The Occupational Risk Assessment Method: A Tool to Improve Organizational Resilience in the Context of Occupational Health and Safety Management

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Abstract. The resilience engineering (RE) approach driven by Hollnagel, Woods and Leveson [1] focuses on the ability of organizations to cope with disturbances. The notion of "control of operations" is essential to the concept of resilience. Hollnagel [2, 3] proposes a regulatory model of the operational control function, broken down into four essential abilities: to anticipate, monitor, respond, and learn. Within the domain of occupational health and safety (OHS) management, the risk assessment method "DIARBENN" was developed through a French approach to contribute to the development of the four resilience abilities of an organization. This method places the analysis of operators' activity at the center of the risk assessment process. The aim of this paper is to present the DIARBENN method as a tool that contributes to the development of organizational resilience in the context of OHS management.

Keywords: Resilience engineering · Occupational health and safety management · Organization · Occupational risk assessment method

1 Introduction

The resilience engineering (RE) approach driven by Hollnagel, Woods and Leveson [1] focuses on the ability of organizations to cope with disturbances. The notion of "control of operations" is essential to the concept of resilience. Hollnagel [2, 3] proposes a regulatory model of the operational control function, broken down into four essential abilities: to anticipate, monitor, respond, and learn. These abilities enable an organization to be resilient, that is, able to *"adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions"*.

RE is often viewed from a macroscopic point of view (i.e. the blunt-end level). The sharp-end level, however, is highly relevant to RE issues [4]; it involves viewing the activity of the operators as a worthwhile object of study for resilience. Executing this

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activity may, under certain conditions and/or when disturbances occur, lead to a loss of control of operations and consequently to the occurrence of occupational accidents, occupational diseases, and industrial disasters. This loss of operational control indicates the inability of operators to adapt, in specific circumstances, to the work activity constraints. In the RE domain, it is therefore worth examining the adaptation processes that enable operators to remain in a safe functioning space of operations [5, 6, 7, 8].

The French tradition of ergonomics research (e.g. [9–13]) is particularly involved in investigating the activity of operators in the context of industrial safety and occupational health and safety (OHS) concerns. Examining operators' activity provides a genuine opportunity to identify all the dangers they are exposed to in order to conduct an accurate assessment of their health- and safety-related risks. Analyzing operators' activity from the perspective of the assessment process of the risks they are exposed to also helps identify the room for maneuver available to them. This room for maneuver is essential to the adaptation process that enables them to keep control of the operations. Organizational resilience, from the sharp-end level, depends upon this capacity to adapt. Consequently, the links between the four resilience abilities (i.e. to anticipate, monitor, respond, and learn), operators' activity, and the risk assessment process are very close. In this context, as part of OHS management, the risk assessment method "DIARBENN" was developed through a French approach at the Health, Safety, and Environment Department of the Lorient University Institute of Technology (France). This method contributes to the development of the four resilience abilities of an organization at the sharp-end level and places the analysis of operators' activity at the center of the risk assessment process.

This paper is divided into three sections. The first section presents the regulatory context of OHS in France and more specifically that of occupational risk assessment. The second one presents the DIARBENN method developed to assess occupational risks and improve organizational resilience at the sharp-end level. The last section is the discussion/conclusion.

2 The Regulatory Context of OHS in France

From a legislative perspective, Directive n°89/391/CEE of June 12, 1989, gave momentum to a common framework within the European Union regarding the prevention of health and safety risks for workers. The directive placed occupational risk assessment at the top of the hierarchy of the general principles concerning prevention. Law n°91-1414 transposed the provisions that the framework directive added into French law. With reference to risk assessment, Articles L4121-1/2/3 of the labor code incorporate the community legislation under three requirements: 1. Employers are required to ensure their workers' health and safety; 2. The general principles of occupational risk prevention must be implemented; 3. Risk assessment must be conducted. Decree n°2001-1016 of November 5, 2001, makes it mandatory to produce a document relating to the assessment of the risk's workers are exposed to in an organization. Failure to comply with this requirement results in subjecting managers to the criminal penalties provided for in Article R4741-1 of the labor code.

The regulatory framework specifies neither the method nor the tools to be used for the occupational risk assessment. It is the managers who must assume the responsibility for the task by implementing an occupational risk assessment process that is adapted to their situation.

The Health, Safety, and Environment (HSE) Department at the Lorient University Institute of Technology has developed a risk assessment method called “DIARBENN”, which is taught to the future occupational health and safety professionals. It has been deployed in many companies for a number of years.

3 The Diarbenn Method

The Diarbenn method is implemented as part of the occupational risk assessment process that represents the backbone of any OHS management system. The Diarbenn method includes four main phases, presented in detail in the following sections. It is implemented by the OHS specialist in a company.

3.1 Phase 1. Breaking the Company Down into Elementary Operational Units

The first phase of the Diarbenn method involves breaking the company down into elementary operational units (e.g. administration, production, logistics, export, maintenance). Next, the job posts in these units are classified into homogeneous exposure groups. Once the breakdown has been set out formally within a dedicated document, Phase 2 of the preliminary risk analysis may start.

3.2 Phase 2. Preliminary Risk Analysis

The goal of the preliminary risk analysis (PRA) is to identify all the dangers operators are exposed to and the risks arising from the exposure. An exhaustive identification of the dangers and risks is conducted for all homogeneous exposure groups within the various operational units. Deeply embedded in mainstream French ergonomics, the PRA first requires analyzing operators’ activity in the different job posts. Hence, all the on-site preliminary observations the OHS specialists carry out help describe all the operators’ activities and view them in the light of the corresponding dangers, risks, and damages. The analysis of activity also helps the OHS specialists determine the room for maneuver available to operators to enable them to keep operational control.

To carry out the PRA, OHS specialists need to fill in the grid shown in Table 1.

Table 1. The preliminary risk analysis grid

PRELIMINARY RISK ANALYSIS							
Work Situation	Operators' activity	Hazard	Risk	Type of risk (Chronic or Accidental)	Type of injury	Location of injury	Penibility factors ? (Yes or No)

To help them avoid potential errors, OHS specialists are given a predefined list of risks (Table 2). The Diarbenn method distinguishes between two main risk categories: 1. Quantitative risks that may be assessed through metrology, hence by using specific quantitative assessment methods usually related to regulatory thresholds not to be exceeded; 2. Qualitative risks that may only be assessed subjectively (or differently but with great difficulty). For this risk category, a single general assessment method has been proposed (see Sect. 3.3).

Table 2. Quantitative and qualitative risks

Quantitative risks related to:	Qualitative risks related to:
Noise	Occupational slips, trips and falls and other movement disturbances.
Vibrations *(hands-arm and whole body)*	Falls from height
Thermal environments (Heat & Cold)	Car travel
Physical workload	Physical activity, including musculoskeletal disorders
Manual handling of loads	Biological agents
Repetitive work activities	Mechanical handling
Chemical hazards	Work equipment
Fire	Collapsing and falling objects
Explosion	Electricity
	Ionizing radiations
	Psychosocial risks

The PRA represents the most important phase of the Diarbenn method as it enables OHS specialists to understand operators' activity together with activity-related constraints and resulting risks.

3.3 Phase 3. Occupational Risk Assessment

When all the risks have been identified and entered into the PRA grid, the OHS specialists may proceed with the assessment of the criticality level of each risk. Two criticality levels are taken into account, which leads to two distinct assessments: 1. The level of "raw" criticality, which is assessed first. This first assessment does not take into account any aggravating factors, the means of controlling the human, organizational, and technical (HOT) resources, and the available room for maneuver. As mentioned in the preceding section, risks are assessed through different methods. Quantitative risks are assessed using the results of the implementation of metrology techniques. In this particular case, the "raw" criticality level of any given risk depends upon the regulatory thresholds. Hence, the OHS specialists enter the corresponding "raw" criticality level in their assessment grid. For qualitative risks, the "raw" criticality level is assessed through a generic method shown in Appendix 1 (see Tables 5 and 6) based upon the failure mode, effects, and criticality analysis (FMECA) method. 2. The level of "residual" criticality that is assessed second, which takes into account all aggravating factors, the HOT dimension, and the available room for maneuver. To assess this second level of criticality, OHS specialists use a second matrix (see Appendix 1, Table 7). The results of this second assessment (i.e. of the residual criticality level) are used to determine the needed remedial actions. The OHS specialists' understanding of the operators' activity is essential for them to be able to assess accurately this level of residual criticality.

The Diarbenn method involves conducting the assessment of two criticality levels, whereas many other methods call for the examination of residual criticality only, which is problematic because a low level of residual criticality may hide a high level of raw criticality. In this case, it is the HOT dimension, the aggravating factors, and the available room for maneuver that induce a low level of residual criticality. Should these three parameters deteriorate gradually while the company is unaware of the changes, the result would be dissonance between the actual level of residual criticality and that recorded in the document presenting the occupational risk assessment results. Taking both criticality levels into account enables the company to monitor its risk control process but also the available room for maneuver.

Table 3 shows the risk assessment grid the OHS specialists fill in, which is matched with the PRA grid (see Table 1).

Table 3. The risk assessment grid

RISK ASSESSMENT PROCESS														
First Criticality Assessment				Aggravating factors					Risk control				Second Criticality Assessment	Comments
Severity	Probability	Exposure duration	Criticality level	Gender	Age	Nightwork	Shiftwork	Lighting conditions	Technical	Human	Organizational	Lack of room to maneuver		

3.4 Phase 4. Implementing and Monitoring the Action Plans

After assessing the second criticality level (i.e. residual criticality) in Phase 3, the OHS specialists are in a position to propose and prioritize a set of actions that need to be implemented within the framework of OHS management.

In addition to the two grids shown earlier, the OHS specialists fill in the following table (Table 4). Hence, they are able to coordinate and monitor the implementation progress of their action plan.

Table 4. The action planning grid

ACTION PLANNING		
Action type	Action manager	Deadline

The Diarbenn method has been implemented in a software program especially developed to facilitate the activities of the OHS specialists. Its user interface enables them to configure their risk assessment methods for Phase 3, to fill in all the grids in the same table, to monitor their action plan, and to produce a document showing all the occupational risk assessment results, namely the "Single Document" that is legally required. This document is then made available to all the company employees and represents a genuine prevention tool. It is dynamic, since it is updated regularly, in particular when changes are made to the various job posts. Hence, the OHS specialists can remain vigilant regarding the operating conditions in effect at the different job posts.

An excerpt from a risk assessment table produced with the Diarbenn program can be found in Appendix 2.

4 Discussion/Conclusion

The Diarbenn method was first created to meet the regulatory constraints in the domain of OHS management. As a second step, it was modified to contribute to the development of the four abilities of organizational resilience [2] at the sharp-end level, namely, to anticipate, monitor, respond, and learn.

The Ability to Anticipate. The risk assessment process implemented through the Diarbenn method is proactive by nature. It helps anticipate all the situations that may lead to loss of operational control. In this respect, it contributes significantly to the development of the ability to anticipate that characterizes any resilient organization.

The Ability to Monitor. The Diarbenn method is a means to support the occupational risk assessment process that constitutes the backbone of any risk management system. This method is based upon two main pillars: 1. The analysis of operators' activity; 2. The assessment of two levels of criticality. From the perspective of resilience engineering, these two pillars are crucial since they contribute directly to keeping operations within an operating space that is viewed as safe. Phases 2 (i.e. the preliminary risk analysis) and 3 (i.e. the risk assessment process) enable the OHS specialists to identify, within the various work situations examined, all the conditions that may lead to the loss of operational control and, in particular, the situation of the available room for maneuver. The operators' ability to adapt depends partly upon the room for maneuver that is available to them [14–16]. A significant step for resilience is the ability to determine the situation of the room for maneuver at the PRA stage and then to take that description into account when assessing the risks operators have to face. Similarly, assessing both criticality levels (i.e. raw and residual criticality) facilitates monitoring the organization from the perspective of its capacity to retain its available room for maneuver and HOT resources. It is essential to be able to identify the nature of the risk encountered in case the organization loses its room for maneuver and HOT resources. Hence, the Diarbenn method contributes to the accurate assessment of the operators' adaptability within their occupational activities, and it helps strengthen the monitoring capacity of the organization regarding the various items that may induce the loss of operational control. This monitoring capacity is essential to any resilient organization. The Single Document also fosters the development of this monitoring capacity because all the organization employees are expected to be aware of it; hence, they are in a position to know the nature of the dangers and risks present in their environment to which they are directly or indirectly exposed.

The Ability to Respond. Following the risk assessment phase, the action plans implemented to deal with the critical risks contribute to the development of the ability to respond of the organization. These actions are intended to contribute to maintaining the organization in an operational space viewed as safe through strengthening the operational control process. Furthermore, regular updating makes the Single Document a genuine prevention tool that also contributes to the development of the response capacity. Any deviation identified by the OHS specialists induces an update; hence, a response is given to a specific situation.

The Ability to Learn. When any accident, occupational disease, catastrophe, and/or incident occurs in an organization, fingers are often pointed at the risk assessment process. This type of event is indicative of the loss of operational control that has poorly, or not at all been anticipated in the Single Document. This type of situation leads the OHS specialists to analyze the causes of the event occurrence and take those into account in the risk assessment process. The workplace situation is once again analyzed following the Diarbenn method. The feedback thus obtained contributes to developing the ability to learn of the organization.

The Diarbenn method, embedded in mainstream French ergonomics, thus represents a tool that contributes to the development of the four resilience abilities of an organization. Implementing it is part of a grounded managerial approach focused upon the operators' activity and located at the sharp-end level. When presenting this approach, a comparison with the Australian approach will be conducted in order to identify the areas of convergence and divergence and the potential developments of the approach.

Appendix 1: The Generic Risk Assessment Method (Qualitative Risks)

Table 5. Probability and severity levels

	ACCIDENTAL RISK	
LEVEL	SEVERITY	PROBABILITY
L1	Accident without treatment	Has never occurred and improbable
L2	Accident with treatment but without work incapacity	Has never occurred but probable
L3	Accident with treatment and partial work incapacity	Has already occurred at least once in three years
L4	Fatal accident or total work incapacity	Occurs at least once a year

	CHRONIC RISK	
LEVEL	SEVERITY	EXPOSURE DURATION
L1	Short-term disability, without reduction of work capacity	Exceptional: 1 to 2 hours per quarter
L2	Chronic disability, without reduction of work capacity	Occasional: 1 to 2 hours per month
L3	Disabling impairment, with reduction of work capacity	Regular but discontinuous: 1 hour per week
L4	Fatal disability or severely disabling	Continuous: more than 1 hour per day

Table 6. Matrix for the first criticality assessment

		Severity			
	LEVEL	L1	L2	L3	L4
Probability OR Exposure Duration	L1	A (SL1)	A (SL2)	B (SL3)	B (SL4)
	L2	A (SL1)	A (SL2)	B (SL3)	C (SL4)
	L3	A (SL1)	B (SL2)	C (SL3)	C (SL4)
	L4	B (SL1)	B (SL2)	C (SL3)	C (SL4)

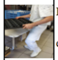
Table 7. Matrix for the second criticality assessment

	RISK CONTROL		
FIRST CRITICALITY ASSESSMENT RESULT	HIGH	INTERMEDIATE	LOW
Criticality LEVEL 1			
Criticality LEVEL 2			
Criticality LEVEL 3			
SECOND CRITICALITY ASSESSMENT			

Immediate action
Medium-term action
Level to maintain

Appendix 2: The Complete Risk Assessment Grid (Example)

Work Unit | UNIT 1 | PRODUCTION

PRELIMINARY RISK ANALYSIS								RISK ASSESSMENT PROCESS															ACTION PLANNING		
								First Criticality Assessment				Aggravating factors					Risk control								
Work Situation	Operators' activity	Hazard	Risk	Type of risk (Chronic or Accidental)	Type of injury	Location of injury	Penibility factors ? (Yes or No)	Severity	Probability	Exposure duration	Criticality level	Gender	Age	Nightwork	Shiftwork	Lighting conditions	Technical	Human	Organizational	Lack of room to maneuver	Second Criticality Assessment	Comments	Action type	Action manager	Deadline
Making cakes	 Making the dough	Machine	Risk related to work equipment	C	Crushing	Hands and arms	No	S2		D2	A(SL2)				x		Operational maintenance	Training	Turnover	x		Time pressure too important	Rearrange tasks + reduce time pressure	Andrew	30/03/2019
	 Preparing the equipment	Weight of the hob	Risk related to physical activity, including musculoskeletal disorders	C	Musculoskeletal disorders	Upper limbs	Yes	S1		D3	A(SL1)	x	x				Adapted equipment	Training	Turnover			Need to remain vigilant	x	x	x
	 Cook the cakes	Gas	Explosion & Fire	A	Deaths, burns	The whole body	No	S4	P2		C(SL4)						Operational maintenance + fire extinguishers	Training	Turnover			Intensify gas detection	Intensify gas detection	Nicholas from maintenance department	01/07/2019
	 Check the cakes	Repetitiveness and gestures	Risk related to physical activity, including musculoskeletal disorders	C	Musculoskeletal disorders	Upper limbs	Yes	S2		D3	B(SL2)	x	x				Adapted equipment	Training	Turnover	x		Workstation not adapted	Modify the workplace	Andrew	01/07/2019
	 Stock the cakes	Weight of the hob	Risk related to manual handling of loads	C	Musculoskeletal disorders	Upper limbs	Yes	S3		D2	B(SL3)	x	x				Adapted equipment	Training	Turnover			Need to remain vigilant	x	x	x
	 Package the cakes	Machine	Risk related to work equipment	A	Cuts	Hands	No	S3	P2		B(SL3)				x		Individual protection equipment & Operational maintenance	Training	Turnover			Need to remain vigilant	x	x	x

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