Annex II of Technical Volume 2
ASPECTS RELATED TO THE HUMAN AND ORGANIZATIONAL FACTORS OF THE ACCIDENT

II–1. THE FUKUSHIMA DAIICHI ACCIDENT FROM A HUMAN PERSPECTIVE

This annex describes how highly trained workers who normally worked in steady state operational conditions were suddenly faced with a multitude of extraordinary human and organizational challenges that brought complexity to all tasks. Imagining how one would respond when faced with the accumulation of these extreme conditions that severely challenged the people should not only result in many learning opportunities, but also bring perspective to this unexpected external event.

The earthquake of 11 March 2011 and the associated tsunami caused significant damage and loss of life in Japan. The accident at the Fukushima Daiichi nuclear power plant (NPP) represents a serious event, not merely to the Japanese people, but particularly to the people at the Fukushima Daiichi and Daini NPPs and those involved in the off-site management of the accident in the hours, days, weeks and months following the earthquake. Workers, engineers, managers, representatives of authorities, politicians, members of civil society, and non-government organizations were working to control the situation on site. The accident at the Fukushima Daiichi NPP was a complex accident that required extraordinary efforts under unimaginable conditions from nearly all persons involved.

The response to the accident should also be viewed in a national context. More than 15 000 people were killed and over 6000 injured and, at the time of writing of this volume, around 2500 people were still reported to be missing [II–1]. This also made it difficult to evacuate and mitigate the situation in the aftermath of the earthquake and the tsunami. As an example of the conditions experienced, Table II–1 provides an indication of the number of aftershocks that followed the Great East Japan Earthquake and Table II–2 provides an indication of the impact of different seismic intensities on the situations indoors and outdoors and on human perceptions and reactions.

TABLE II–1. AFTERSHOCKS OF THE GREAT EAST JAPAN EARTHQUAKE (JAPAN METEOROLOGICAL AGENCY) [II–2].

Number of aftershocks on 11 March 2011	
180	> M 5.0
38	> M 6.0
3	> M 7.0
Total aftershocks the first week	
463 times	> M 5.0

It is important to note that there were difficult physical, environmental conditions at the plant and conditions of work for the personnel. Moreover, during the emergency response work and after the hydrogen explosions, it was difficult the working conditions in the main control room (MCR) because full-body protective clothing had to be worn. Fatigue was also an important issue. Sleeping facilities were not enough, with the result that personnel could sleep for short durations after the accident. In the first weeks, staff working in the Emergency Response Centre worked for many days continuously. As soon as it was possible an infrastructure for rest and recovery of the staff was available. Sanitary facilities including showers and toilets were not sufficient and could not be maintained in a proper manner.

TABLE II–2. IMPACTS OF DIFFERENT SEISMIC INTENSITIES (JAPAN METEOROLOGICAL AGENCY) [II–3].

Seismic intensity	Human perception and reaction	Indoors situation	Outdoors situation
4	Most people are startled. Felt by most people walking. Most people are awoken.	Hanging objects such as lamps swing significantly and dishes in cupboards rattle. Unstable ornaments may fall	Electric wires swing significantly. Those driving vehicles may notice the tremor.
5 Lower	Many people are frightened and feel the need to hold onto something stable	Hanging objects such as lamps swing violently, dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move and unstable and unstable furniture may topple over,	In some cases, windows may break and fall. People notice electricity poles moving. Roads may sustain damage.
5 Upper	Many people find it hard to move, walking is difficult without holding onto something stable.	Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over.	Windows may break and fall, unreinforced concrete-block walls may collapse, poorly installed vending machines may topple over, automobiles may stop due to the difficulty of continued movement.
6 Lower	It is difficult to remain standing.	Many unsecured furniture moves and may topple over. Doors may become wedged shut.	Wall tiles and windows may sustain damage and fall.
6 Upper	It is impossible to remain standing or move without crawling. People may be thrown through the air.	Most unsecured furniture moves, and it is more likely to topple over.	Will tiles and windows are more likely to break and fall. Most unreinforced concrete-block walls collapse.
7		Most unsecured furniture moves and topples over, or may even be thrown through the air.	Wall tiles and windows are even more likely to break and fall. Reinforced concrete-block walls may collapse.

The psychological working conditions were no less difficult than the physical conditions, in particular after the arrival of the tsunami and the hydrogen explosions. Many people at the site worked not knowing about the well-being of their families or were grieving for the loss of relatives. Furthermore, they had to cope with a very high degree of uncertainties, such as concerns over plant status and its evolution, risks of explosions, and radiation exposure in a difficult environment.

II–2. COMPLEX ACCIDENT CONDITIONS

The complexity of the accident at the Fukushima Daiichi NPP was increased by the fact that it involved multiple units at the site. The organizations and the staff were not dealing with one single accident, but with severe accident conditions at three units (Units 1–3) simultaneously, still aiming to keep the other three units (Units 4–6) as well as the spent fuel pools under control.

Accident mitigation activities at the different units were partially performed by the same personnel, shared between at least two units. For example, one shift crew in the Units 1 and 2 MCR shared duties between Units 1 and 2 and only a few persons were fully dedicated to one unit. The reactors and safety systems were similar but not the same in the various units, requiring differentiated knowledge of the systems as well as different activities by the staff at the units. Moreover, the accident progressed in different ways at each unit and the accident progression and the accident management activities within and among the units in some cases impacted each other. It should be noted that, working sometimes in darkness with radiation doses, wearing full-face masks and full-body protective

clothing, in a difficult environment, with aftershocks, as well as with tsunami alarms, with a lack of communication and working tools, infrastructure and systems damaged and inoperable, not knowing what the conditions of the plants were, under high time pressure, not knowing about the well-being of their families, being tired, with events unfolding in parallel in multiple units. Despite these unbearably harsh conditions and the high complexity, personnel on and off-site fought against the deteriorating situation to regain control of the units and worked to find the best solutions to the problems that constantly arose, while communicating in parallel with many of the external stakeholders.

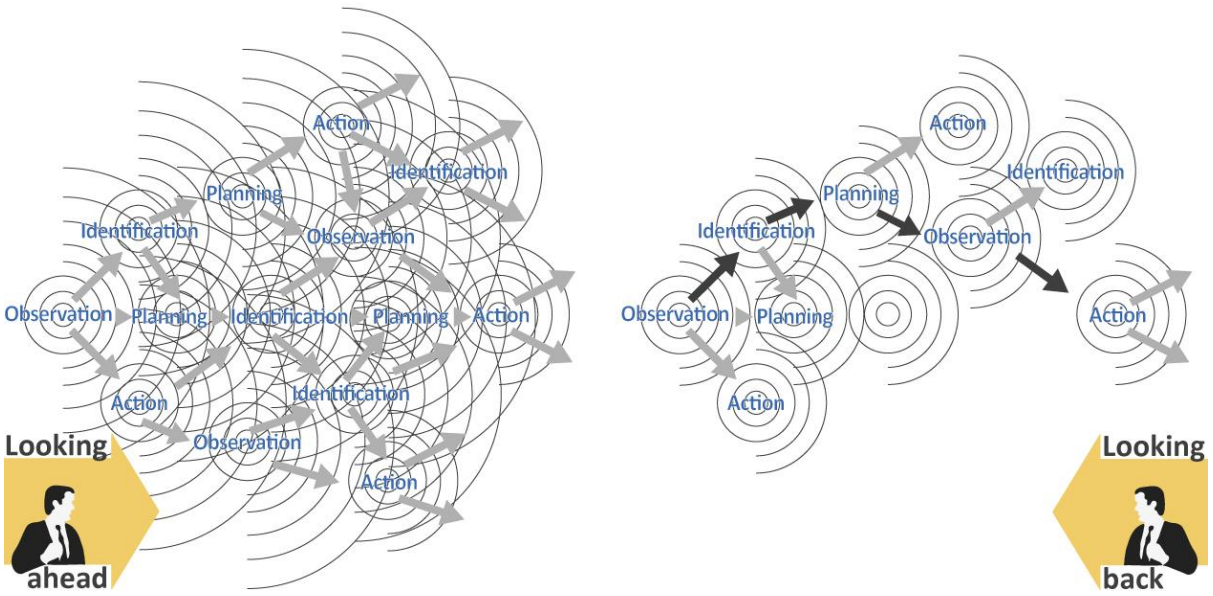
II–3. BIASES IN THE ANALYSIS OF COMPLEX ACCIDENTS

This introduction presents some common biases in the analysis of complex accidents that, if not addressed can prevent investigators as well as readers from understanding important aspects of this accident.

II–3.1. The hindsight bias

When analysing an accident that has occurred in the past, investigators as well as readers must be aware of the fact that they, are reconstructing the accident and making sense of it in hindsight. People tend to judge a process by its outcome [II–4] and the knowledge of the outcome deeply influences the way they investigate and judge the past event [II–5].

As depicted in the Fig. II–1, we see a well-ordered, sequential chain of events leading from a trigger (e.g. the tsunami in the case of the Fukushima Daiichi NPP) to the three core damages. The perception before the accident is very different. The involved staff are embedded in an evolving context and must act under uncertainty, without knowing or being able to predict whether their actions will be successful [II–4], as depicted in the Fig. [II–2]. The ‘orderliness of looking back’ [II–6] perceived by accident investigators and readers of investigation reports as opposed to the ‘indeterminacy of looking ahead’ [II–6] perceived by the practitioners at the ‘sharp end’ [II–4] is known as ‘hindsight bias’.



(a) (b)

FIG. II–1. (a) The indeterminacy of looking ahead; (b) the orderliness of looking back [II–6].

II–3.2. Oversimplification

Along with ‘hindsight bias’, it is important to recognize that accident investigation reports are written in a linear manner. As is the case with the present report, one can only describe the facts and unfolding situations in a compartmentalized way, i.e. one event at the time, each ‘on a different page’, despite all efforts to describe the event in the best possible way and from as many different angles as possible. Therefore, although efforts are made to look at the accident from many different perspectives, what happened at the Fukushima Daiichi NPP typically is described in a chronological manner, unit by unit, topic by topic. This natural constraint can create an oversimplification of the overall picture which makes it hard to acknowledge the complete picture of the event. Nevertheless, despite these limitations, it needs to be kept in mind that the accidents at the different units at the Fukushima Daiichi NPP required that the emergency organization staff deal with several problems at the different units while interacting with each other. Relationships with the off-site environment and stakeholders also had an impact on accident management. For example, the damaged infrastructure surrounding the plant site had an impact on the accessibility of staff and external support and transport of heavy equipment to the site. In addition, communication and coordination with external participants, such as the central government and local authorities as well as Tokyo Electric Power Companies (TEPCO) headquarters, had to be managed.

II–3.3. Distancing through differencing

An accident provides an opportunity to learn, not only for the organizations involved in the accident, but also for the other organizations within and outside the industry concerned. After an accident a ‘learning window’ opens where it is possible to ask questions that are usually not asked during non-accident times [II–7]. However, learning after an accident is far from easy. One must not focus on just trying to learn the ‘obvious’, but must also capture more subtle, important lessons as they emerge over time. Learning after an accident is subject to barriers. One of these barriers is a mechanism called ‘distancing through differencing’, exemplified by the statement “this can’t happen here”. Such a response is likely to occur particularly in organizations that are distant enough from the ones directly involved in the accident; for example, operators and regulators in other countries. One example of this is the missed opportunity to address the operating experience gained from the 1999 flooding event at the Le Blayais NPP in France.

An indication of such a response could be, for example, the tendency to entirely attribute an accident to specific issues or particular aspects related to safety culture and to perceive them as being very different from those in one’s own context. It is important, therefore, to remain aware of the mechanism of ‘distancing through differencing’ and to consider how a similar situation could happen within one’s own organization.

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