, if he hands a loaded shotgun to his 13-year-old son without instruction, does his son have the common sense to operate it without instruction (Woodward 2018)? This goes for operating tools, using safety equipment properly, not to mention complex systems like flying airplanes, operating nuclear power plants, etc. I will always remember being called by the front gate security at the PPG chemical plant I worked at in the early 1980s and told a tank truck driver was delivering a load of chemicals and he refused to take an escape respirator. Anyone who worked or entered our plant was required to carry an escape respirator. So, I hiked down to the gate and told the driver I would have to accompany him into the plant if he wouldn't take an escape respirator. He told me he had a respirator and showed me a half-face piece cartridge respirator. However, it had dust purification cartridges. I told him it wasn't acceptable, and he needed one of ours. He refused and, so, I followed him to the point where he had to unload the chemicals. The driver got out of the truck, and I noticed the respirator was hanging upside down on his neck by the bottom strap. I asked him if he knew how to use it. He proceeded to put the respirator up to his face, with the chin cup over his nose and the nose cup over the chin. So, while the operators hooked up the truck to the storage tank, I stood by in the event there was a release, with an extra escape respirator, because the driver obviously had the common sense to know how to use his dust cartridge respirator correctly. Yes, that is sarcasm.

Safety is not common sense. All workers, whether 12-year-old mowing lawns, undergraduate students in chemistry labs, graduate students in nuclear labs, new skilled trade workers, office workers, and engineers must have training and education on how to work safely. This includes people in their homes standing on chairs to reach top shelves or to water plants. Remember, a 6-ft fall can kill a person.

Organizations must not rely on "common sense" to form the basis of their safety culture. They must develop their safety cultures with sound safety management.

1.5 Interviews with Safety Professionals

Five people/organizations were interviewed or supplied information on five questions concerning safety culture. The five questions were:

1. How do you define safety culture?
2. How does safety culture impact the operation of your facility/company/oversight function?

3. Describe an incident/accident that a negative safety culture impacted the outcome.
4. Describe an incident where a positive safety culture has prevented a catastrophe.
5. How does your organization assess safety culture?

The five professionals/organizations were:

- Ron Farris – Human Performance Specialist
- Shane Bush – Human Performance Specialist
- Lt Donald Olsen – US Navy
- Leif Åström – Former Wing Commander, Swedish Air Force
- United States Nuclear Regulatory Agency

The interviews were recorded using Zoom and the Dictate tool on Microsoft Word. Efforts were made to edit double words, vocalizations like um and ah from these interviews. However, the interviews for the most part are in the words and phrases of the interviewees. The information that was supplied by the other people/organizations are exactly as provided.

Ronald Farris, Consultant

Mr. Farris is a co-author of the book; Critical Steps: Managing What Must Go Right in High-Risk Operations, CRC Press, 2022, By Tony Muschara, Ron Farris, Jim Marinus.

1. **How do you define safety culture?**
   The collective behaviors of the organization, good or bad, that produce the work outcomes.
2. **How does safety culture impact the operation of your facility/company/oversight function?**
   I am a consultant that works with numerous high-risk industry partners in support of improving organizational performance and safety improvement. For me culture is something that directly impacts these organizations' bottom line. It is always difficult to measure the current safety culture as the workforce is not static, that is, people come and go on a regular basis. Additionally, leaders are always changing from frontline supervisors clear up to the top leader. This constant state of change means that if you measure safety culture, what you get is a result that is not the current safety culture. In other words, it is a lagging indicator of the current state not the actual one.
   As for the impact on operations, I believe that collective behaviors directly impact work outcomes. My simple perspective based on my military and

(Continued)

(Continued)

civilian experience is simple. Leaders set standards and expectation, how these standards and expectations are enforced and reinforced by front-line leaders (foreman, crew-chiefs, supervisors, and frontline-managers), creates the culture of performance, and this culture creates the work outcomes.

3. **Describe an incident/accident that a negative safety culture impacted the outcome.**
   As a consultant I will provide an example of a near death accident that was experienced by a petrochemical client. The safety culture at this refinery was one of accepting the unacceptable. The unacceptable was obvious in that there were numerous housekeeping issues such as tools and debris strewn about in the production areas, numerous tripping hazards in the facility, and there were obvious OSHA infractions such as missing or dangerous handrails. When I got a tour to go see the location of the accident, nobody seemed to notice the issues except me and the corporate safety director. The accident was straight forward. At the top of a platform that was about 10 ft off the ground an operator fell backwards after losing their balance, fell backwards, landing on the concrete floor. The individual sustained bruises and contusions but had come within inches of their head hitting a concrete support that had a sharp corner. The accident was a result of the individual having to use an inadequate fixed ladder that lacked either fixed siderails at the landing and or a cage.
4. **Describe an incident where a positive safety culture has prevented a catastrophe.**
   This is a tough one, but I will use an example of what we teach organizations to do to proactively prevent incidents. When organizations are proactively seeking to prevent incidents with consistency, they have a good safety culture. As a consultant I want organization to consciously seek out landmines, report them, and resolve them. A landmine defined: A metaphor for an undetected hazardous condition in the workplace that is poised to trigger harm. A workplace condition that increases the potential for an uncontrolled transfer of energy, matter, or information with one action – an unexpected source of harm – unbeknownst to the performer. Includes compromised or missing defenses; also known as an "accident waiting to happen."
   As a consultant I teach organizations to identify a variety of visual cues that something is not right such as landmines (latent conditions) and to respond by calling a STOP-Work and to seek technical help. A strong safety culture is one that instills "Mindfulness" and a healthy "sense of unease,"

that produce recognition and control of landmines. Formal prework discussion prime front-line workers to expect and detect landmines. Often what I find is that if these landmines are not promptly corrected, become workarounds.

I believe that latent error prevention that creates these latent conditions is not the objective of organizational leaders, rather it is their responsibility to identify and correct the latent conditions left behind. In his book, Human Error, Dr. James Reason says, that "it is neither efficient nor effective to prevent "latent errors," but to quickly find and detect the unsafe outcomes of these errors." "Latent conditions accumulate everywhere within an organization and pose an ongoing threat to safety."

5. **How does your organization assess safety culture?**

   As a consultant in a company that starts with assessing reliability, our assessment includes safety culture. We typically measure the following:

   - Culture surveys (what people think/believe)
   - Number of work-arounds present
   - Number of deferred maintenance items
   - Leadership field presence (top to frontline leaders)
   - Number of STOP Work used by workforce
   - Near Misses fully investigated (free lessons treated like an actual incident)
   - Formalized use of error detection/prevention techniques
   - Work Instruction adherence (Standard Operating Procedures and Maintenance Instructions)
   - Use of Defense-In-Depth approach to protect assets from built-in hazards
   - Presence of formal pre-work discussions (prejob briefings, huddles, etc.) prior to work activities

Shane Bush – Human Performance Professional

1. **How do you define safety culture?**

   In consulting I'd always been told that a safety culture is the accumulation of behaviors right. It's the accumulation of behaviors of the workers and the management, just basically anybody in the way they're exhibited.

   I still believe that to be true. I still believe that a safety culture is defined by what you see in what you hear, which takes me back to the definition of a behavior.

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I also learned early on, through behavior-based safety and other theories that behaviors can quite often be described as anything you see or hear. So, if that's a behavior you want to know how your culture is doing, then you look at the behaviors being exhibited within that culture. That culture is the accumulation of all the behaviors. Now having said that, we have grown so much over the last several years at least in my experiences working with so many companies, big name companies that the culture has also got a lot of hidden parts of it. So, I think in addition to what you see and what you hear there's the unwritten rules as we sometimes describe it, or there's what I say but not what I do kind of messages or the opposite probably.

I think culture is something that we will continue to learn more and more about and define more and more. I think we tried to keep it simple.

I believe that it's just too difficult to keep the idea of culture simple, that there's too many attributes that have to come in for a culture to work.

2. **How does safety culture impact the operation of your facility/company/oversight function?**

There's the unwritten or the behind the doors talked about topics that drives a culture as well. So, again, I believe that culture still is described as what you see in what you experienced there, but I also believe now that there are many things that are very difficult to measure that can, if not drive a culture heavily, influence the culture.

I've been given permission to use some names and some examples but obviously I've signed documents where some stuff I can't share. From my experience and just for a reminder to you in the human performance consulting I do for the audience, it is obviously dealing with human error and human fallibility. Human error and human fallibility occur in many more areas that just safety.

Having said that, there's no doubt in all my years of what I currently am doing, and, for that matter, my whole career in safety has always been a topic that is universal.

It doesn't matter whether I'm going into Disney World, it doesn't matter whether I'm going to Cirque du Soleil, going for food, to do we government or non-government, safety is the number one topic.

As an example, with human performance, then they realize that it's much bigger than just safety it's a business initiative.

But safety is such a cornerstone part of any business that without a good safety culture. I don't care how good of a product you produce. I don't care how well you've done in improving it.

If safety is not at the competitive levels of either your peers, or what is expected. It will eventually affect your business period.
That is why so many companies in my opinion, spend so much time on safety is because, one, it's a building block that I to have as best as I can and then we learned so much and safety, because a lot of people realize it really needs to be a business initiative. I think the first relationship, we made with company components was quality, safety and quality have to be hand in hand, without safe you don't have good quality without good quality don't have good safety, W we spent years talking about that. And then it just basically moved into production and moved into I mean, even in six sigma and lean manufacturing and all these other product process improvement initiatives that are out there, they still come back and want to reevaluate. To have the improvements we've suggested hindered or caused any sort of harm to our safety or safety culture.
I don't see any day ever in the future in which safety is not a number one subject or a priority, which course when you, when you learn about safety with some of the behavior list they'll say, safety can't be a priority safety has to be a value.
Right. We've heard that a lot and practice priorities change and priorities, switch.
But values are always the same. One example and this is what I can talk about because it's open, and it's a well-known example is at the Idaho National Laboratory (INL), this has been years ago so this activity involves previous contractors. Many people are unaware that we have Three Mile Island (Nuclear Power Plant) (damaged) fuel at the INL, and we had to move it from one location to another. It involves taking it, I believe it was in in stored in water, to begin with but anyway it was in one facility, but it had to go to dry storage,
I know that it ended up at one of our facilities and dry storage.
So, we called it a campaign, and it was about a six-month campaign, the beginning to the end we planned around this we're going to do it in six months.
As a lab, we're ahead of schedule and under budget. Bonuses were being talked about etc. Corporate then came in and they looked at the safety statistics what they could look at the time which is your typical total recordable case rate, daily case rate, the stuff that quite often comes up.
And for this given organization that had again. Come in, ahead of schedule under budget, their safety statistics were almost twice in the negative way,

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twice as bad as the regular company average, and the actual corporate said their words not mine, that we would consider this an overall failure.

Because even though you came in ahead of schedule and under budget, and we didn't really have any big safety incidents. There were numerous indicators that we easily could have had a major incident. This was my first impression that corporations really understood the importance of safety and then of course you get into the big events like you had with the Deepwater Horizon, where you have potential of management going to jail because of safety.

This takes it to a whole other level. Maybe not for the right reason, maybe they're doing it because they don't want to go to jail but at least they're doing it right.

I see safety will always be the foundation, no matter what approval processes, whether it's voluntary Protection Program (VPP), whether it's integrated safety management system, or for process improvements, it'll always be a foundation block that we absolutely need to continually improve and there's been some companies that have done wonderful in improving their safety cultures and seeing great benefits.

One other quick example I want to give you. When we implemented the VPP at the INL I was a part of the core team, my specific assignment was teaching management the different principles of VPP. One of the things that we did specifically talk about was how do we, if we're going to grow a culture at the INL, how are we going to get the subcontractors up to speed. How do we get the subcontractors to take on that same culture?

We actually got approval eventually that subcontractor could not even bid on a job at the INL unless they met certain criteria, they were having safety meetings they were talking about hazard analysis, they were reinforcing the use of VPP all the things we find routine today.

It was the solid companies that really had good programs that were extremely thankful because they were trying to compete with fly by night companies that were really skimming and cutting corners.

So, once again, safety came back to not only address safety, but now you had to be good performer in all areas in order to have the resources to compete with companies that are required to be at a certain level in certain performance criteria.

I thought that was a good example of how you can take safety and get a lot higher caliber subcontractor or workers or whatever, by what you reward and what you don't reward.

3. **Describe an incident/accident that a negative safety culture impacted the outcome.**

   One that I actually, and again I have to be careful what I say here but I was working with a company in Montana I can't tell you the company's name, but involves a bunch of linemen.

   And these linemen, for whatever reason, they had been picked up by a company to do a documentary on them.

   And the documentary meant that they were followed for a couple of weeks with cameras and lights and all sorts of stuff.

   So my involvement obviously came after the incident or the accident, but to kind of set it up, they had a call out one evening in which they had to go out and replace what's called an H structure, which basically means two poles one cross member it looks like an H, and they videoed it from numerous corners like I mentioned, it was at night.

   They had floodlights on and they were replacing a rotted power pole. A worker grabbed it with a great big grappler, a great big tool that can hold it. They disassembled all the lines and everything on it. Then that person takes that pole and lays it down. Grabs the new poll and he or she holds it in place while they fasten the lines and the cross member, etc.

   SA little bit of context here is important, you're outside it's blowing. It wasn't deep winter, but it was cold weather, so you're not going to verbally be able to hear each other so the workers usually communicate with sign language. They have sign language, the universal with that field or that particular industry. But what the person is supposed to do is take that pole hold it, and then someone on the ground chokes it off with a chain in a smaller little hand driven crane that they can actually take the weight off of it. That person up there can loosen their grip because they really can't go up and down very easy, it's too big of machinery, but they loosen their grip and then the person down below, actually lowers the pole down into the hole and then they do all their work on the ground.

   Over time there is system drift or process drift. They quit confirming with sign language what they were doing because they can visually see each other and they just figured; well I can see that they're doing so why do I need them to confirm something I can visually see. So, on this day the person at the bottom chokes it off and walks away and the person up top assumes good to go.

   Unbeknown to him, the person at the bottom hadn't completely choked it off. I think they call it a turn buckle, that you put through the chain and then you could pull it.

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As he was walking away when the person up top loosens their grip the pole completely went out of their control and fell directly on the top of the employee and killed him instantaneous.

By the way, another side note here is when I interviewed the CEO of the company; he talked about the difficulty of visiting a wife and two kids and explaining why their father is not going to go home because of something as simple as communication.

I have found is the absolute number one source of errors and mistakes that result to unwanted outcomes, especially safety communicating it might be verbal nonverbal and one thing we have taught since this incident was communicate.

One thing we have taught since this incident was to communicate your intent and what we call critical risk important steps. Communicate your intent. In other words, if either one of them had communicated they wouldn't be dead

The person up on the pole got their attention says I'm going to loosen the grip. There's no doubt the guy on the ground would have said hold the pole (Shane crossing his arms over his chest) which is a universal sign for stop what you're doing. A worker might indicate that he is getting ready to leave or not done, whatever that language is. It's so sad that we have such significant catastrophic outcomes, where a simple tool, if they continue to use it, could have prevented it and to be home safely.

It is all about your willingness of being diligent because we use it for a while, whatever it is we get a new tool, we get a new process, we use it for a while, we kind of get a little bit lazy. Honestly, the one other thing that I have found is, I am totally convinced, that no matter how much training you give people, no matter how much you talk about defenses or controls or hazards, everybody does real time hazard assessment in your head. You know the rules you know the requirements, but you will look at something, and you'll immediately start running rationalizations it in your head as to why you do or don't need to do something this time, or why you can do something this time that you don't normally do. This real time rationalization of hazard control I think is a huge thing that needs to still be dealt with.

What a sad story. What a sad story that could have prevented with one small communication tool.

There's no such thing as common sense. There's a book out there that says that there's no such thing as common sense, common sense to you is absolutely going to be different or interpret different than me. That's your point

is that it is such a personal thing that it does not exist. I totally agree 100% it doesn't exist. And by the way, there's another book out there that I can't remember the title of, but it talks about there's no such thing as a routine task. There's no such thing. All you have to do is change how much sleep the worker got from one night to the next and the task is different, or you got to do is change the fact that you and your spouse had an argument.
The task is different. So, there's no such thing as a routine task and there's no such thing as common sense. And the more we understand that the more we can deal with this real time hazard assessment that we tend to do as human beings.
So, again, you've kind of talked about this but describe an incident where a positive safety culture of preventative out a catastrophe. I'll let me give you a really good one, and this one again, I can talk about.
So, as again you may be aware, I am, or was I was getting ready to leave my current job, but I was asked four years ago to get the Human Performance Improvement (HPI) program back up and, and we're calling it a reinvigoration of HPI at the INL.
There are three categories that we're always looking at simultaneously always and its safety mission, interruption, and physical damage.
So, if there's anything that an error or mistake or misinterpretation, if it happened could result in a safety incident.
Mission interruption which is kind of a catch all phrase involving reputation as you reputation of the lab and or physical damage to something you hold a value, we're going to concentrate on those steps.
So having said that, we have a biofuels test apparatus where they take these biofuel experiments and the containment that they put them in. The lid weighs, I have to guess about a ton.
They have a lifting device that looks like a forklift but it's a tele-handler if you're familiar with the tale-handler. It not only can go up and down, but it can go in and out and it can even tilt.
They were going in and using this tele-handler. A little bit of context here is important when they actually installed the tele-handler, they had to install it high above the deck because of all the equipment in the way. So, the straps are quite long. That is going to play into this. So you got straps coming down X feet, they hooked to the lid. Every time the lid is either lifted, or lowered, workers have to be out 25-ft radius away.
This has been the practice for seven or eight years.
One day, this was about two years ago, they're doing the job.

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What they were doing in this case as they lifted up and they had replaced the experiment successfully. Now they're ready to lower it back down, which is about a 3-ft drop is a better way to say it.

Now, all the workers go out 25 ft.

As this thing is lowering, where do you think all the workers' attention is on this lid, on the tele-handler, on the experiment, where are we looking? I'm looking at the experiment. Right, so nobody's paying attention to anything but the experiment, which is how it has always been. And as they're watching it, everything is looking normal because it's coming down; unbeknown to them the tele-handler has two levers side by side; they are co-located and look the same. One lifts the tines up and down; the other level tilts the tines. The operator accidentally grabbed the wrong one and started tilting the tines, which gave us the exact same immediate action it lowered it, but it tilted it to such a level that the whole lid slid off of this tines and boom, it came crashing down.

Now, we actually had a huge safety celebration that day. Management actually had a safety celebration that day because for seven years, it finally paid off to have workers stand back 25 ft.

But remember our second category mission interruption. Did we celebrate mission interruption? No, because now we were behind schedule and had equipment damage. So, two of our three things, but from safety was concerned, we celebrated safety.

One thing that we've started to do is you really need to look at the different components of a job or an activity and separate safety from all the other stuff.

And if the other stuff doesn't go well, address it accordingly. But if the safety components go well, you need to celebrate that so you still get the continued behavior you want.

When we talk about resiliency and again what I'm about to share with you I presented a national conference and now I've got people using it everywhere with a lot of really good feedback on how it has helped him in just about everything and anything (Boyce et al. 2020)

They've been doing related to looking at the potential of an unwanted outcome mind you related to human error and human fallibility, but it's just continuing to cross into the organizational performance etc.

So basically, this is how the resiliency tool works (Figure 1.12). If you take any activity, doesn't matter what the activity is and the pictures are intended to, to help with examples, in this case, obviously a railroad crossing.

Figure 1.12 Concept of resiliency. Source: Shane Bush.

But if you look at the pictures what they're intended to do is give you an idea on how resilient you are.

And again, this could be safety so if you're in a number one it depends on people not making errors regardless of knowledge, skills, and abilities. Low resiliency because we know people now remember we're talking critical and risk important steps, not everything or you're going to go broke. But number two if you provide them at least with a job aid or a checklist or label or sign. You've increased the resiliency and then three safety tools for temporary bound us five you engineer that now is this related to the, to the hierarchy of controls. Yes, but it's specific to human error and human fallibility. What we have found with this is people are using it.

You may not be aware but we had a job where we actually put out a request for proposal, we granted it to the subcontractor, they came in, they built the building, the prime contractor wrote them a check, and through that whole process we didn't provide the proper details. If you want to piss off management spend millions and not get what you paid for.

Now while that wouldn't fall into a safety thing, the scale absolutely applied, because it was mission interruption.

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Within the last two years we sent out, at least on one occasion, we made an offer to a candidate, who was the wrong candidate because of all the corporate crap and interrupted our process and everything. The wrong candidate accepted it. I don't know how far along they got but it was far enough along of the person selling their house, to quit their job that we're in the middle of a lawsuit.

So, this resilience scaling has really turned out to be a really cool thing.

The other thing that I think is important and this is something that we've really been pushing a lot.

I work with Todd Conklin and have a good explanation of our resilience process. Listen what he says and this is basically our premise right now every time we go out. This is exactly how we approach safety and the private world.

So having said that, do you see Todd on there yet. Yes. Okay. Let's listen to this clip. Just when I started here. Tell me if you can hear him.

> "So really about automobile safety in the 1950s. Back then, the automotive industry said these words, asking drivers to not wreck is not very effective.
>
> It feels like the right thing to say, but it doesn't reduce the number of vehicle accidents.
>
> Our job has to change. And so what they said is, let's assume everybody driving in a car has a chance that they're going to wreck. Because when you deal with uncertain outcomes. You've got to use certain terms. And so what they said is, let's not manage the absence or presence of the failure.
>
> Let's actually manage the cars, ability to handle the failure.
>
> And the idea became that we can actually make cars safer and safer and safer. Now what's interesting is if Industrial Safety were in charge of vehicle safety.
>
> I don't think they could make the claim of zero fatalities.
>
> Because if Industrial Safety were in charge of vehicle safety here's what it would look like in your company, we'd have a program where before you got to drive, you have to take the mandatory don't wreck the car training. And then once a year, you'd have to take the don't wreck refresher class, but that's on the web. So it's pretty easy to take. And then we tell everybody to drive on not wrecking louder and slower. What part of not wrecking did you not hear the last time we did this.

In fact, I'm going to suggest, our target for safety has to change.
I think this is our new definition.
Safety is not the absence of accidents.

This is the theme we use all the time. Now, when we look at a process, we don't look at it as you're well aware for years and years when we go into new companies how healthy is your safety program oh good How do you know, well look at our total recordable rate look at our day with a trade look at our close calls or near misses or whatever and it's like, that tells me nothing and the question is, what did you get that by luck or did you get that because you're good?
What we do now is we go into any system or process help them identify their critical risk important steps, and then help them put the appropriate level of defense in place to catch the air but more importantly reduce the consequences of error at those steps, whether its safety, whether its mission interruption, or whether it's physical damage. I'm telling you, it's amazing because, and then they have to put it on a scaling, they actually have to go in identified the steps, given a scaling of where we're currently at whatever that is. Our guidance and I can even send you the procedure we have because it's only five pages.
The guidance says, take these critical and risk important steps and get the resiliency to as high as reasonably achievable. So, as you probably picked up on we stole the ALARA (As Low As Reasonably Achievable) concept right to as high as reasonably achievable. We just flipped it, and that way they don't feel like, "Oh my gosh, there's no way I can get every step to a five." We're not asking you to just get it to as high as reasonably achievable.
This graph that I showed a second ago is the organization's accountability to get safety to a level, and then the accountability goes to the worker. We've got it in there and by the way we've got a critical step here, and it's relying on pure check to be successful,
It's relying on procedure adherence to be successful it's relying on an independent verification to be successful. So, you've got organizational accountability; get it the best you can.
Then the individual accountability which we absolutely felt was critical in the bar for company leadership to buy into this, because it didn't, we didn't want to make it look like we're handing all the accountability off to the company in this endeavor. We've got to keep that individual accountability, but it comes after we've developed processes to the best we can.
I in fact have my students fill out the exam for getting their certificate for the class I teach. So, I do give them an option go watch the last, what's it

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called Deepwater Horizon. I tell the students go watch it and identify the precursors the critical steps, the performance modes, etc. and write me a report and I'll let you do that if you want you can enjoy a movie.
It's amazing. It's, I mean I've had books sent to me by students.
Every time I hear a story about wannabe rescuers dying in an emergency event, it's like it usually takes three rescuers dying before the realization of a hazardous situation. One goes down, a second person doesn't know what's going on, so they go down and the third by the third person they're kind of thinking, okay there's a pattern here, what is it?
Whether it's confined space problem or whatever, right, or steam. With that seems, by the way, that sounds so familiar to our TES (Thermal Energy Storage) incident, we just had. Are you familiar with our TES incident?
TES is the name of the experiment. It is where they were trying to vent off what they thought was water, but it was hot oil.
The reason that that we came up with that mission interruption term was because there were so many people at my workplace trying to exempt themselves from human performance, you know, it's people who turn valves or people will flip switches and when we start talking about well what about people who get a job offer when they shouldn't worry about contracts you get issued when it shouldn't or what about and QA standards that are met. Again, it usually comes back that human error was a big role. So, I feel so fortunately that again my internal sponsor is very supportive. I must give him credit. He has always been supportive to me.

Lt Donald Olsen – US Navy

1. **How do you define safety culture?**
   Having a culture meaning something, where you're from top to bottom kind of unified on the idea, when it comes to safety for that it goes beyond just having training shows to some extent that the community is holes invested in safety, but it's kind of limited in getting that full investment for everyone, because we have training for so many things. I think kind of dulls the impact of training, but when you hold people accountable, and show that there is that accountability especially at higher levels, that's where we really start to see a lot more investment from people all throughout the ranks oftentimes. We end up holding the lowest guy accountable and that

ends up with people, saying, obviously, the community doesn't really care that much about it, because they were trained by so and so or so and so was in charge when this happened and yet they got a slap on the wrist, whereas this other guy got fired. I've seen good and bad safety culture, and as far as good safety culture goes, it has been best, where that accountability was equal throughout all the ranks.

2. **How does safety culture impact the operation of your facility/company/oversight function?**
   So, for the new clear community in the Navy, we have these watch standing principles. I have these written down, and I don't mess them up, but we've got integrity level of knowledge formality, questioning attitude, procedural compliance, and forceful backup. Each one of these ends up really coming into play, when it comes to having a positive impact on operations through our safety culture for integrity. Having that encouragement of people being open and honest about what happened really has a huge positive impact on safety culture and our ability to operate and correct our mistakes. We don't make repeat errors, whenever a ship has any kind of mishap that incident will end up being very thoroughly investigated. Punitive measures occasionally come into play, but that's usually only, if someone was blatantly negligent or did something maliciously, because we want everyone to be very willing to be open and honest. We don't want people afraid of negative impacts on their career just because they were saying OK, if I did this thing the wrong way, it ended up causing this thing to happen and now this thing is broken, or someone got hurt. We want that discourse to be able to happen uninhibited. So, the repercussions are usually minimal, whenever it comes to someone, who's being open and honest for what they've done. So that what went wrong is as soon as that investigation is done that information is promulgated throughout the entire fleet. This helps not just a single ship being one part of the fleet; it helps not just them to avoid this mistake again, it also helps every other ship that has similar symptoms to not make this the same exist for level of knowledge on that. We really expect even at the lower levels, especially at the lower levels, we want them to be subject matter experts (SMEs), if they're knowledgeable about the system. This has a huge positive impact on their ability to be safe around the system. The more they know about the risks involved and the more they know about how to use the system properly, the less likely we are to run into safety concerns, whenever you're talking about human reliability analysis, you often end up considering the level of expertise of the personnel involved. I've seen that more experienced personnel

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are far safer in operations and people who have that knowledge, then formality and procedural compliance kind of come into play together for this. Having that well written procedure and then going through the formal process of doing the same way every single time really helps you to promote safety. If it worked safely this one time and you, did it this one way, it should work safely doing it every single time, if you stick to what has been done and what is written for you to do, and then with that formality having a formal process not just, when it comes to procedural compliance, but also whenever it comes to things like watch turnover. You want to make sure that you have a set process where the people who are going to be taking the watch being the people, who are going to be on their shift essentially. It's working in shifts, the people who are coming on shift will get full scope of what's going on before they end up taking control of it and that helps set some continuity throughout, and as long as everyone does everything the same way. It makes it easy for someone to step in and then for that questioning attitude. I don't really promote this as much, as it's promoted in the Navy, but having a questioning attitude and being willing to ask the question and actually say, is this safe or is this how we are supposed to do it, that is very highly encouraged and when you look at a lot of major problems that have happened in engineering and in industry over history, a lot of these problems could have been mitigated, if someone had the courage to actually speak up and ask a question. Part of this requires the culture to not have punitive measures for those, who are willing to ask the hard questions and then that forceful backup this concept is where someone is willing to say to step in and say you are not doing this correctly. This is how it should be done now. This often happens when you got supervisors who are talking to subordinates and they're saying, "hey you're not doing this correctly," and that's common place in a lot of workplaces, but what the Navy does an excellent job with is empowering subordinates to be able to do this now. It's still within the military structure. They're still doing it with tact and doing it with a lot of respect in it, but they are the subject the enlisted the lower ranking people are the SMEs meaning, they're the ones who in their area. They should know the most at least from a technical standpoint. Now the officers and the people managing them won't necessarily know quite as much about that they know. Where they are more like a Jack of all trades where they know a little bit about everything in the plant and how it comes together. Let me play empowering those lower ranking people to be able to say, "excuse me Sir, excuse me ma'am." This is what the book says on this. We're not

doing this in accordance with what the book says. I can't comply with that order because as a matter of fact, the book was signed off by and Admiral, who's far higher ranking than the officer who's ordering them to do something. It's not like they're disobeying a lawful order or anything like that, but having that empowerment to give subordinates the ability to raise their hand and say "no we have to do it this way because this is how it's written" is something that has always really helped me and it really helps I think maybe as a whole in making sure that we are as safe as we can be in our operations.

3. **Describe an incident where a positive safety culture has prevented a catastrophe.**
   I can't go into specifics, but I can talk about just generally, what we do in the Navy and how it regularly ends up preventing catastrophe, and this feeds back into that a safety culture aspect. Even at the very lowest level, let's say you've got a brand-new junior sailor. They've just come into the Navy and they're doing their first maintenance item, so they are instructed to do something, let's say as simple as replacing a light bulb and believe it or not yes, we have procedures for replacing light bulbs. They have this maintenance requirement card, or an MRC and they're supposed to go through step by step and at the very beginning of every single MRC no matter how simple it is it's going to have some safety precautions listed up at the top and a part of that is always going to regardless of what it is it will always be referring to some form of the NSTM or Navy service technical manual. You'll have to check me on that one, but it's going to be referring to the safety portions of this and whatever safety portions are applicable to it, but it always at least includes general safety, which has everything from holding onto hand rails, while going down a ladder well which is steep stairwell essentially, and believe it or not a lot of people regularly go down ladder wells without holding on to the hand rails and it's just not worth it, because ships can move unpredictably. If a wave pops up and hits you suddenly, you don't see what's happening you could end up falling or getting hurt. God forbid crashing into something suddenly and, if you're not holding onto something you could get hurt. I've known of several people who have fallen and gotten hurt on ladder wells, but it will also include electrical safety portions and part of this. They do their maintenance, and they replace the light bulb OK. That's a good start and they, hopefully, followed the full procedure and had all their safety equipment together etc. Now we have what's called a spot check, and that's, where a supervisor is going to come and check, that they know how to do the maintenance properly.

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There are several different forms in which this can be done sometimes, it's historical, and you'll have to follow along behind them and check too. They will walk you through what they did in the past, and you'll just see that they knew how to do it, and then sometimes you can actually just watch them actively doing the maintenance, but in almost every single one of these, we as supervisors are encouraged to ask them about some of the specifics, about the safety portions of the NSTM (please define), that they used and now the expectation isn't that they had to read the entire chapter of the NSTM every single time. It's good to make sure that they, at some point, read it, and that they are familiar with what's needed from that, and then whenever it comes to things that are more technical in nature like electrical safety, they better have had that open and actually gone through all of the actual safety precautions, because those are those are steps in air required procedure, but for general safety, you're wanting to make sure, they have a good idea of what's happened now a little bit more on electrical safety; a lot of the incidences that you hear about in the public world and in the military often end up being related to electrical shock, and this can be catastrophic both for the people involved, but it can also damage equipment which on a warfighting platform. That's not good, especially, if you're out to sea and you need to be able to make it back home, so going through all those actual initial voltage verifications and every bit of the checks is extremely important and that is why we very regularly end up having additional supervisors, or will, if for everything on, honestly, we end up having additional supervisors. There is as someone, who's not hands on in it, and they can check and make sure that everything is being done in accordance with the safety requirements.

4. **How does your organization assess safety culture?**
   For assessments, we have a lot of different ways that we do this. I touched a little bit on kind of the lowest level on the last question, where we have the spot checks for maintenance stuff and that's part of the self-policing, that ships are supposed to be able to accomplish, and in order, to make sure, that ships can check themselves doing their own self assessments. We have outside entities come in and investigate them, but I'll touch a little bit more on ship's own self assessments first, so in the new clear community on top of having there are spot checks. We also have audit and surveillance programs. There is a whole lot of reviewing paperwork making sure paperwork is all up to date. Believe it or not that is actually a huge impact on safety for the nuclear side, because if your paperwork

is not correct sometimes, that can be, or if there are errors or not necessarily errors. If there are things that are noticed whenever you reviewing this old historical paperwork, you can end up catching things that weren't originally caught by the operators and you can find problems with the ship before it ends up becoming a bigger problem, and obviously structural integrity, and chemistry controls, and radiological controls. These are all things that can end up causing huge incidences and in problems. You could lose the public's trust in our ability to operate nuclear reactors, if you end up with some of these more severe problems occurring, but we've got these surveillance programs as well where this may not be a the MRC card type maintenance and not the standard maintenance kind of things, but maybe something a little more complex or an operation you could be observing an operation like the startup of a nuclear reactor or something like that. These are going to be experienced personnel to know a lot about that area and then they're going to come in as an observer. They can step in if they need to for the sake of safety, but they're just there for assessment purposes and that's within ships force, and then, if you're working with the shipyard, they're going to have their own civilian entities. They're going to do very similar things for their own personnel and for the ships force, because you're going to have them both working together quite a bit, but then at a higher level, you've got the type commanders. So, a command is going to be underneath the overarching fleet. Let's say the Pacific fleet would have several type commanders, he would have SURFPAC and AIRPAC audit commanders, who were in charge of the surface fleet on the Pacific side or the aviation side of it, which includes aircraft carriers on the Pacific side. These leaders are both administratively and operationally in charge of the individual units, so part of that includes their need to perform assessments, and they've got several entities that can help do this, but you've got like mobile training teams in the float training group. They are two of the biggest examples of assessment teams that will actually go out from ship to ship, no matter where they are in the world they will even fly out to ships on deployment, and then they will do these multi-day sometimes over a week long assessments, where they're doing extremely in depth review of all the administrative stuff, but also checking for our ability to perform operations, and a huge part of what they check is can we notice the same problems. They notice and then we notice a problem, or if they notice a problem first, and we don't notice it until they bring it up how do we correct that and it's looking for the ship's ability to do that self-releasing. I was talking about an issue that's been noted, how quickly

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is that issue communicated and where is that communicated all the way up to the appropriate level, or did it die ahead the at a lower level. It should have this secret and it did end up being held at the divisional level, or did it make it all the way up to the department head and who can then choose whether, or not it's worth the captain's time to know about it and then how did they fix it, how quickly did they fix it, and did they follow procedure, when they fixed it. It just gives them even more that they can observe as you're trying to fix these issues, and a lot of times these end up coming down to operational issues. Someone messes up procedurally and they catch it, if they're looking for obvious. You can't go back in time and fix that, but they're looking for your ability to then promulgate that information out to the relevant people who could also make that same mistake, and how are you doing. We've noted this issue three times in the last couple of weeks, obviously, this is a little more than just on an individual level that people are making mistakes. We're going to train on it as a whole or who knows, maybe, it is just a one-off thing, and just that one individual needs to do a little bit of extra, when it comes to their qualifications or improving their level of knowledge. We call those upgrades, but so sometimes it's as simple as an individual made a mistake because we are humans, and we will make mistakes and that individual just needs to recognize that and then do a little bit of learning on it too. They themselves can avoid repeating that error, then at an even higher level, we have a bigger entity that can end up doing investigations. Like for the nuclear side naval reactors will come out and do big investigations are not necessarily assessments. They'll do a big assessment on ships periodically, and every single ship ends up with an assessment on a regular basis, and these are very much outside entities. If they end up noticing, the ship is not safe to operate, the type of commander also gets in trouble. That encourages the type of commanders to really thoroughly investigate on that lower level, and do very thorough assessments, then that way when naval reactor shows up, they are noticing this ship has significant problems that haven't been addressed by the mobile training teams, and they're making sure that the ship is in fact going to do everything, they need to do to maintain that public trust that we need in order to continue to operate many nuclear reactors right off of some of our busiest ports. It's very important to our national safety and we need to maintain that trust.

Leif Åström – Former Swedish Air Force Wing Commander and Aviation Accident Investigator

The following was derived from a slide presentation provided by Mr. Åström and not an interview (Åström 2019).

Mr. Åström's experiences included:

Swedish Air Force

- **Squadron Commander attack at Air Force Base (AFB) F6** (10 years)
  - "Supplier" in the Command Chain
- **Wing Commander Flying at AFB F6**
  - Operations Commander in war
  - "Customer" in the Command Chain
- **Also worked with:**
  - System Safety Analysis Gripen (Saab)
  - Mid-Life Update of AJ 37/S 37 Viggen ("the AJS-mod")
  - Development of Command/Control/Mission Support System
  - Electronic Warfare system (VMS I) for JAS 39 Gripen
  - Responsible at HQ for Flight Safety JAS 39 Gripen
- **Chef FLSC *(Flygvapnets LuftstridsSimuleringsCentrum)***
  - Combat Training of pilots
  - Tactics Development
  - Weapons and System studies

Private Consultant

- Air Power, EW
- Accident Investigations

Sweden is a relatively small country. The population was approximately 7.8 million people in the 1960s. The current population is 10.4 million. However, it is very technologically and industrially advanced. Before 1990 Sweden had the fourth largest air force in the world. In the 1960s the Swedish Air Force (SAF) had a problem. They lost 215 aircraft and 97 crew members to accidents. This loss was comparable to combat losses in a war.

The SAF knew something needed to be done. The quote provided says: "We cannot continue to crash ourselves away in peacetime, we must do something!"

The SAF blamed the pilots and crews involved in the accidents and it was said the pilots didn't have the "right stuff."

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The SAF conducted a thorough analysis and in the late 1960s they introduced:

- Simulators
- A modern and readily accessible system for submission of Occurrence Reports

The SAF introduced the following changes:

- 1970s:
  - Better Pilot Selection
    - Knowledge tests
    - Psychological tests
    - Medical tests
    - Ability tests
- 1980s:
  - Leadership training:
    - 2-ship and 4-ship leader
    - Squadron commander (including Competence Evaluation)
    - Wing commander
    - Flight training focused on training rather than selection
- 1990s:
  - Simulators
    - Realistic training of dangerous procedures
    - Instructors with dedicated training
- 2000s:
  - Improved simulators
    - Outside world visual system
    - Realistic cockpit motion
    - Networked simulators
  - Dynamic simulator – Fighter jets can operate up to 9-G forces and pilots have to be able to withstand that level of G-force. Figure 1.13 shows the G-force simulator and the results of the testing on the human body.

Figure 1.13 G-force simulator. Source: (i) Courtesy of Sven E Hammarberg.

The SAF developed a "toolbox" to combat the high incidence of mishaps. Figure 1.14 shows the reduction in incidence over time as the changes were implemented.

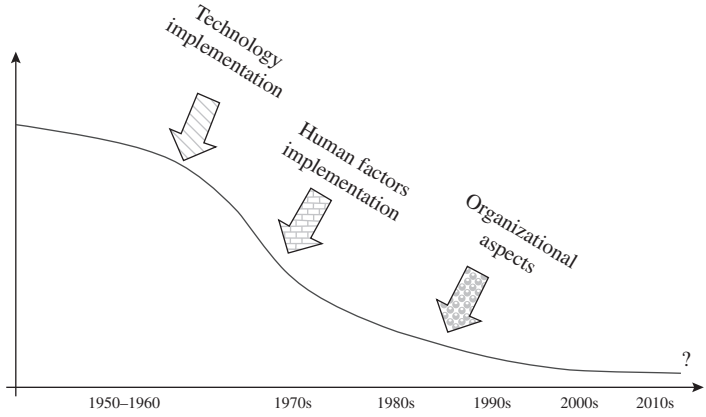

Figure 1.14 Swedish air force incident trend. Source: Åström (2022).

The SAF toolbox contained:

- Technology
  - Reliability of systems
  - System safety analysis of systems
  - Man–machine interaction improvements

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- Human Factors
  Human capabilities and limitations
  - Selection of pilots
  - More focused and better training
  - Better planning and preparations
  - Making use of Lessons Learned
- Organizational aspects
  - Balance tasks – Resources
  - Safety culture of the fighter squadrons
- Continued monitoring
  - Medical evaluations
    - Physician examinations
    - Fitness and circulation testing of pilots
    - G-force tolerance testing over the career of the pilots
  - Knowledge evaluations
  - Ability evaluations
    - Simulator evaluations
    - Live flight exercises
  - Monitoring should be taken seriously because two recent commercial airline events occurred because the pilots possible had mental disorders. These are the Germanwings Flight 9525 in which Andreas Lubitz, the young co-pilot, deliberately crashed a Germanwings airliner into the French Alps on 24 March 2015, killing himself and 149 other people, started flying as a teenager. This was called "suicide by pilot (BBC 2017)."
- Traditional risk management
  - The focus of traditional risk management was on (Figure 1.15)
    - Consequences, direct causes
    - Non-safe actions by operational personnel
    - To not "function safe" is punished
    - Takes care only of identified safety problems
    - *WHAT? WHEN? WHO?* But not always *HOW? WHY?*
- Swedish Air Force took the attitude that
  - "If we know about incidents, we can avoid accidents"
    - Let us monitor and correct less serious occurrences
    - In that way we can discover and correct serious problems
    - Occurrence management was implemented that reports were easier to enter and information was easier to access.

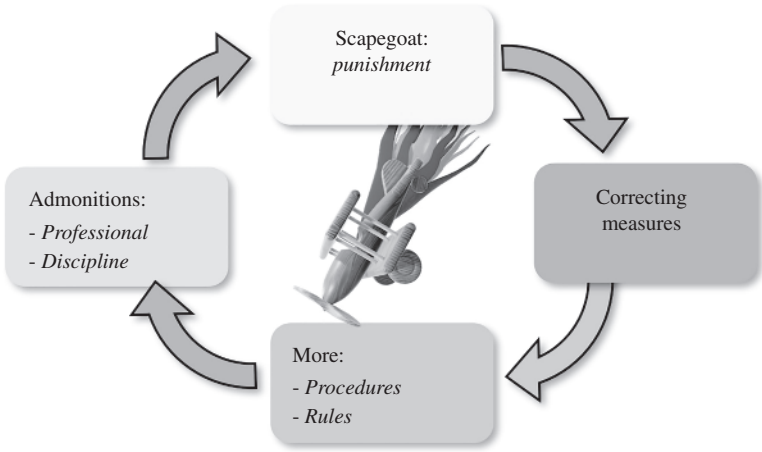
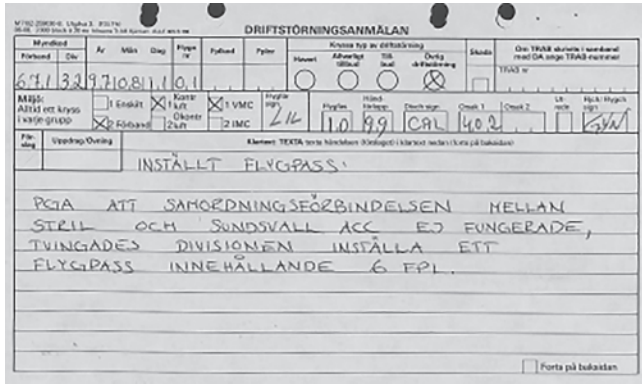


Figure 1.15 Traditional risk management. Source: Redrawn by Ostrom (2022).


DRIFTSTÖRNINGSANMÄLAN

INSTÄLLT FLYGPASS:

PGA ATT SAMORDNINGSFÖRBINDELSEN MELLAN STRIL OCH SUNDSVALL ACC EJ FUNGERADE, TVINGADES DIVISIONEN INSTÄLLA ETT FLYGPASS INNEHÅLLANDE 6 FPL.

Figure 1.16 Example occurrence report form. Source: Åström (2022).

- Figure 1.16 is an example of an occurrence report. Note it is in Swedish.
- The SAF established a system for Occurrence Reports
  - In service since the late 1960s
  - An open and honest system – No punishment
  - Methodically structured, computerized and continuously developed
  - Data base today, comprising more than 100,000 reports
  - About 4000 reports are submitted annually from crew members, technicians, fighter controllers, and others

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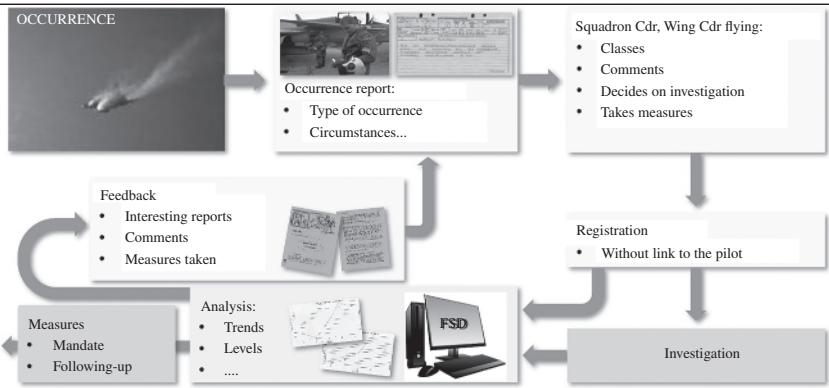

Figure 1.17 Occurrence report system. Source: Åström (2022).

- Figure 1.17 is the occurrence reporting system.
- Open, honest reporting prerequisites:
  - Non-Blame Culture!
- The system must not be used to reprimand involved individuals.

Confidence in the System

- Is built slowly
- Prerequisites that anonymity is possible
- Can be ruined in no time by one person's mistake

No-Blame Culture: Many organizations contend to have no-blame cultures. However, examples of how an organization that claims to have a no-blame culture but then comes down hard on individuals when an incident occurs are not uncommon.

One example is when a fighter experienced a fuel loss during flight:

- While flying suddenly a large quantity of fuel was missing
- The pilot aborted and wrote an Occurrence Report (honest!)
  - "I checked the fuel before start but could not swear on it in this case."
- The AFB Commander: Reprimand the pilot for misconduct!

A dialysis case:

- A nurse unintentionally shut down fluid level alarms and the patient died.
- Shortcomings in equipment design and the equipment was scrapped soon thereafter.
- Court of Appeal: Blamed nurse for other persons death.

- The nurse was particularly blamed, as she had earlier remarked on the shortcomings.
- Could not happen with an open reporting culture.

Occurrence Report

- The pilot/operator is responsible to report deviations:
  - Personal mistakes (errors, breaking clearances, etc.) or potential mistakes
  - Events that have affected flying negatively (technical problems, faulty information, organizational circumstances, etc.)
- To not write an Occurrence Report is
  - An active distancing from the Occurrence Reporting System – Not acceptable!
  - Highly unusual
- Writing an Occurrence Report gives
  - No protection when rules have deliberately been broken, for instance the pilot of the C130 Hercules was banned from flying after breaking clearance rules (Figure 1.18).

Figure 1.18 Pilot flies C130 too low in violation of flight rules. Source: Åström (2022).

- Occurrence Reporting must
  - Be quick and simple
  - Provide analyzable info
    - Showing trends, level alarms, etc.
    - Fundamental for actions

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    - Base for feedback on actions and risks
  - Without actions and feedback the system dies!
- Examples of info in Occurrence Reports
  - Occurrence category
  - Occurrence type
  - Flight phase
  - Cause of occurrence (if obvious):
    - Function
    - Pilot error
- Analyzable statistics requires
  - Thought-out report codes
  - Codes being stable over time
- Analysis can for example provide
  - Trends
  - Level alarms
- Examples:
  - Equipment failures
  - Pilot error
  - Broken clearances
- Feedback to operators
  - Essential for maintained willingness to report!
  - Readily accessible for all concerned personnel!
  - While the occurrences still attract interest…
- Example: Fly Day (FlygDags)
  - Every month
  - Occurrences of the month of special interest
    - Comments from Squadron Cdr/Wing Cdr Flying
    - Comments from HQ Flight Safety Section
    - Measures taken when problems/failures are found
- Examples of failures:
  - False Ground Collision Warning on the JAS39 A/B aircraft. Many reports were given on this problem.
    - Pilots' belief was: "By now they must have got it…"
    - Flight Safety's belief was: "Seems like the problems are solved…"
    - Consequence:
      - Contributed to a belly landing with a JAS39 C Gripen
- The seriousness in an occurrence must never be played down, neither in the report or in the following management.

  - Personal mistakes or potential mistakes
- Incident 2000-01-25 with a Swedish C-130 Hercules at Kebnekaise

  There was a near collision to the same mountain, but the report was played down.

- In 2012 a Norwegian C130J crashed at the same location, with five killed. Figure 1.19 is a photograph of the crash site.

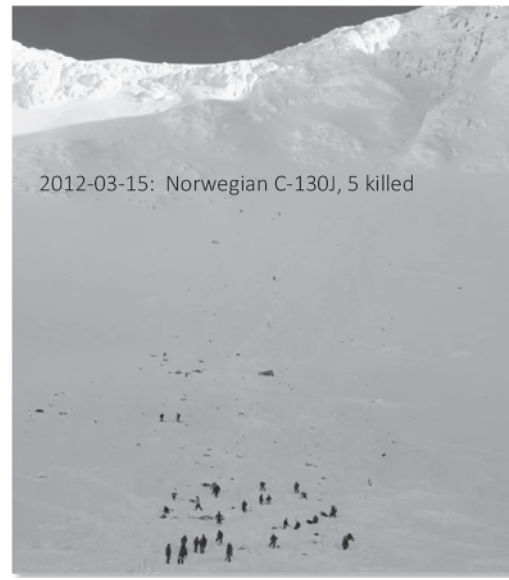

Figure 1.19 Crash site of Norwegian C130J. Source: Åström (2022).

One of the tools for solving aircraft related issues was the Gripen's Chief Engineer's Problems Resolution List, called the CI PAL. The engineering group met once a month to discuss and find solutions for aircraft engineering issues. At first, the meetings were not successful because the issues were not taken seriously and detested by industry. However, with persistence the program was implemented as was found to be one of the prerequisites for the Gripen export success. The CI PAL was mentioned as the base for Saab's present quality system. Figure 1.20 shows a Gripen fighter being flown by Wing Commander Åström.

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Crisis Management

– The SAF's current policy is to eliminate before they result in a crisis.
- Economic implications are

  If you think safety is expensive…
  …try an accident!

  - Direct costs for an accident:
    - » Damages (personnel, equipment)
    - » Technical, operational costs
    - » Disruptions in processes, production, etc.
  - Indirect costs for an accident:
    - » Immaterial costs: Reputation, brand, lost orders, etc.
    - » Losses: Lost revenues, machine time, work time, investigation time, etc.
    - » Sanctions: Lawsuits, fines

Figure 1.20 Gripen aircraft flown by wing commander Åström. Source: Åström (2022).

Figure 1.21 shows a graph that correlates cost with risk and losses. The graph shows that there is an optimal point. This point is called ALARP or As Low as Reasonably Practicable.

Example SAF Accident
On April 19, 2007 a JAS39 C Gripen at Vidsel airbase crashed. Before landing the pilot was experiencing high G-loading when turning to the downwind leg before landing. During reduction of the G-load the canopy exploded, and the pilot was ejected. Figure 1.22 shows the crashed aircraft.

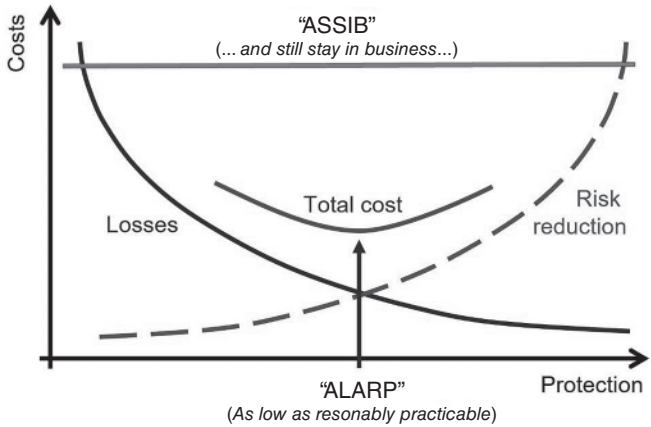

Figure 1.21 Risk/reward graph. Source: Åström (2022).

The maintenance/flight data recorder had to crash protection and the memory cards were torn away. However, the data was retrieved.

The pilot said he had his hand on the throttle and the stick. The flight data recorder showed that the aircraft functioned flawlessly, no fault alarm before ejection and the throttle and Stick movements gave credibility to the pilot's statement. Examination of the ejection seat showed no signs of malfunctions or discrepancies. However, the ejection mechanism was triggered.

The main question from the initial accident investigation was how could the ejection mechanism be activated during flight without the handle being touched by the hands?

Tests were carried out in the dynamic simulator with the handle from the crashed aircraft and two other designs of the ejection seat handle (Figure 1.22).

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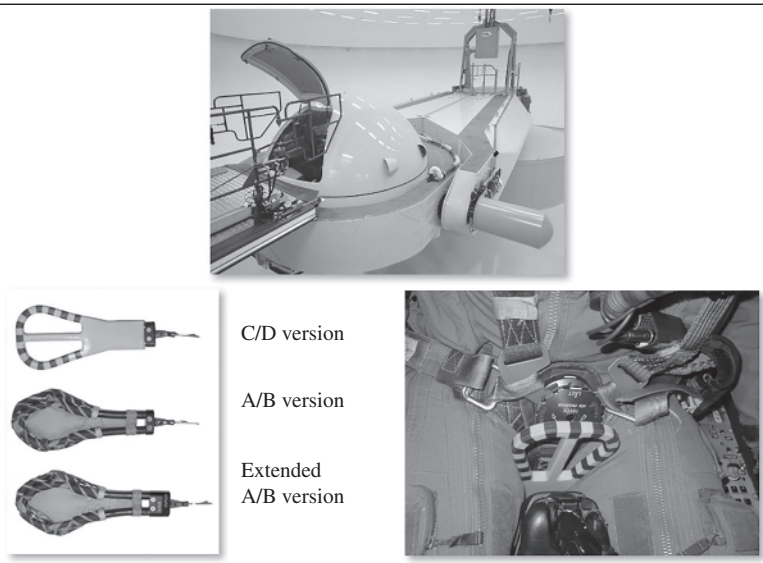

Figure 1.22 Ejection seat handle testing. Source: Åström (2022).

Tests in Dynamic simulator found that

- Four pilots of four were ejected
- Retaining forces were measured on 15 mechanisms:
  - Initial force (ball lock for the handle)
  - Firing force (wedge lock for firing pins)

Further examination found that

- There were uncocking problems frequently reported for more than 10 years.
- In systems report and risk analysis: Pilot's thighs can affect the handle.
- No detailed analysis concerning unintentional ejection.
- Documentation – Forces on the ejection mechanism.
- There was no requirement for lowest firing forces.

However, an old requirement documents at FMV found that the Initial force should be 150 N and the firing force should be 220–290 N.

From a delivery of 70 ejection seats, 54 seats were below specified initial force, 48 seats were below lowest firing force. There had been a change in personnel and only the highest firing force was checked.

A description in the pilot's manual (AOM) said: "Push the handle back to its parking position." Due to this AOM-text, the pilots perceived the problem with

ejection seat as normal and acceptable. Uncocking problems therefore often resulted in no Occurrence/Technical Reports.

The following were the modification of the ejection mechanism:

- 2000-11-01: Decision on modification, was included in Mod package C
- 2005-04-13: Mod package C was stopped for economic reasons
- 2006-08-16: The measures were included in a Technical Order (TO)

The case was therefore removed from Problem List Gripen JAS39.

In the new TO, modification of the ejection mechanism was missing.

The accident was caused by shortcomings in the Quality Assurance of the Flight Safety Process within and between Saab, FMV, and FM.

These shortcomings resulted in activation of the aircraft's rescue system after repeated high G-loads due to

- The shape of the handle
- The surface friction of the handle
- The low holding forces of the mechanism

A sobering thought that the Gripen had participated in numerous international air displays, involving high G-loads and it is lucky the ejection seat was not activated.

Nuclear Regulatory Commission (NRC) Response to Questions from Lee Ostrom

Please note that the references for this section are at the end of the section and are listed independently from the rest of the chapter.

1. **How do you define safety culture?**
   The NRC's Safety Culture Policy Statement (SCPS) sets forth the Commission's expectation that individuals and organizations establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions. The SCPS is not a regulation. It applies to all licensees; certificate holders; permit holders; authorization holders; holders of quality assurance program approvals; vendors and suppliers of safety-related components; and applicants for a license, certificate, permit, authorization, or quality assurance program approval, subject to NRC authority. In addition, the Commission encourages the Agreement States (States that assume regulatory authority over their own use of certain

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nuclear materials), their licensees, and other organizations interested in nuclear safety to support the development and maintenance of a positive safety culture within their regulated communities. The NRC's Web site contains more information on Agreement States.[1]

The SCPS addresses both safety and security. Organizations should ensure that personnel in the safety and security sectors appreciate the importance of each and should emphasize the need for integration and balance to achieve both safety and security in their activities. Safety and security activities are closely intertwined. Although many safety and security activities complement each other, instances may occur in which safety and security interests create competing goals. It is important that consideration of these activities be integrated so that one activity does not diminish or adversely affect the other; therefore, mechanisms to identify and resolve these differences should be established. A safety culture that accomplishes this would include all nuclear safety and security issues associated with NRC-regulated activities.

The SCPS defines nuclear safety culture as the core values and behavior resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment.

The SCPS includes nine traits that further define a positive safety culture. These traits describe patterns of thinking, feeling, and behaving that emphasize safety, particularly in goal conflict situations, such as when safety goals conflict with production, schedule, or cost goals. The traits listed in Table 1.1 are not all-inclusive. Some organizations may find that one or more of the traits are particularly relevant to their activities. In addition, the SCPS may not include traits that are important in a positive safety culture. More information on the SCPS appears on the NRC's Web site.[2]

2. **How does safety culture impact the operation of your facility/company/oversight function?**

   The NRC recognizes that it is important for all organizations performing or overseeing regulated activities to establish and maintain a positive safety culture. The NRC's approach to safety culture is based on the premise that licensees bear the primary responsibility for safety. The NRC provides oversight of safety culture through expectations detailed in policy statements and the oversight processes.

Table 1.1 Safety culture policy statement traits.

Leadership safety values and actions	Problem identification and resolution	Personal accountability
Leaders demonstrate a commitment to safety in their decisions and behaviors	Issues potentially impacting safety are promptly identified, fully evaluated, and promptly addressed and corrected commensurate with their significance	All individuals take personal responsibility for safety
Work processes	**Continuous learning**	**Environment for raising concerns**
The process of planning and controlling work activities is implemented so that safety is maintained	Opportunities to learn about ways to ensure safety are sought out and implemented	A safety conscious work environment is maintained where personnel feel free to raise safety concerns without fear of retaliation, intimidation, harassment, or discrimination
Effective safety communications	**Respectful work environment**	**Questioning attitude**
Communications maintain a focus on safety	Trust and respect permeate the organization	Individuals avoid complacency and continually challenge existing conditions and activities to identify discrepancies that might result in error or inappropriate action

Beginning in 1989, the NRC published the first of three policy statements about safety culture at nuclear power plants. The first policy statement describes the Commission's expectations for the conduct of operations in control rooms. The NRC published the second policy statement in 1996 to establish the Commission's expectation for maintaining a safety conscious work environment (SCWE) in which workers are able to raise nuclear safety concerns without fear of retaliation. Finally, the NRC published the third policy statement, the SCPS, in 2011 to establish the Commission's expectations for licensees to maintain a strong safety culture.

The NRC staff developed outreach materials that can be used to educate stakeholders about safety culture and the NRC's SCPS. These materials include brochures, posters, "Safety Culture Case Studies," "Safety Culture Trait Talk," "Safety Culture Journey," and "Educational Resource." As part of

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ongoing outreach activities, the NRC staff makes presentations at meetings and conferences in a variety of industry forums to share information with stakeholders about the SCPS and participates in international and interagency efforts on safety culture. The NRC Web site provides all of the NRC outreach and educational materials and the SCPS.[3].

Safety Culture is included in the NRC's oversight processes, the Allegation Program and the Enforcement Program. The NRC provides training to inspectors and other experienced staff to become qualified as safety culture assessors for safety culture assessments under Inspection Procedure (IP) 95 003, "Supplemental Inspection for Repetitive Degraded Cornerstones, multiple Degraded Cornerstones, Multiple Yellow Inputs, or One Red Input." The Reactor Oversight Process (ROP) is the NRC's program for assessing the performance of operating commercial nuclear power reactors, which includes guidance and procedures for inspecting and assessing aspects of licensees' safety culture. In addition to the oversight processes, the NRC's Allegation Program evaluates and responds to safety culture concerns raised by workers at the agency's licensed facilities and by the general public. Furthermore, the Allegation Program and Enforcement Program address safety culture through the use of chilling effect letters (CELs) and confirmatory orders (COs). (*See question 5 for more information on NRC assessment and oversight of safety culture*).

3. **Describe an incident/accident that a negative safety culture impacted the outcome.**

   The NRC has developed Safety Culture Case Studies to provide real-life events where review of the circumstances surrounding the event and the results of the investigations found clear examples of the role that safety culture played in contributing to or in lessening the causes and consequences of the event.

   These case studies are learning tools. Those responsible for regulating or using radioactive material in a safe and secure manner should not become complacent and should be open to learning from the mistakes and the problems others have faced in an effort to prevent recurrences.

   The NRC has also developed a Safety Culture Case Study User Guide to help individuals and organizations use the various case studies more effectively, providing them with a better understanding of why a strong safety culture and safety-first focus are critically important. It is recommended that you review the User Guide prior to reviewing the case studies.[4]

- ***June 2009 Collision of Two Washington Metropolitan Area Transit Authority Metrorail Trains Near Fort Totten Station, Washington, DC***: The case study will enable the staff to identify and learn from the findings made by the National Transportation Safety Board (NTSB) about the collision of two Washington Metropolitan Area Transit Authority (WMATA) Metrorail trains in June 2009. The collision resulted in the loss of nine lives and multiple passenger injuries. The NTSB report points out that WMATA failed to implement many significant attributes of a sound safety program. Many of these attributes parallel the positive safety culture traits the NRC has incorporated into its Safety Culture Policy Statement.[5]
- **Partial Collapse of the Willow Island Cooling Tower**: This case study describes the safety culture shortcomings that led directly to the partial collapse of a natural draft, hyperbolic, reinforced concrete cooling tower at Willow Island, WV, on April 27, 1978. The cooling tower was one of two towers being constructed by Research-Cottrell, Inc., for the Pleasants Power Station, a coal-fired electric power station owned by Allegheny Energy Supply Company. The resulting deaths of 51 construction workers represent one of the costliest accidents, in human terms, of any in the US construction industry's history.[6]
- **April 2010 Upper Big Branch Mine Explosion – 29 Lives Lost**: This case study provides the regulated community with the findings of West Virginia Governor Manchin's appointed independent investigation panel and the results of an investigation conducted by the US Department of Labor's Mine Safety and Health Administration (MSHA). Many of these findings contrast starkly with the positive safety culture traits that the NRC has incorporated into its safety culture policy statement.[7]

4. **Describe an incident where a positive safety culture has prevented a catastrophe.**
   - **US Airways Flight 1549: Forced Landing on Hudson River**: This case study is intended to provide a useful tool for the US Nuclear Regulatory Commission (NRC) staff as it interacts with their stakeholders. It will also enable the regulated community to identify with and learn from the findings made by the National Transportation Safety Board (NTSB) regarding the forced landing on the Hudson River by US Airways Flight 1549. The positive safety culture traits that contributed to the successful outcome of this event parallel those traits the NRC has incorporated into its SCPS.[8]

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5. **How does your organization assess safety culture?**

Safety Culture Assessor Training

Qualification as a safety culture assessor requires the completion of a variety of activities, each of which is designed to help gather information or practice a skill that may be important during safety culture assessments. When qualified, the safety culture assessor will have demonstrated the following competencies:

- understanding of the regulatory processes used to achieve the NRC's regulatory objectives
- mastery of the techniques and skills needed to collect, analyze, and integrate information using a safety culture focus to develop a supportable regulatory conclusion
- the personal and interpersonal skills needed to carry out assigned regulatory activities, either individually or as part of a team

Additional information on IMC 1245, "Qualification Program for New and Operating Reactor Programs," Appendix C12, "Safety Culture Assessor Training and Qualification Journal," dated February 1, 2016, appears on the NRC's Web site.[9]

Safety Culture Common Language

Before work began on the 2011 SCPS, the nuclear power industry approached the NRC about developing a shared set of terms to describe safety culture. With insights gained during the development of the SCPS, the Office of Nuclear Reactor Regulation, along with the Institute of Nuclear Power Operations and Nuclear Energy Institute, hosted a series of public workshops beginning in December 2011 to discuss the idea of a safety culture common language. The intent of this initiative, as requested by the industry, was to align terminology between the NRC's inspection and assessment processes within the ROP and the industry's assessment process. This initiative was within the Commission-directed framework for enhancing the ROP treatment of cross-cutting areas to more fully address safety culture.

NUREG-2165 documents the outcomes of the public workshops to develop a common language to describe safety culture in the nuclear industry. These workshops included panelists from the NRC, the nuclear power industry, and the public. NUREG-2165 outlines a suggested common language for classifying and grouping traits and attributes of a healthy nuclear safety culture. The common language initiative identified 10 traits of a healthy safety culture (the 9 traits from the SCPS plus a 10th trait, decision-making), 40 aspects included under

those traits, and numerous examples for each aspect. These common language traits and aspects have been incorporated under the three cross-cutting areas of the ROP. NUREG-2165 is available on the NRC's Web site.[10]

Regulatory Oversight

Oversight Processes

Reactor Oversight Process: The NRC's approach to safety culture is based on the premise that licensees bear the primary responsibility for safety. The ROP is the NRC's program for assessing the performance of operating commercial nuclear power reactors. The ROP uses inputs from performance indicators and inspection findings to develop conclusions about a licensee's safety performance. Performance is evaluated systematically and continuously through planned inspections and mid-year and end-of-year assessment meetings.

The ROP framework contains three key areas and seven cornerstones, as shown in Figure 1.23. Each cornerstone has corresponding performance indicators and inspection procedures to assess licensee performance. Safety culture is considered within three cross-cutting areas: (i) human performance, (ii) problem identification and resolution, and (iii) SCWE.

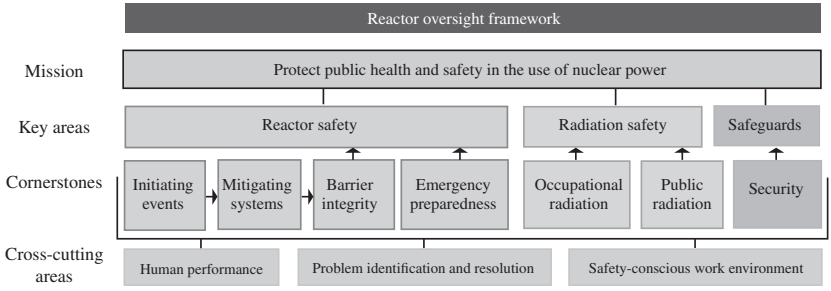

Figure 1.23 Reactor oversight framework. Source: NRC 2022/United States Nuclear Regulatory Commission/Public Domain.

Based on the NRC's assessment of safety performance, licensees are assigned to a column in the ROP Action Matrix, and that placement in the ROP Action Matrix determines the level of NRC oversight for that particular licensee. The NRC's approach to safety culture assessment is a graded process (see Figure 1.24). The extent and complexity of a safety culture assessment is generally based on a licensee's placement in the ROP Action Matrix. The scope and complexity increases with increased oversight, and the focus of the assessment may be tailored based on the

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original performance deficiency. An assessment may focus more heavily on one part of the plant or on one area of safety culture, such as the SCWE.

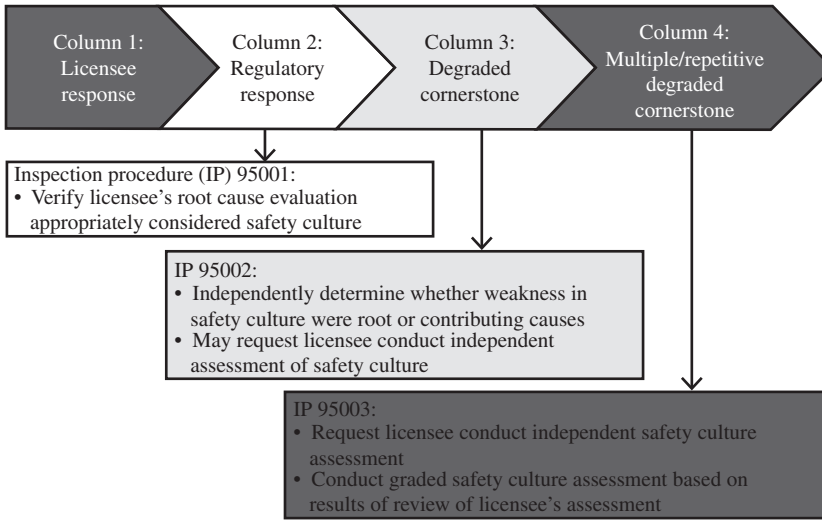

Figure 1.24 ROP action matrix. Source: 2022/United States Nuclear Regulatory Commission/Public Domain.

The NRC's ROP Action Matrix with the four columns of increasing oversight is based on performance indicators and inspection findings. Licensees in column 1 are subject to the NRC's baseline inspection program. As licensees move to columns 2, 3, or 4, they are subject to additional oversight in the form of supplemental inspections.

Qualified NRC safety culture assessors evaluate the licensee's third-party safety culture assessment and then determine the scope of the NRC's assessment based on that evaluation. The NRC assessors conduct the assessment on site and identify and document safety culture themes in the inspection report. The assessors also review the licensee's planned and completed corrective actions to evaluate whether they address the identified safety culture themes and whether the licensee needs to develop follow-up actions to deal with any remaining concerns. The NRC Web site contains a detailed description of the ROP[11] and NUREG-1649, "Reactor Oversight Process," Revision 6, issued July 2016.[12]

Construction Reactor Oversight Process: The Office of New Reactors (NRO) staff revised the cROP based on the ROP assessment program methodology, including the use of safety culture traits and cross-cutting issues, and completed a pilot of the revised cROP in December 2012.

Based on the results of the pilot program, NRO revised the construction oversight process, including IMC 0613, "Power Reactor Construction Inspection Reports," dated February 9, 2017, and IMC 2505, "Periodic Assessment of Construction Inspection Program Results," dated January 6, 2017, to provide guidance in assessing the safety culture of a construction site. NRO revised IMC 0613 to include a list of cross-cutting aspects that can be assigned to inspection findings. Assigned cross-cutting aspects are generally associated with the root causes of performance deficiencies and are evaluated to identify cross-cutting themes that are assessed as outlined in IMC 2505. IMC 2505 also references the supplemental inspection procedures that are used when safety performance declines at a construction site. These procedures provide NRC inspectors with guidance on how to assess the safety culture at a construction site with escalating levels of efforts commensurate with the significance of a site's performance decline. The supplemental inspection procedures also give NRC inspectors the tools to communicate safety culture issues to stakeholders. The NRC's Web site contains IMC 0613 and IMC 2505[13] and additional information on the cROP.[14]

Allegation and Enforcement Programs

In addition to violations of NRC regulations and potential wrongdoing, the NRC's Allegation Program and Enforcement Program address discrimination against licensee employees for raising allegations related to nuclear safety concerns and the potential resulting chilling effect on the employee or coworkers. An allegation is a declaration, statement, or assertion of impropriety or inadequacy associated with NRC-regulated activities, the validity of which has not been established. Workers in the nuclear industry or members of the general public have the option of reporting nuclear safety concerns directly to the NRC.

Safety Conscious Work Environment: The Commission describes a SCWE as a work environment in which employees are encouraged to raise safety concerns and concerns are promptly reviewed, given the proper priority based on their potential safety significance, and appropriately resolved with timely feedback to the originator of the concerns and to other employees as appropriate. Fostering an environment for raising concerns continues to be an important attribute of a positive nuclear safety culture and is incorporated as one of the traits of a positive safety culture in the NRC's SCPS as "Environment for Raising Concerns." The NRC's Web site contains additional information on SCWE.[15]

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The NRC places a high value on nuclear industry employees being free to raise potential safety concerns to both licensee management and the NRC regardless of the merits of the concern. Unlawful adverse actions taken against an employee for raising safety concerns or perceptions that such actions have been taken may create a "chilling effect" on the employee or other workers who may wish to raise concerns (i.e. the employees may not feel that they are free to raise concerns without fear of retaliation). When the chilling effect is not isolated (e.g. multiple individuals, functional groups, shift crews, or levels of workers within the organization are affected), the NRC refers to the situation as a "chilled work environment."

If the NRC suspects that an organization has created a chilled work environment, the agency may ask the licensee for more information, or the NRC will investigate through follow-up inspections. If the NRC is concerned about the licensee's awareness of, or efforts to address a known chilled work environment, the agency may issue a CEL. A CEL is a public way for the NRC to communicate with the licensee, the public, and the licensee's employees. The intent of such action is, in part, to prompt the licensee to act to mitigate the chilling effect that the discriminatory act or other event has caused. The NRC's Allegation Program includes guidance on the agency's SCWE policy and issuance of CELs and is available on the NRC's Web site.[16]

The NRC's Enforcement Policy ensures, through appropriate enforcement action against a licensee or licensee contractor (and, when warranted, against the individual personally responsible for the act of discrimination), that adverse employment actions taken against licensee or contractor employees for raising safety concerns do not have a chilling effect on the individual or others who may wish to report safety concerns. The NRC vigorously pursues actions against licensees or licensee contractors who discriminate against their employees for raising nuclear safety concerns. The NRC's Enforcement Program includes information on sanctions for discrimination against employees who raise safety concerns and is available on the NRC's Web site.[17]

Safety Culture Corrective Actions: Through the identification of cross-cutting issues, safety culture assessments in supplemental inspections, or findings of discrimination or chilling effect, the NRC typically documents the concerns publicly, and the licensee responds to the concerns with planned corrective actions. The NRC may also use its Alternative Dispute Resolution Program (ADR) to resolve discrimination and wrongdoing cases or other specific cases subject to enforcement action through mediation rather than through the NRC's traditional enforcement processes. The ADR Program

comprises two entirely different subprograms: (i) a pre-investigation ADR subprogram and (ii) an enforcement ADR subprogram. The first subprogram, commonly referred to as "early ADR," is offered before the initiation of an investigation by the NRC's Office of Investigations (OI). Early ADR is available to allegers and their employers for resolving allegations of discrimination only. It is an opportunity for the parties to resolve their concerns early in the process. The second subprogram, formerly referred to as "post-investigation ADR," is offered after the completion of an OI investigation. Enforcement ADR is available to licensees (including contractors and employees) and the NRC for resolving wrongdoing or discrimination cases in which the NRC has concluded that enforcement may be warranted. Enforcement ADR is also available for escalated non-willful (traditional) enforcement cases with the potential for civil penalties (not including violations associated with findings assessed through the ROP). The enforcement ADR subprogram documents agreements between the NRC and the licensee on the licensee's planned actions, which then becomes the basis for a CO. The CO is legally binding. The NRC's Web site contains additional information on the Enforcement Program[18] and the ADR Program.[19,20]

References for the NRC Section

1 NRC (2022). Agreement state program. http://www.nrc.gov/about-nrc/state-tribal/agreement-states.html (accessed February 2022).

2 NRC (2022). Safety culture policy statement. http://www.nrc.gov/about-nrc/safety-culture/sc-policy-statement.html (accessed February 2022).

3 NRC (2022). Outreach and education materials. http://www.nrc.gov/about-nrc/safety-culture/sc-outreach-edu-materials.html (accessed February 2022).

4 NRC (2022). Safety culture case study user guide. https://www.nrc.gov/docs/ML1519/ML15196A440.pdf (accessed February 2022).

5 NRC, Safety Culture Communicator (2011). US Airways Flight 1549: Forced landing on Hudson river. https://www.nrc.gov/docs/ML1122/ML11228A218.pdf (accessed February 2022).

6 NRC, Safety Culture Communicator (2011). June 2009 Collision of Two Washington Metropolitan Area Transit Authority Metrorail Trains Near Fort Totten Station, Washington, DC. https://www.nrc.gov/docs/ML1115/ML11159A220.pdf (accessed February 2022).

7 NRC, Safety Culture Communicator (2011). Partial collapse of the Willow Island cooling tower. https://www.nrc.gov/docs/ML1126/ML11264A019.pdf (accessed February 2022).

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8 NRC, Safety Culture Communicator (2012). April 2010 Upper big branch mine explosion—29 Lives Lost. https://www.nrc.gov/docs/ML1206/ML12069A003.pdf (accessed February 2022).

9 NRC, Inspection Manual Chapter (IMC) 1245 (2011). Qualification program for new and operating reactor programs, Appendix C12. Safety Culture Assessor Training and Qualification Journal, ADAMS Accession No. ML16020A397. https://adamsxt.nrc.gov/navigator/#:~:text=Accession%20Number-,ML16020A397,-ML16020A397 (accessed February 2022).

10 NRC, NUREG-2165. Safety culture common language. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2165 (accessed February 2022).

11 NRC. ROP framework. http://www.nrc.gov/reactors/operating/oversight/rop-description.html (accessed February 2022).

12 NRC, NUREG-1649 (2022). Reactor oversight process. Revision 6. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1649 (accessed February 2022).

13 NRC, IMC 0613 (2022). Power reactor construction inspection reports and IMC 2505, Periodic assessment of construction inspection program results. http://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/index.html (accessed February 2022).

14 NRC (2022). Construction reactor oversight process (cROP). http://www.nrc.gov/reactors/new-reactors/oversight/crop.html (accessed February 2022).

15 NRC (2022). Safety conscious work environment. http://www.nrc.gov/about-nrc/safety-culture/scwe.html (accessed February 2022).

16 NRC (2022). Safety conscious work environment policy guidance. http://www.nrc.gov/about-nrc/regulatory/allegations/scwe-mainpage.html (accessed February 2022).

17 NRC (2022). Sanctions for discrimination against employees who raise safety concerns. http://www.nrc.gov/about-nrc/regulatory/enforcement/sanctions.html (accessed February 2022).

18 NRC (2022). Enforcement program overview. http://www.nrc.gov/about-nrc/regulatory/enforcement/program-overview.html (accessed February 2022).

19 NRC (2022). Pre-investigation ADR. http://www.nrc.gov/about-nrc/regulatory/enforcement/adr/pre-investigation.html (accessed February 2022).

20 NRC (2022). Enforcement ADR. http://www.nrc.gov/about-nrc/regulatory/enforcement/adr/post-investigation.html (accessed February 2022).

1.6 Chapter Summary

This chapter covered a great amount of information on early safety professionals, culture, and safety culture and the problems that can arise when there isn't a positive safety culture in an organization. There is always a safety culture, whether it is positive or negative. Accidents can occur in positive safety cultures but are more likely to occur in negative safety cultures. I wish to thank Ron Farris, Shane Bush, Lt Olsen, Wing Commander Åström, and the NRC for their contributions to this chapter.

References

Åström, L. (2019). *Safety Culture & Crisis Management (PowerPoint Slides)*. Sweden, AB: GKN Aerospace.

BBC (2017). Germanwings crash: who was co-pilot Andreas Lubitz? https://www.bbc.com/news/world-europe-32072220 (accessed February 2022).

Bird, F.E. and Germain, G.L. (1996). *Practical Loss Control Leadership*. Loganville, GA: Det Norske Verita.

Charles Rivers Editor, *Dagestan: The History and Legacy of Russia's Most Ethnically Diverse Republic* 2019.

Franco, G. and Fusetti, L. (2004). Bernardino Ramazzini's early observations of the link between musculoskeletal disorders and ergonomic factors. *Applied Ergonomics* 35 (1): 67–70. https://doi.org/10.1016/j.apergo.2003.08.001.

Heinrich, H.W. (1931). *Industrial Accident Prevention: A Scientific Approach*. New York, NY: McGraw Hill Book Company [Google Scholar].

Heinrich, H.W., Peterson, D., and Roos, N. (1980). *Industrial Accident Prevention*, 5e. New York, NY: Mcgraw Hill.

Hollnagel, E. (2012). *FRAM, The Functional Resonance Analysis Method: Modelling Complex Socio-Technical Systems*. Ashgate Publishing, Ltd.

Hollnagel, E. and Örjan, G. (2004). The functional resonance accident model. *Proceedings of Cognitive System Engineering in Process Plant*, Tohoku University, Sendai, Japan.

David D Boyce, Shane Bush, Danielle E Lower, Tyson Todd Allen, John K Epperson. (2020) *INL Human Performance Improvement Guide, GDE-863* (No. INL/MIS-20-57536-Rev000). Idaho National Lab.(INL), Idaho Falls, ID (United States).

Ostrom, L. and Wilhelmsen, C. (2015). *Factoring in Safety Culture into a Risk Framework*. Vienna, Austria: Presented at the International Atomic Energy Agency.

Ostrom, L.T. and Wilhelmsen, C. (2019). *Risk Assessment: Tools, Techniques, and Their Applications*, 2e. Wiley.

Ostrom, L.T., Wilhelmsen, C.A., and Kaplan, K. (1993). Assessing safety culture. *Journal of Nuclear Safety* 34 (2).

Pidgeon, N. (1991). Safety culture and risk management in organizations, business. *Journal of Cross-Cultural Psychology* 22: 129–140.

Reason, J. (1990). The contribution of latent human failures to the breakdown of complex systems. *Philosophical Transactions of the Royal Society (London), series B.* 327: 475–484.

Reason, J. (1997). *Managing the Risks of Organizational Accidents*. Aldershot, UK: Ashgate Publishing Limited.

Safeopedia (2017). What does accident causation model mean?. https://www.safeopedia.com/definition/617/accident-causation-model-occupational-health-and-safety#:~:text=Simple%20linear%20models%20(Heinrich%2C%201931,accident%2C%20injury%2C%20etc. (accessed February 2022).

Woodward, M. (2018). Safety Myths Debunked! Safety Isn't Common Sense. https://previsorinsurance.com/blog/safety-myths-debunked/ (accessed February 2022).