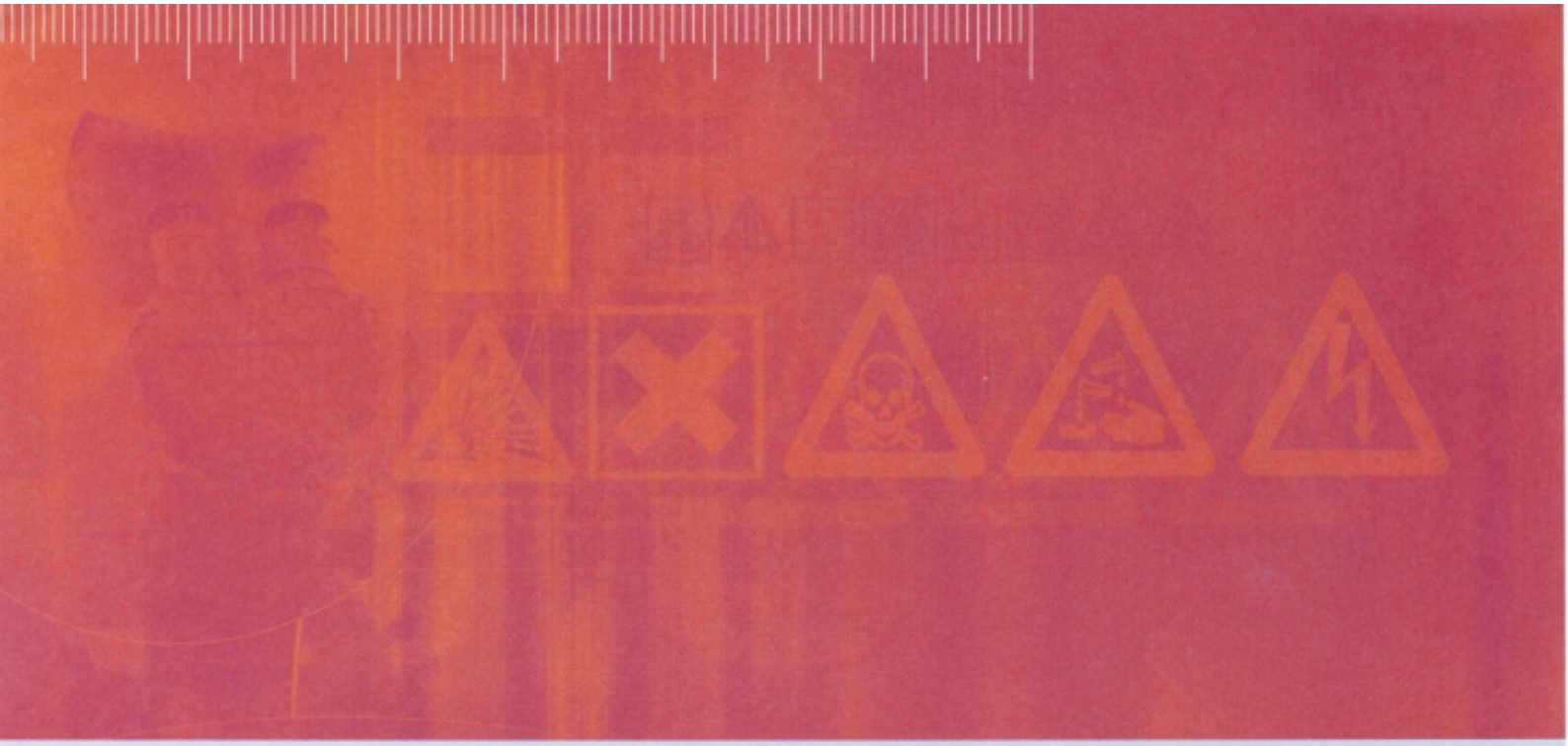

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DRA77 – Operation A

The Guide to Human and Organisational Factors (HOF) Engineering

INERIS
maîtriser le risque
pour un développement durable

DRA77 – Operation A
The Guide to Human and Organisational Factors (HOF) Engineering

Verneuil-en-Halatte, France

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Foreword

The developments which are presented in this document are based on numerous experimental studies and research in the area of industrial risks, in a great variety of systems, as well as INERIS's scientific publications in the area of Human and Social Sciences (HSS), indicated in the references of this guide. They are based on multidisciplinary knowledge acquired through research programmes or expert studies aimed at promoting a multidimensional approach to industrial safety.

1 INTRODUCTION

1.1 SUMMARY OF THE GUIDE

This HOF[1] engineering guide has the objective of proposing to industrial safety agents who are non-specialists of HOF reference points for a structured approach in the field of HOF in high-risk industry. Specifically, it indicates precisely what is understood by an HOF approach, lists the most common HOF approaches, simple mapping of them, and provides descriptive sheets (appendix A).

In addition, the guide presents a matrix to analyse the capabilities of HOF engineering to:

- first, to make an evaluation,
- second, to structure an action plan of HOF engineering.

This first version of the HOF engineering guide will be complemented (particularly the descriptive worksheets) and evolved from use and associated feedback.

1.2 OBJECTIVES AND LIMITS OF THE GUIDE

The objective of this guide is to propose a reference framework of HOF (Human and Organisational Factors) so as to better understand this field. This reference framework has the goal of allowing safety agents to clarify the HOF commitment of high risk businesses by use of a tool which maps the great diversity of existing approaches and the conditions for implementing HOF engineering in a given business according to past experience and available resources.

In fine, this guide should allow an organisation to evaluate its commitment to HOF and help to structure its policies in this field.

This guide does not supply:

- a procedure to implement a specific or generic HOF approach: methodological aspects of HOF approaches are not described (ordering of activity observation techniques, individual or group interviews techniques, leading working groups, etc.) To find this type of information, the reader should consult academic methodological guides or publications by institutional agents or consultants.
- a critical opinion on the logged HOF approaches: limits, specific successful conditions, possible misuses… The approaches are described non-critically.

[1] Human and Organisational Factors

1.3 ICPE FACILITIES IN RELATION TO OTHER RISK SYSTEMS

Since many years ago, numerous and diverse experiments within high risk industries exist, including aeronautics, nuclear or Classified Installations for the Protection of the Environment (ICPE) in the field known as HOF. For each at-risk sector, such as nuclear, aviation, or railway transportation, there is a specific history concerning the introduction of HOF engineering approaches. HOF experts in these major branches have at certain occasions expressed themselves to give a point of view setting forth the specific methods they have implemented (Lagrange, 2011, nuclear, Figarol, 2010, air-traffic control), developed research programmes (Blatter, 2004, railways) or even the implementation of a network of HOF specialists or consultants (Vautier, 2010, CEA).

Historic events (for example accidents), institutional contexts (regulation, organisation of monitoring authorities) but also international instances (IAEA - nuclear, ICAO - aviation) of these different at risk systems have specifically configured the commitment to these Human and Organisational Factors approaches (cf. Comparative study of the integration of HOF in high risk industries, INERIS, 2014). For example, for nuclear energy production in France, by considering the operator Electricité de France (EDF), the institutional and organisational configuration in relation to HOF approaches is based in a simplified manner on:

- internal means at EDF on HOF (e.g. HSS department in R&D), with interactions with universities and specialised consultants in HOF;
- a network of facilitators (e.g. on-site HF consultants in the nuclear plant) but also;
- external surveillance oriented on this theme (e.g. HOF specialist of IRSN (French Institute for Radiological Protection and Nuclear Safety) supported by ASN (French Authority of Nuclear Safety), as well as a permanent group of authorities and operators on this theme which holds regular meetings);
- a profession organised on the international level, with the production of guides and standards in HOF (e.g. IAEA (International Atomic Energy Agency), 'safety culture', WANO (World Association of Nuclear Operators));
- 'governance' on this theme led by the ASN (in which numerous agents participate).

This industrial branch thus has means and resources that are incomparable to those of the agro-food industry, which also belongs to realm of Installations Classified for the Protection of the Environment (ICPE). In this industrial domain, internal means, monitoring and the dynamic of the profession or national or international associations on the theme of HOF are different from those in nuclear. It is not a question of criticizing this sector but to use it as a means of measuring the importance of contexts.

Thus, it is important to keep in mind that the means and resources of a business, and a sector overall, condition the deployment possibilities for an HOF engineering approach. This idea is central in this guide.

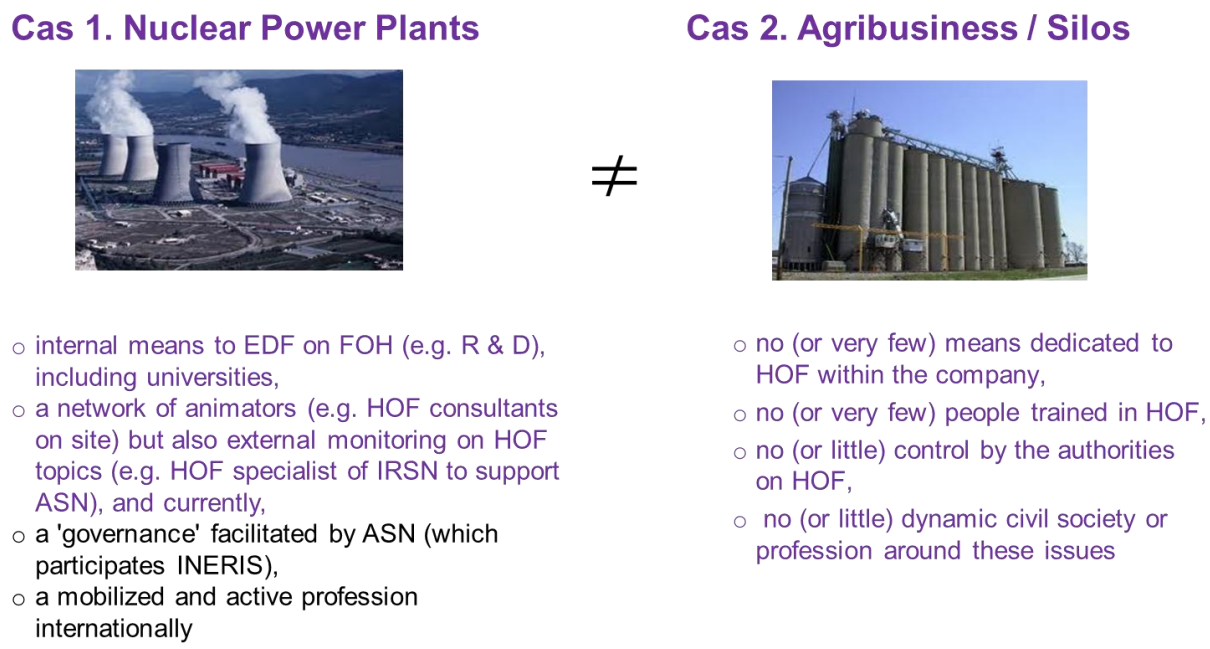

Figure 1: Differences between high risk systems on the level of HOF means and resources

1.4 WHAT DO WE MEAN BY AN HOF ENGINEERING APPROACH?

The term "engineering" as used in this document insists on the transformation dimension. HOF engineering proposes concrete solutions to previously identified problems (from the point of view of the business, following incidents, for example, or on the basis of a more or less explicit approach of evaluation or diagnostics).

In this engineering guide, evaluation is considered to be the first essential stage in HOF engineering, which, even in the absence of a precise action plan, will change the vision of certain members of the business. The notion of HOF evaluation is the subject of several specific studies by INERIS (development of the ATHOS safety model proposing Technical, Human and Organisational Safety Analysis), and the present document does not have the objective of describing them.

The goal of this guide is to make clearer the stages of HOF engineering, which consists by passing from an organisation in which the principles of human and organisational factors are absent (at least in discourse, certain practices can be in the back of one's mind) to an organisation in which HOF are at the heart of daily activities (*Figure **2***).

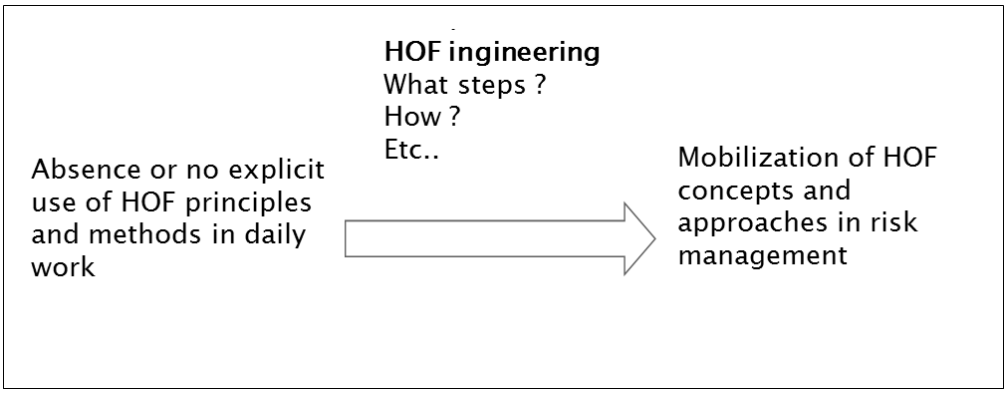

Figure 2 : HOF Engineering

1.5 WHY AN HOF ENGINEERING APPROACH?

High risk plants have implemented HOF approaches so as to give themselves the means to understand and react in complex systems combining social and technological dimensions, in order to prevent large scale accidents, particularly by:

- better understanding the interactions between men and interfaces, which are becoming more and more automatic and computerised;
- better describing the interactions within work collectives belonging to different judicial entities (externalisation);
- better taking into account the impacts of organisational changes on the quality of the coordination and cooperation between departments;
- better understanding the process of collective learning related to high-risk technological phenomena, etc.

Thanks to this growth in empirical and solid conceptual knowledge, these HOF approaches bear a significant contribution to safety, facing high civil societal expectations and a growing need of plant operators to demonstrate an acute understanding of socio-technological phenomena related to the dynamics of accidents and safety.

1.6 THE GREAT DIVERSITY OF HOF APPROACHES

Today there exist a great diversity of HOF approaches in the ICPE, which correspond to as many different manners of understanding HOF. Moreover, there is no standard definition in this field. This guide proposes a definition, which seeks to combine several aspects.

HOF Definition (INERIS)
"Human and Organisational Factors (HOF)" approaches designate **multidisciplinary** approaches that mobilise knowledge, models, and techniques from the Human and Social Sciences in order to understand **socio-technological** systems in their **actual operation**. These approaches thus apply to the evaluation of these systems, feedback and design, with an objective of preventing industrial and professional risks.

This definition distinguishes HSS (Human and Social Science) knowledge from HOF (Human and Organisational Factors) approaches. HOF approaches are actually developed based more or less explicitly on knowledge from the field of HSS. It is interesting to distinguish these two aspects in order to indicate the applicative dimension of HOF in relation to HSS knowledge. These lead, indeed, to the practical outcome expected from HOF approaches in industry. HOF approaches are used by industry for specific problems and their pertinence is drawn from their applications and the satisfaction that businesses draw from them. HSS knowledge is developed in research areas that allow advances in knowledge in relation to a diversity of problems in diverse scientific disciplines. There is no opposition, but rather interactions and complementary relations between HOF approaches and HSS knowledge.

Many possibilities of encounter with HOF exist in industries at risk. Examples:

- Study of the work of operators in the context of the design of a new Human Machine Interface, assisted by an external consultant specialised in ergonomics.
- Implementation of "safety talks" by a company's QHSE department in order to create dialogue and exchange between different agents on a daily basis, led by someone trained in this field.
- In-depth investigation following an accident by a specialised team of a large group (e.g. HOF consultants) for an industrial site, based on an "HOF" model accident.
- HOF awareness or training of employees of a business by a specialised consultant agency.
- Development of a "behavioural safety visit" approach based on the principle of an on-site presence of the hierarchy in order to approach real situations and conditions applying procedures.
- "Safety culture" diagnostic approach by an external consultant by means of perception questionnaires filled out by the majority of employees.

Certain businesses use several of these approaches at the same time. If such combinations are possible, it is sometimes difficult for organisations to understand their complementarity, but also the pertinence of leading several of these approaches while maintaining a global vision. It is also difficult for these companies to situate themselves in relation to all that is possible in this field when one has performed one

study, and the diversity of possibilities is nowhere explicit. Neither the contours nor the scope of the approaches are always clear, and thus confusion as to how to follow up on them can occur. Sometimes, equally, businesses believe one HOF intervention covers the entirety of the approach.

This situation can sometimes destabilise organisations that wish to go forth with an HOF engineering approach and have difficulties determining, faced with the diversity of possible approaches in relation to disciplines as well as investigated situations, which track to follow. The goal of this first version of "The Guide to HOF Engineering" is to allow businesses wishing to undertake (or carry on) an HOF approach to step back and consider the bases of explicit principles. It is a question of identifying, calibrating and engaging in an HOF approach that is viable in relation to available resources, competencies and time of a business, but also in relation to the most significant dimensions for safety (i.e. what should be the first priority).

1.7 IMPORTANT NOTES

- ***Note 1***

It is not impossible that the practices of a business be very close to certain HOF approaches, even if this business has not made it explicit. For example, a business can implement a management of the gap between the prescribed and reality, without making different reference to contributions of ergonomics on this theme (e.g. activity theory). In this case, the engineering approach is to clarify to what extent these principles are long-term, but also other HOF fields that are not treated with these principles. One of the goals of engineering is to help businesses make explicit and valorise their HOF practices.

- ***Note 2***

The inverse situation can also be imagined. A business that posts and advertises HOF principles in its policies and resources may not actually be applying these principles in its daily operations (even if these elements–policies, resources–are important). Only knowledge of the true practices of the business in relation to its use of HOF approaches can allow the evaluation of the on-site implementation of these principles.

- ***Note 3***

HOF approaches enrich our understanding of the operation of collectives, business and man. What was treated previously in a rather implicit manner is now the subject of greater visibility by the intermediary of knowledge based on HSS. For example, taking into account the variability of practices, around a rule for operators in an operational context, requires a fine understanding of the activity, but also of man in the workplace. This enriching of our understanding of the actual activity becomes, after an immersion stage and concrete application, a gain on the operational level of the business and abilities to understand HOF phenomena related to safety.

1.8 THE GUIDE'S STRUCTURE

To treat this particularly complex subject, the approach proposed in this guide is to progress in two stages.
The first takes the reader into the universe of methods in the field of HOF. It places these methods by a mapping principle, allowing to situate them in relation to each other, retaining pertinent criteria in relation to the objective. This approach is complemented by the method sheets that describe their principle characteristics.
The second stage proposes to put these methods (and the associated mapping) in perspective in relation to the ability of businesses to use them. This second stage is the heart of HOF engineering. A matrix of HOF engineering and a self-evaluation grid are proposed to help organisations judge their current situation and to structure their reflection on future HOF actions.

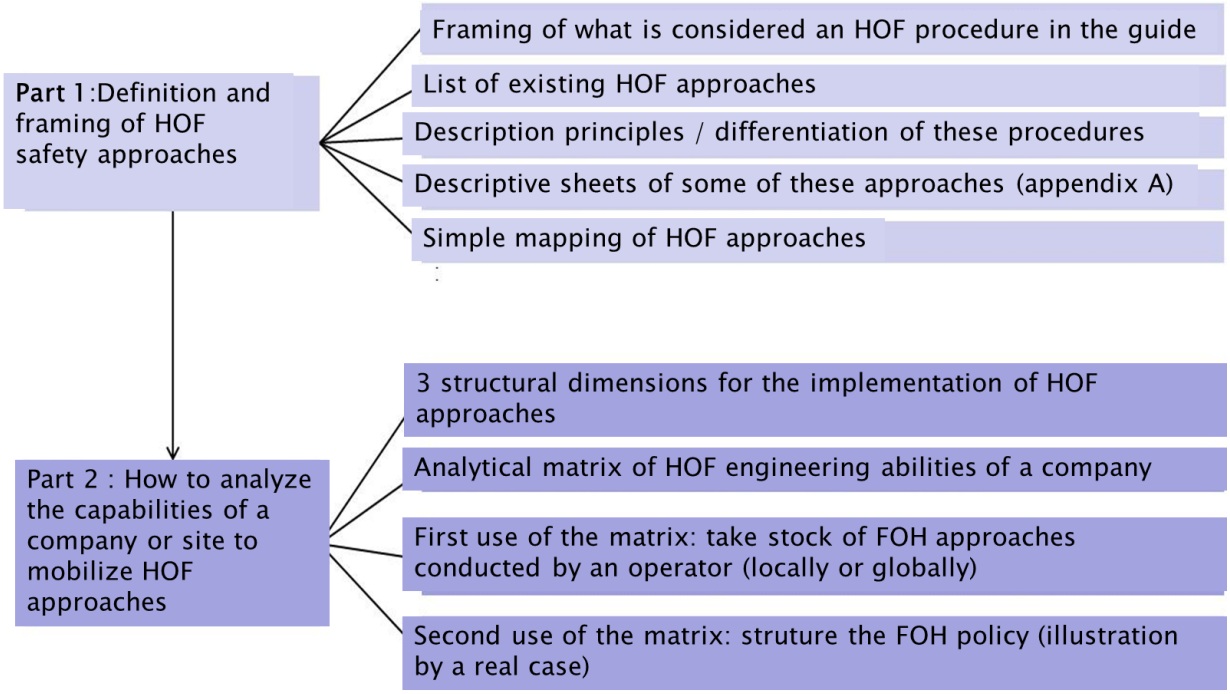

Figure 3: Structure of the guide

2 FIRST STAGE: DESCRIPTION OF HOF APPROACHES

In this first stage, it is a question of:

- specifying what we mean by an HOF approach;
- proposing a list of existing HOF approaches;
- mapping in a simple manner the diversity of HOF approaches.

2.1 CONCERNING HOF APPROACHES

Expertise in the field of HOF in industrial safety has developed over the last thirty years, based on HSS. It is accompanied by a range of approaches (knowledge, practices and techniques of data collection) which are potentially available to businesses. This knowledge, practices and techniques are the fruit of interactions between universities, industries (e.g. nuclear, aviation, chemistry), institutes and consultants. There is also abundant literature on the subject with numerous methods (work observation, interviewing techniques, questionnaires, etc.) representing a great number of disciplinary leanings and intellectual positions.

This document will not make an exhaustive review but rather propose descriptive principles so that the organisation already employing HOF approaches can better find their bearings. The goal of this guide is to allow businesses to situate themselves and understand the complexity of the subject, all while rendering it accessible. Indeed, there exists, on the one hand, university approaches of which the objective is to advance a field of knowledge within a research tradition, and, on the other hand, approaches that are primarily operational for businesses seeking viable solutions to problems they confront (in relation to their constraints and resources).

On the academic side, there is abundant literature which proposes descriptions of HOF approaches. Very numerous examples exist (e.g. Stanton et al, 2005). The audience of these works is experts in the field, so that their training and practice lead to the deployment of a certain level of conceptualisation. **On the side of operational methods,** which have the objective of taking into account human and/or organisational dimensions, numerous examples are also available. One can cite approaches said to be behaviourist (also called BBS or Behaviour Based Safety) or the "checklist." This classification is certainly a bit simplistic, for there exist possibilities of intermediary postures.

Thus, there exist academic research traditions having claimed practical finalities, such as ergonomics or management science, and which work with businesses with the objective of using them to resolve specific problems, by the production of ‘actionable knowledge’ (Avenier, Schmitt, 2007). Businesses also deploy approaches necessitating the mobilisation of an HSS expertise, be it internal (in the case of structures within large groups in high risk areas, such as nuclear, Lagrange, 2011) or external, calling upon specialised consulting agencies in relation to their needs.

This dichotomy, with, on the one hand, research destined to a knowledgeable public and, on the other, approaches usable by business with less HSS competency, all be it simplistic, provides structure in relation to the objective of this guide.

Thus, the choice of retained approaches, of which certain are presented in the form of sheets (appendix A) in this first version of the guide, is based on the three following criteria:

1. The selected approach must have been sufficiently applied and diffused to be visible for HOF experts in the field and for businesses, thus allowing feedback and the possibility of criticism (notably on its interest but also its limits);
2. The HOF approach must be as much as possible anchored in the literature and models of the HSS field in order to be able to assure a traceability between the principles and the background scientific concepts;
3. The approach necessitates for its implementation the mobilisation of a minimal competence in HOF, showing the introduction of principles of which the explanation, debate and criticism on the level of these HSS foundations, is possible.

This guide thus adopts an inclusive posture by taking into account so-called HOF approaches by industrial leaders and operators, even if HSS aspects are not explicit or even absent.

2.2 DESCRIPTION PRINCIPLE OF HOF APPROACHES

Up until this point, it has been a question of "approaches" without having described this notion. In the HOF field, there is not a normalised vocabulary. We retain here that an approach includes, at least:

- one (or more) background model(s) (e.g. on man, organisation, safety);
- methods or techniques for collecting data (e.g. questionnaires, interviews, observations, etc.) and,
- implementation principles (e.g. passage from description to the formulation of problems and solutions).

In order to not lose the reader in theoretical or methodological considerations, we will not use these three basic but too difficult descriptive aspects.
Others can bring information that is easier to understand by a non-specialist and which will allow the differentiation of HOF approaches, such as:

- levels of analysis (e.g. work station, the team, interaction between departments, etc.);
- degree of expertise required by the approach;
- time of intervention (e.g. design, daily, post-event);
- objectives (e.g. error reduction, communication in collectives, etc.);

- disciplinary anchoring and references (e.g. sociology, ergonomics, psychology, etc.);
- justification (e.g. regulations, incident, etc.);
- types of needs;
- concerned agents (e.g. operator, team leaders, directors, engineers, etc.);
- means/resources to be mobilised;
- efficiency,
- advantages and disadvantages for the business;
- key factors of success and failure;
- temporality;
- …

Certain of these appreciative elements were thus combined in the presentation sheets of the selected approaches in this first version of the engineering guide (table 1). This principle of descriptive sheets is then used in order to present the approaches (these are available in appendix A). The goal is to provide elements to describe an approach, without entering into detail about its implementation.

Title of the approach			
Objective (What is it for? What is the goal?)			
Structure and principles of the approach (how do you implement it?)			
Levels of analysis, degree of expertise and moments		**Methods for collecting data (inputs)**	**Produced results (outputs)**
Advantages	**Disadvantages**	**Scientific literature (debates / models)**	

Table 1. Content of a descriptive sheet for an approach.

2.3 IDENTIFICATION OF HOF APPROACHES

As indicated in the introduction, the diversity of approaches today is an obstacle for businesses wishing to analyse and reinforce their HOF practices.

Here is a non-exhaustive and unorganised list of HOF approaches representative of this multitude:

- checklist;
- ethnographic enquiry on safety with a diagnostic aim;

- safety talks;
- golden rules;
- event investigation using a causal tree;
- practices of reliability of human performance;
- safety management system (and audits);
- change management;
- in-depth and systemic enquiry of an accident;
- “safety culture” perception questionnaires (safety culture diagnostic);
- behavioural approach or BBS (or Behaviour Based Safety);
- safety visits;
- Crew (or Cockpit) Resource Management (CRM) training;
- Ergonomic work analysis;
- user-centred design;
- implementation of a feedback process.

This non-exhaustive list is established on the basis of knowledge of industrial practices and according to the previously announced criteria (§ 2.1). It includes approaches requiring specific expertise in HSS (e.g. ergonomics for activity analysis or sociology for ethnographic enquiry on safety) and approaches that require much less, such as "golden rules" or "safety talks," which can be implemented with very little expertise in HSS. It was nevertheless decided to conserve these latter in this guide in order to show the range of existing methods called HOF in industry, but also to question their limits (notably under the angle of the explanation of HSS models). They are representative of current discourse and approaches.

This posture has the advantage of helping to contrast the diversity of HOF approaches and to underline the central character of the level of expertise in HSS to implement them (this point will be developed more precisely in the second part of this guide). Moreover, these approaches apply to operators in the workplace both individually and collectively, and others aim or integrate a study of management functions and managers. In the first case, the HF approaches are primarily activated and derive from diverse disciplines of HSS (e.g. ergonomics, psychology, psycho-sociology), in the second, it is OF approaches which are called upon (e.g. sociology, management, political science) (*Figure 4*).

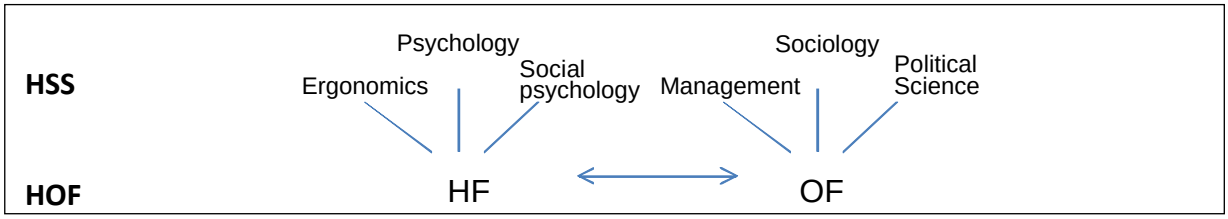

Figure 4: HSS disciplinary links and HF and OF approaches

2.4 CHOICE OF DESCRIBED APPROACHES BY MEANS OF THE SHEETS

In this first version of the guide, four approaches are described in the format of sheets, described in table 1. These are first presented succinctly in the following table (***Table 2***), then detailed in the sheets in Appendix A. They illustrate very different approaches.

HOF Approaches	Presentation elements	Sheet Number
"Safety Culture" approaches based on perception investigations	"Safety culture" approaches began being developed in the 90s and then through the 2000s. Some approaches were developed in the nuclear field following the Chernobyl accident in 1986, then progressively in other fields, such as chemicals and petrochemicals as well as aeronautics. The goal of these approaches is to understand the operation of the entirety of more or less vast units, with the aim of identifying cultural "springs" in the operation of an organisation. They are based on techniques and models that are sometimes very different, from the perception approach by means of a questionnaire to the ethnographic approach.	Sheet 1
Crew, Cockpit or Company Resource Management (CRM)	CRM-type approaches are inspired by training of the same name in the aviation field. They were implemented at the beginning of the 90s to respond to accidents in which non-technical factors were shown. CRM training was developed to limit risks by raising awareness of the strengths and weakness of H-H and H-M interactions. CRM approaches have offered solutions to other sectors for the last decade (medical, energy…).	Sheet 2
Checklist	The checklist has the goal of assuring that the steps of a task are followed by the agents responsible for performing it. This method is used in many industrial and high risk fields. The systematic dimension of the method should prevent omissions from occurring during sensitive situations and routine ones, in which attention may by elsewhere to the detriment of certain steps that are indispensable to the safety of operations.	Sheet 3

In-depth and systemic accident investigations	In-depth investigations of accidents have the goal, after major events, to investigate the involved human and organisational elements. By considering these dimensions, businesses seek to act on the level of recommendations that take into account for numerous aspects beyond technical, local or restricted causes, such as "human error." A great range of methods and models exists in this field since the 90s and 2000s.	Sheet 4

Table 2. HOF approaches described in this document.

2.5 MAPPING OF HOF APPROACHES

By crossing the first three criteria described in paragraph 2.2 (level of analysis, degree of HOF expertise, and intervention time), we obtain a map (*Figure 5*) proposing an overall vision of the approaches contained in the list in paragraph 2.3.

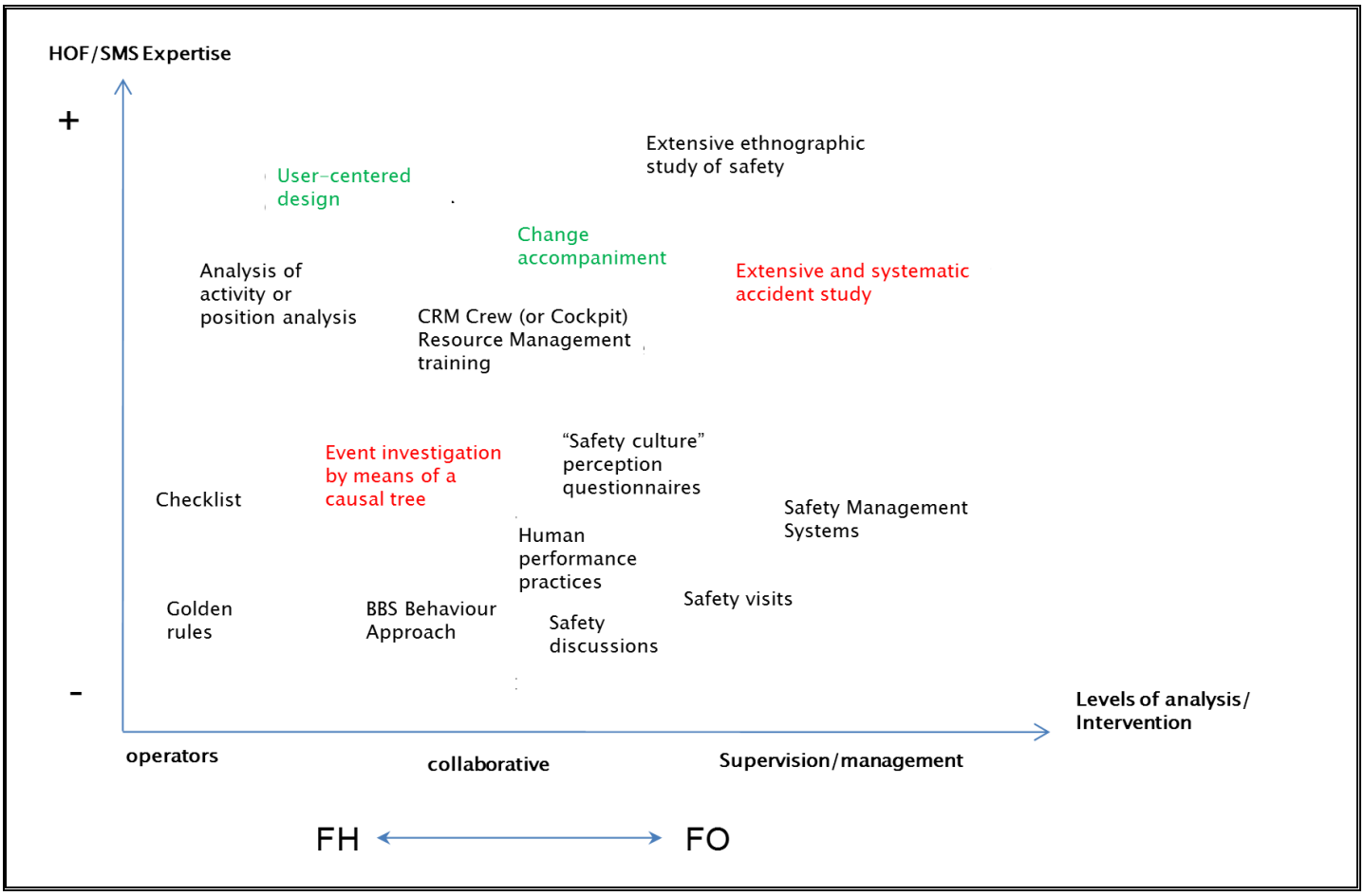

Figure 5: Mapping of HOF approaches.

The levels of analysis treated by the approach are along the horizontal axis, the degree of HOF expertise required along the vertical axis, and the intervention moments are colour coded. The three colours presented in the graphic represent the different moment when the approach intervenes:

- Green: design
- Black: operation
- Red: event analysis

From this mapping, we can observe that:

- The distribution of HOF approaches is homogenous, occupying all defined space, which shows that **HOF engineering is able to:**
  - be applied to different problems (the operator in his work station, a group in a workshop, the structure and operation of an organisation);
  - be adapted to different levels of expertise in the field of HSS.
- **Whatever the targeted level of intervention** (individual, collective, organisational), **HOF approaches of all levels of expertise are available**. The choice of implementing one or another requires knowing what one hopes to accomplish and to assure that the required competences are available in the short-, mid-, and long-term to guarantee the success and longevity of the approach.
- **One singular approach cannot cover the entirety of needs**. It is rather the synergy of HOF approaches within an organisation, allowing the treatment of the entirety of targets or organizational levels (individual, collective, organisation) in an adapted manner (level of mobilised expertise).
- There are HOF approaches for all different times in the life-cycle of a business (design, operation, post-event), although approaches treating operation are the most numerous. **It should be noted that certain approaches can be mobilised for a different period than that initially conceived by their designer**.

The three criteria (degree of expertise, level of analysis, and intervention time) used to map HOF approaches are now going to be used to frame the HOF approaches in a company. To do so, they are going to be defined and explained in the following paragraph.

3 SECOND STAGE: ANALYSIS OF THE HOF ENGINEERING ABILITIES OF A COMPANY

In this second stage, it is question of framing HOF engineering in order to define the concrete conditions of the implementation of approaches as well as their scope. One of the structuring principles of this guide is to go beyond the description of HOF approaches (sheets) to better take into consideration the concrete realities of their deployment. An approach depends indeed on the conditions in which it is implemented as well as its suitability to the problems it is meant to treat. The appreciation of these conditions and the implementation context of the approaches make up determining factors of every HOF approach, which we propose to treat in this chapter.

Thus, a great importance is given to the theme of engineering, the observation of available means and resources in the business to deploy these approaches. To elaborate a suitable framework, the three following steps are proposed:

- present an engineering matrix allowing one to “situate” the HOF approaches according to three structuring dimensions (described in this chapter)
- use the matrix to evaluate the HOF commitment of a company or a site
- guide and structure the choices of the business in relation to HOF engineering, basing its thoughts on the evaluation.

In the mapping of HOF approaches proposed in the preceding chapter (figure 3), two structuring dimensions of HOF engineering were identified: the necessary level of expertise for the implementation of the approach and the level of analysis of the approach.

To advance in engineering and help the company in its choices of HOF approaches, it is proposed to mobilise a complementary dimension. It is the period during which HOF methods are deployed. These periods are distinguished here between first, “design,” then “day-to-day” and finally “the event” (or “before,” “during”, and “after”).

Three dimensions, discussed below, are thus structuralising and taken up in the HOF engineering matrix:

1. the degree of expertise,
2. levels of analyses and,
3. intervention time.

The choice of these dimensions is based on INERIS research and feedback from studies led with companies on these questions of deployment of HOF approaches. The approach we propose depends therefore on concrete applications and choices and simplifications which reply to an operational objective.

3.1 DEGREE OF EXPERTISE, LEVELS OF ANALYSIS AND INTERVENTION TIMES: EXPLANATIONS

Degree of expertise

Three levels were retained for this criteria:

1. Professional “know how” (acquired through experience and the professionalism of individuals);
2. The awareness of different categories of personnel of HSS knowledge and HOF (and sometimes, their implementation);
3. Expertise in the field of HF or OF (ergonomics, sociology…), this experience may be:
   I. internal, and/or
   II. external.

As indicated in the introduction, a highly discriminating factor for mobilising HOF approaches is the **availability of expertise** in the field. The situations met on this point in industry are very contrasting:

- certain organisations have internal services with specialists in ergonomics or sociology;
- other companies find these competences in consulting agencies, more or less frequently, depending on the situations and problems encountered, or even following the demands of monitoring authorities;
- businesses increase awareness or train over varying time periods people of which the initial training was not in the HSS. In this case, depending on the training and the level obtained by these persons, they can identify the problematics and perform themselves studies, or else call upon a pertinent external expert according to the problems met (i.e. choice of consultant agencies, choice of the type of pertinent expertise).

When the organisation is of a certain size, these trained personnel can be one or a network of HOF facilitators who meet and draw from their different experiences to make up a common ground of HOF practices. A methodological and documentary corpus can then be developed, demonstrating a formal correspondence of this HOF knowledge and practices within the activities of the business.

When none of these degrees of expertise is available (i.e. initial training of specialists or increasing awareness / training of personnel), the degree of expertise will be considered in this guide to be level « 1 » in HOF competence in order to take into account the ‘**professional expertise’** of individuals. This term is used to designate technical and relational competences of different categories of personnel (operators, engineers, managers, etc.) acquired through experience. Indeed, HOF expertise is a

complementary quality that does not replace the professional expertise of business personnel, but rather goes with it.

To know more

It is the intersection of different degrees of HOF expertise (internal, external or training / developing awareness of personnel) and professional expertise that shapes the overall approach of the business to HOF. This interaction brings about an acculturation which corresponds concretely by means to confront problems as well as a vocabulary demonstrating the acquisition of the interpretation principles. HOF contributions are indeed conceptual and methodological. The emission of these concepts allows the company to progressively change its outlook on its practices. To the expressions of 'behaviour,' 'conformity' and 'respect of rules', are added those of 'understanding', 'adaptation' or 'variability'; to the vocabulary of 'structure', 'organigram' or 'process', little by little are added those of 'agents,' 'negotiation', 'regulation', 'identity' or 'strategy.' This new lexicon corresponds to a passage from one form of understanding to another, which is complementary, more anchored in the knowledge of HSS, principally ergonomic, cognitive and sociological.

Levels of analyses (and area of expertise)

The level of analysis, going back to the area of expertise, is equally very important. Indeed, two disciplines, such as ergonomics or sociology, for example, do not propose identical analyses, and are complementary. They offer different perspectives on business operations at risk, with different purposes and with different analysis levels.

In order to be pragmatic, two levels are considered in the engineering matrix that we propose in the following chapter:

- **The 'HF' level**, which treats work situations, individuals or groups and interaction with their diverse material or symbolic interfaces. This is the subject of disciplines such as ergonomics, psychology and social psychology. Traditionally (and historically), operators are the subject of specific studies in these disciplines, even if other categories of agents may be concerned;
- **The 'OF' level**. It includes disciplines such as sociology, management science, and political science, and introduces, on the one hand, the study of other categories of agents (engineers, managers, directors, regulators) and, on the other hand, concepts to reflect upon the business overall.

This somewhat minimising proposition does not allow for all the nuances that it should to present a more academic perspective, but that is not the objective of this guide.

These choices have a practical bearing:

a. HF: more on operators and collectives;

b. OF: more on management, services, directors and regulations.

To know more

Ergonomics is a discipline whose objective is to adapt work to humans and is traditionally associated to the study of work stations and the design of work environments, taking into account physiological, psychic, cognitive realities as well as social situations (Falzon, 2004). Sociology is a discipline that brings means of organisational analysis, taking into account the interactions of different categories of members of the business (Vrancken, Kuty, 2001, Osty, Uhalde, 2007). These distinctions, simplified here for our purposes, are very important. We might also discuss other disciplinary trends that equally propose alternative breakdowns: psychology, psycho-sociology, management science, political science, etc. It is not a question of opposing or stating which approach is more legitimate than the other, but to highlight a principle of pluralism that recognizes a diversity of viewpoints (Dupré, Le Coze, 2014, Le Coze, 2014). On the level of HOF engineering and related business approaches, it is therefore appropriate to clearly define the level of analyses, and thus field of expertise being mobilised.

Intervention moments

Three times are considered:

a. before (corresponding activity: design);

b. during (corresponding activities: day-to-day, operations, maintenance …);

c. after (post-event, corresponding activities: feedback or crisis management).

These moments allow the targeting of business activities in time and correspond to the large families of HOF approaches.

The first period, **design**, concerns this important step in the life of businesses when new installations or new organisational structures are envisioned. It is given the temporal marker '**before**.' Numerous methodological possibilities are proposed, from 'user-centred design' in ergonomics to 'change management' in sociology, for example. "Checklist" and "SMS review" (safety management system) are also approaches that are met and deployed in relation to the business's appreciation of in-progress modifications, these approaches sometimes being related to those implemented before the new actions.

The second period, **day-to-day**, corresponds to the operation of the activities of the business such as production, maintenance or even safety in daily situations in the life of the business. This period of time is designated by the expression '**during'**.

Finally, the third period**, post-event**, is focalised on anomalies, incidents or accidents. It is '**after'**.

For each of these periods, HOF approaches are available, from "causal trees" to "in-depth and systemic investigation," or methods to analyse daily work situations: "safety visits" through "workplace analysis."

Note

This grouping of activities in respect to time markers (before, during, after) is compatible with the lifecycle of a business, its design, installation, operation, maintenance, and dismantlement. Design and installation can be grouped together in 'before,' operation, maintenance and dismantlement in 'during.' 'After' remains the feedback activity (or management of emergency situations) during these different stages in the lifecycle.

3.2 PRESENTATION OF INERIS'S MATRIX FOR HOF ENGINEERING

The HOF engineering matrix that we propose is made up of three inputs:

1. Available expertise for the business, three levels:
    1. Professional "know how" (acquired through experience and the professionalism of individuals);
    2. The awareness of different categories of personnel to HSS knowledge and HOF (and their place in the work chain);
    3. Expertise in the field of HF or OF, this expertise could be:
        i. internal, and/or
        ii. external (noted 4 in the matrix).
2. The levels of analysis and fields of expertise :
    a. HF: rather operators and groups;
    b. OF: rather management, services, upper management and regulations.
3. The time in which methods and expertise are implemented:
    a. during design (before);
    b. day-to-day (during);
    c. post-event (after).

By crossing these entries, we obtain the 3-dimensional HOF engineering matrix (table 3). A completed version of this matrix following a real case is proposed in paragraph 3.3.2 (table 4).

	Before				During				After			
HF	1 *Expertise métier*				1				1			
	2 *Sensibilisation HOF/réseau*				2				2			
	3 *Expertise HOF (internalisée)*		4 *Expertise HOF (externalisée)*		3		4		3		4	
OF	1 *Expertise métier*				1				1			
	2 *Sensibilisation HOF/réseau*				2				2			
	3 *Expertise HOF (internalise*		4 *Expertise HOF (externalisée)*		3		4		3		4	

Table 3. INERIS matrix of HOF engineering

3.3 THE TWO USES OF THE MATRIX: EVALUATING AND STRUCTURING HOF ENGINEERING

How is this matrix to be used? By looking specifically at what the business does in the HOF field in order to (1) position it (2) envision what it would like to implement thereafter.
Two uses are thus proposed: **evaluate** the HOF commitment of the business, and **help it to structure** the choice and implementation of a future HOF approach.

3.3.1 Evaluation of HOF engineering: a self-evaluation grid

The first thing that is proposed to businesses is to help them establish a report, by means of a self-evaluation grid. It is a series of questions which ensue from the structuration proposed by the matrix, taking up the three criteria and which help to position it. These questions may be asked by a person or a group of people in the business responsible for establishing this report (or by external consultants). The questions are introduced in the following boxes (boxes 1, 2 and 3).

Box 1:Self-evaluation questions on the criteria of degree of expertise

Expertise
What is the degree of expertise available in the business in the field of HOF?
Is this expertise more in the field of ergonomics (HF) or sociology (OF)?
Is this expertise internal or external?
How often is this expertise called upon by the business?
Is it expertise that depends on the development of awareness of the business's personnel?
In what field(s) have these persons been trained in?
Was this awareness accompanied by a concrete implementation of the acquired knowledge?
Is there an organisation or network of HOF-trained or experts exist in the business that meets regularly?
Where is this expertise situated in the organisation: in what department(s)?
Is there a centralisation and coordination of this expertise in the business?
Do the implemented methods correspond to the level of available expertise?
Who can call upon HOF expertise (internal or external) within the organisation?
Does the business have HOF documents spelling out the policies, principles, and HOF methods of the business?

Box 2 : Self-evaluation questions on the criteria of the level of analysis

Level of analysis

What studies or approaches were led in the field of HOF?

What agents and situations were observed and met during these HOF studies and approaches?

Were these studies and approaches applied to work stations?

Were these studies and approaches applied to the function of operational teams?

Did these studies and approaches center on the directional teams or relations between business departments?

Were these studies and approaches directed toward the operation of the board of directors from a safety angle (OF)?

Did these studies and approaches analyse the operation of the business and its interactions with subcontractors?

Box 3: Self-evaluation questions on the criteria of time of intervention

Time of intervention

At what occasions are HOF studies and approaches deployed?

Is it a question of studies and approaches that concern design phases during modification or of the project (before)?

Were these HOF studies and approaches implemented on a daily basis, such as during operation or maintenance (during)?

Were post-event (incident or accident) activities such as feedback or crisis management the subject of HOF studies or approaches? Were all these studies and approaches implemented regularly for these different moments or only occasionally, depending on circumstances?

Where is the business today? From the perspective of this report, one sees it through the questions—determining the degree of expertise available and mobilised (time, level of analysis) in this field by the business, and the actions that result from it, identifying concrete HOF experiences of this implemented expertise, from some methods and at some moments, in some overall strategy (table x).

This questioning is simple in principle but requires an in-depth enquiry to consider all angles, particularly for someone external to the organisation. Although a self-evaluation grid is proposed, this questioning is easier when the investigator has solid knowledge of HSS and HOF approaches. It is necessary to interview different members of the business, observe some of them, in order to measure the level of HOF engineering that is deployed.

With the help of this questioning, the company obtains an overall vision of the integration of HOF in its operations, as well as the possibilities for developments in fields where nothing had previously been engaged, depending on its needs.

To know more

The notion 'HOF experience' indicates those moments in the life of a business when HSS knowledge, by the intermediary of HOF methods (brought by those familiar with or experts in the field), are diffused. This emission relies on the observation of concrete results in the implementation of HOF concepts and methods. The fruit of these experiences, the number of agents making concrete use or participating in concrete use of this knowledge, varies in relation to the levels of analysis and degree of implication of different categories of the personnel. It is at the juncture of professional expertise and HOF expertise in real situations that the acculturation of a business develops.

3.3.2 Report of HOF engineering: illustration with a concrete case

The case presented below is fictitious. It was however developed on the basis of real cases.

Box 4: Study of an illustrative case

The company has a person responsible for facilitating HOF questions, called the HOF facilitator. This mission was desired by the director following a serious accident several years before that put into question traditional approaches. This business has 80 employees and approximately 40 subcontractors (two service providers). It is organised in production / logistics, safety / quality / environment / health, maintenance / inspection, methods, human resources, purchasing and management departments. The HOF facilitator had no initial training in this field, is part of the safety/quality/environment/health department, and was later trained on the subject, primarily on HF methods. He has been in contact for several years with an ergonomics (HF) consultant. This interaction allows him to implement his knowledge and to become familiar with expertise in the field. The company calls upon this external resource from time to time to help with projects to modify its facilities, deploying a user-centred approach (taking into account the actual activity of operators). The business's HOF facilitator launched two projects that he is responsible for: (1) safety visits and (2) implementation of accident investigations using causal trees. Moreover, a day-long awareness session was held for the entirety of the personnel, with an external consultant, concentrated principally on HF approaches and methods. In addition, the business requires that its providers make its personnel aware of HOF. These expectations are written out by the safety facilitator in the context of the call for proposals and requirements specifications. All these approaches are introduced into the business's safety management system in order to link them to the more classic approaches implemented by the business several years previously.

For such a case, it is necessary to reflect systematically about what is done by the business and described in the box, taking up the 3 dimensions of the HOF engineering matrix:

1. What is the degree of expertise in HSS for the implementation of the HOF methods?

Three degrees of expertise appear:

- an external consultant who intervenes on design problematics from time to time, in relation to modification projects of the business, their complexity and their importance;
- an internal facilitator who was trained in HF methods to be able to accompany the company's approach, supported by management, who is implementing two projects: safety visits and accident analyses (based on causal trees);
- an awareness of the entirety of the personnel to HF problematics (human error, behaviour, group phenomenon, etc.).

2. What are the mobilised levels of analysis and field of expertise?

It is principally knowledge and levels of analysis relative to HF that are deployed:

- the external consultants are specialists in ergonomics;
- the training of the facilitator and the overall awareness of the personnel bears principally on HF, and little, even not at all, on OF approaches.

3. What moments are concerned?

One may note that:

- the intervention of the external ergonomist bears on the modification of facilities (design, thus 'before');
- the facilitator launches a project of safety visits (day-to-day, thus 'during) and accident analysis (post-event, thus 'after');
- the facilitator is writing a requirements specification guide as well as an introduction of these two approaches in the business's SMS (day-to-day, thus 'during').

Now that all this information is collected, it is possible to fill out the matrix (table 4).

		Before			During			After			
HF	1	/			1	Project in progress to deploy "safety visits" for the operators by the HOF consultant and following the awareness of all of the personnel		1	In progress project for the safety facilitator for deployment, by operators in different departments, of accident analysis.		*Professional expertise*
	2	/			2	The HOF-trained facilitator implements two HOF projects including safety visit. HOF facilitator writes awareness expectations of the provider		2	The HOF-trained facilitator implements two HOF projects including accident analysis. Participation in certain foreseen analyses.		*HOF/network awareness*
	3	/	4	Ergonomic consultant for installation modifications.	3	/	4	External consultant for FOH awareness session for all personnel	3	/	4	/	*HOF expertise internalised (3) or externalised (4)*
OF	1	/			1	Integration of HOF activities in the company's management system.			1	/			*Professional expertise*
	2	/			2	/			2	/			*HOF/network awareness*
	3	/	4	/	3	/	4	/	3	/	4	/	*HOF expertise internalised (3) or externalised (4)*

Table 4. Illustration of engineering from a case study

This representation can thus serve as a report for the business in question but also as a springboard for HOF engineering, highlighting the fields that have been developed and those that should, depending on business operations. These choices are those of company management, activation thresholds of associated means and resources being dependent on the context of the business (including regulations) and of its capacities to invest.

3.4 STRUCTURING AN HOF ENGINEERING APPROACH

The structuration of an HOF engineering approach makes explicit the steps and means to be implemented in order to mobilise the HOF concepts and approaches to manage business risks (figure 6).

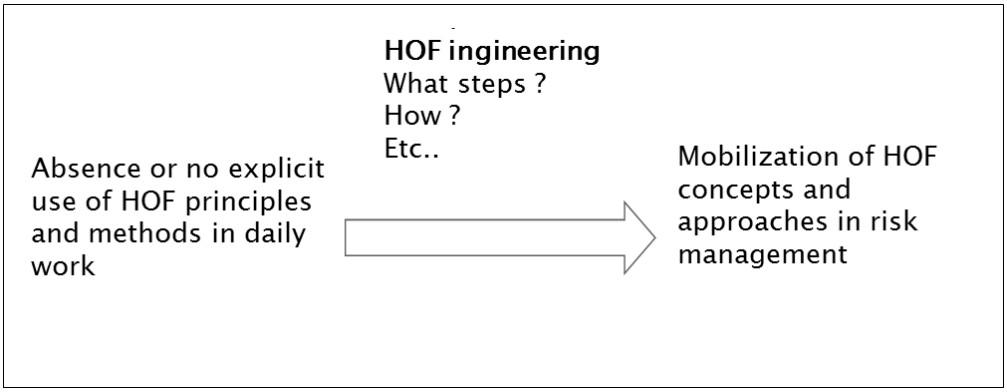

Figure 6. HOF Engineering

3.4.1 Support and questioning for the structuration of an HOF approach

Once the report has been completed, it is possible to construct the company's approach in a systematic manner. The different boxes in the matrix that served as a reference for the report now serve as references for a questioning on the means and resources that the company wants to maintain or increase (***Table 5***).

		Avant				Pendant				Après			
FH	1	?				1	?			1	?		
	2	?				2	?			2	?		
	3	?	4	?		3	?	4	?	3	?	4	?
FO	1	?				1	?			1	?		
	2	?				2	?			2	?		
	3	?	4	?		3	?	4	?	3	?	4	?

Table 5. Table to build an HOF engineering approach

For this, the business must first ask itself questions about its context (box 5), notably in relation to the constraints and resources it has to deploy its approach.

Box 5: Questions to construct an engineering approach: Context.

Business context

What is the business environment (or of a site within a group) from the viewpoint of HOF?

Do there exist external requirements from authorities (regulatory, local) or the profession (guide)?

Is the group making explicit demands which must have repercussions in different branches and sites (new tools, new organisations)?

Did an accident show the limits of classic approaches for the business, which now wishes to advance in HOF?

Is there a current managerial tendency pushing the business to introduce HOF questions?

The company must then decide the deployment structure of its HOF engineering by replying to a certain number of questions in box 6.

Box 6: Questions to construct an HOF engineering approach: Structure of the approach.

Structure of the HOF engineering approach

What activities and operational problematics have priority?

What moments and level of analysis will be considered first?

What will be the structure of the HOF engineering approach?

- Will it begin by targeted analyses on already identified problematics, or on a timely basis?
- Will you first train / increase awareness of HOF resource personnel in the business?
- Is it foreseen to launch a group approach, general mobilisation by means of working groups and questionnaires?
- Will outside experts be called in to evaluate the overall situation before deciding which approach to follow?
- Will several of these strategies be undertaken simultaneously?
- Will these approaches be coordinated by one person, a department, several people, or several departments?
- How much time will the business dedicate to the implementation of this project?
- What HOF methods are favoured?

3.4.2 Illustration using the case study

Based on this case study, the use of the matrix for the report indicates the boxes where no action had been taken (table 3). For example, no internal or external expertise had been mobilised concerning event analyses, be it at an HF or OF level. Is this a deliberate choice of the company? Likewise, no action was led by the HOF facilitator on design activities. Was this noticed by the company? Was it meant to be considered later so that, for example, those responsible for design could introduce HF dimensions in their processes?

These questions can also be asked in a systematic manner to envision the future structuration of the HOF action plan, in relation to the available means and resources.

In the case of this company, the following action plan was enacted:

1. Mobilise an external OF consultant (sociology) to aid in the absorption by the company of a smaller company in the same sector. This action has two goals:
    - anticipate problems that change can cause in the flow of information and on the quality of negotiations between the different objectives of the company;
    - make the company aware of the OF approach and envision using this approach for feedback following a relatively grave incident in order to test its pertinence.
2. Expand the responsibilities of the HOF facilitator to include a field « Take into account HF in design ». The retained principle is to build upon acquired knowledge of technical modifications thanks to interactions with external consultants. A checklist will be produced in collaboration with the methods department in order to take into account upstream the potential impacts on work situations in modifications to the facilities.
3. Train in HOF, in the context of the merger, a second person in order to assure the approach endures in case the first facilitator leaves, and, on the other hand, to respond to the increased number of employees.

The business's HOF matrix is thus completed in the following manner:

		Avant		Pendant		Après	
FH	1		1	(3)	1	(3)	Expertise métier
	2	(2) (3)	2	(3)	2	(3)	Sensibilisation FOH/réseau
	3	4 (3)	3	4 (3)	3	4	Expertise FOH (internalisée ou externalisée)
FO	1		1	(3)	1		Expertise métier
	2		2		2		Sensibilisation FOH/réseau
	3	(1) (3) 4	3	4	3	(1)(3) 4	Expertise FOH (internalisée ou externalisée)

Table 6.

Legend:

Result of the report presented as an illustration in paragraph 3.3.2.

(1) (2) New approaches following a reflexion on HOF strategy

(3) Reinforcement of the entirety of the HOF strategy visible on the matrix by a reinforcement of personnel.

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5 LIST OF APPENDIXES

Reference	Title	Number of pages
Appendix A	HOF Method Sheets	4

APPENDIX A: HOF METHOD SHEETS

- Sheet 1: “Safety Culture” Perception Questionnaire
- Sheet 2: Checklist
- Sheet 3: Crew Resource Management (CRM)
- Sheet 4: In-depth and systemic study of an accident

Sheet n. 1

"Safety culture" approach based on perception studies

Objective (What is it for? What is the goal?)

The objective of the approach is to describe the 'safety culture' of a company and to gain information about it to make it progress if necessary.

Structure and principles of the approach (How do you implement it?)

This approach can be initiated by the management of a site or a group. There exists in practice several possible variants. For example, after a pre-diagnostic phase (targeted interviews with part of the management, documentary analysis), a steering committee is put into place and the managers and the health and safety department are made aware of the procedure. A questionnaire on the perception of safety as well as on the implication perceived of management is then elaborated and administered to a representative sample of employees. Discussion groups are then put into place with the objective of illustrating the questionnaire with concrete experiences. Finally, axes of progress are identified and implemented (writing of a charter relative to safety policies, instauration of short weekly safety meetings, reflexion on fairness and management modes …), steering takes place over a defined period of time with regular monitoring committees.

Levels of analysis, degree of expertise and intervention times	Methods for collecting data (inputs)	Produced results (outputs)
This approach collects information on the perceptions and beliefs of different categories of personnel relative to safety by the means of questionnaires, by targeting safety themes (feedback, procedure, management, etc,). It is an approach to the daily operation of the business and the level of analysis depends on the nature of the questions in the questionnaires (centred on the work station or the operation of the organisation), and of which the required degree of expertise is relatively high.	• Initial documentary analysis • Interviews with management • Questionnaires • Discussion groups	• Oral restitutions and written documents of the interpretations • Working groups based on the results for interpretation and an action plan

Advantages	Disadvantages	Scientific literature (debates/models)
• allows one to easily mobilise a large number of people • offers an overall view that is relatively easily accessible by the quantitative treatment of the questionnaires • allows a first awareness to the world of 'HOF'	• relies on perceptions and not real practices • potential difficulty of giving meaning to the mass of data collected • can lead one to think it is possible to "measure" safety culture • does not specify the passage from interpretation to action • does not integrate technical work dimensions	The underlying models of 'safety culture' under the angle of perception enquiries are detailed in the literature and can vary from one approach to another. One must underline the existence of a debate in this field between approaches using questionnaires and approaches using interviews and observations. Here are three references. • Simard, M. La culture de sécurité in Daniellou, F. et al. (2009). Les cahiers de la sécurité industrielle : facteurs humains et organisationnels de la sécurité industrielle, un état de l'art. Toulouse : FonCSI. • Hudson, P. 2007. Implementing a safety culture in a major multi-national. Safety science. 45. 697-722. • Antonsen, Stian. (2009) Safety culture assessment – A mission impossible? Journal of Contingencies and Crisis Management. Volume 17 (4).

Sheet n. 2

Checklist

Objective (What is it for? What is the goal?)
The approach's objective is to assure that essential steps to the safety of an operation are followed by personnel responsible for this operation.

Structure and principles of the approach (How do you implement it?)
This approach relies on an identification of tasks to be implemented, a knowledge of the actual activity of the personnel in order to assure the effective implementation of the checklist. There are several ways to achieve this result. For example, participation of the personnel responsible for its implementation is completely possible during the development of the checklist, and a prior analysis of the activity may be desirable. Several combinations are therefore possible and observed in industry.

Levels of analysis, degree of expertise and intervention times	**Methods for collecting data (inputs)**	**Produced results (outputs)**
This approach concerns daily situations and covers themes of error as well as action reliability of which problematics of decision, memorisation and representation. The level of analysis is the work station and activity. The required expertise is professional and a good understanding of cognitive ergonomics.	• Technical specification of the task • Observation of the work situation • Interviews • Working groups	• Knowledge of the task and the activity • Production of a checklist-type document (this can be computerised)

Advantages	**Disadvantages**	**Scientific literature (debates/models)**
• allows personnel to rely on a systematic approach, avoiding the negative effects of interruption while performing an activity • produces a common professional reference (useful for newcomers) • allows collective agreement on the sensitive points of the activity	• can create a too rigid framework for action when confronted with non-anticipated situations requiring improvisation • can become a routine checking of the boxes without making verifications if the design of the checklist does not take into account the constraints of the actual activity • can become a simplistic reference in relation to fault in case of an incident	The underlying models to the checklist are those of cognition, cognitive processes in actual situations, but also errors. There is abundant literature on this subject. There also exists literature on the design and implementation of these approaches. Here are some references: • Reason, J. 1990. L'erreur humaine. PUF. • Hollnagel, E. 1993. Cocom. Taylor and Francis. • Hales,B. M., & Pronovost, P. J. 2006. The checklist—a tool for error management and performance improvement. Journal of Critical Care, 21, 3, 231-235. • Montmollin, De M, 1967, Les systèmes Homme-Machine, Introduction à l'ergonomie…, Presse Universitaire de France (volume 26 de « Le psychologue).

Sheet n. 3

Crew Resource Management (CRM)

Objective (finality, type of orientation : evaluation/intervention, justification, type of need)
The objective is to guarantee the safety of operations of a group. This objective is reached by an enrichment of representations of what agents do with their own know-how, the stakes and risks of the profession. This enrichment has the goal, in terms of safety, to positively change refereeing and interaction strategies between members of the group having conscience of available resources (in the greater sense) to work safely.

Structure and principles of the approach (temporality, concerned agents, resources to be mobilised)
This approach relies on the production of training modules adapted to the specific activity, which are then put in perspective in relation to the members of the group. These modules contain knowledge on the number of physiological, cognitive and psycho-sociological mechanisms that allow one to see more clearly daily interactions within teams and to envision positive safety strategies.

Levels of analyses, degree of expertise and intervention times	**Methods for collecting data (input)**	**Produced results (outputs)**
This approach concerns day-to-day situations and covers themes of error, as well as cognition reliability, including problematics of decision, representation, communication, coordination, and cooperation in the workplace. Themes of fatigue or stress are also introduced. The level of analysis is that of frontline operators in high-risk work situations. The required expertise is professional and a very thorough knowledge of cognitive and social psychology.	• Observation of the work situation, interviews • Debates and seminars (particularly concerning incidents or accidents) • Witness accounts • Other experimental possibilities, self-confrontation, role play)	• Training modules and facilitators (trainer training) • Explanation of modes of interactions within groups • Development of communication, coordination, and cooperation strategies

Advantages	**Disadvantages**	**Scientific literature (debates/models)**
• Allows personnel to better understand the conditions of interaction within the group • Allows a better understanding of physiological, cognitive and psychological constraints and resources that control action • Allows the offering of reference points for debates and discussions on problems met daily in interactions and to enrich understanding of events.	• After the first phase exciting interest, the approach can lose momentum over time • Organisational aspects are little treated if not at all • May give the impression to the operators targeted by the approach that all safety should be managed at their level as they are the last link in the chain of production.	The underlying models of CRM are cognition as well as team dynamics associated with the problematics of reliability and errors. There is abundant literature on this subject, as well as on the deployment of these approaches (initiated in aviation in France at the beginning of the 1990s). Here are some references: • Reason, J. 1990. L'erreur humaine. PUF. • Hollnagel, E. 1993. Cocom. Taylor and Francis. • Weick, K., Sutcliff, K.M., Obstfeld, D., 1999. Organising OFr high reliability: processes of collective mindfullness. Research in Organisational Behavior 21, 81–123. • Wiener, E., Kanki, B., Helmreich. R. 2010. Cockpit resource management. San Diego, CA: academic press.

Sheet n. 4

In-depth and systemic studies of accidents

Objective (finality, type of orientation: evaluation/intervention, justification, type of need)

The goal of the in-depth and systemic study of an accident is to better understand, beyond technological problematics and behaviourist explanations focused on 'human error', the managerial, organisational and decisional dimensions that contributed to a sufficiently important event so as to require deep questioning of the business. The interest of this approach is to establish the "profound causes" that are at the origin of the large event in order to better anticipate and prevent their recurrence.

Structure and principles of the approach (temporality, concerned agents, resources to be mobilised)

Accident investigations depend first on collecting data to establish a timetable and hypotheses about the technical causes of the accident. Based on these elements, the goal of the enquiry is to collect data to understand the role of different persons, in space and time, at different hierarchical levels, who contributed to conditions favourable to the accident. Recommendations are then produced from these conclusions. These steps can lead to different things, from a team of independent investigators to the production of a report or a very open investigation involving different participants and stakeholders during different stages of the process.

Levels of analysis, degree of expertise and intervention times	**Methods for collecting data (inputs)**	**Produced results (outputs)**
The considered themes are very vast for they can cover the entirety of HOF themes retrospectively. All the different levels of the business are concerned: from the work station to decision making by the board of directors on the operation of the business to strategic decisions made by the directors. The required expertise, other than strong technical knowledge, ranges from cognitive ergonomics to sociology (management and political sciences may also be used).	• Data on damage • Technical data • Interviews • Documentation • Reference to an accident model (centred on technical aspects, the operator, the organisation, or all 3)	• Scenario hypotheses • Investigation report • Recommendations

Advantages	**Disadvantages**	**Scientific literature (debates/models)**
• limits biases of technical analysis or 'human error' • shows explicitly links between technical, human and organisational causes in safety • allows basing oneself on a systemic vision that recognizes the contribution of multiples agents	• Problematic of selecting recommendations from multiple causalities, retrospective bias … • Difficult interaction with other investigations in progress in the case of accidents involving death of personnel or others • Can give the impression that events are foreseeable and simplify situations of incertitude met daily	The debates in this field are rich. There are very numerous developments in investigation models, detailed in a number of works and articles, for example: • Underwood, P. and Waterson, P.E. 2013, Systems thinking, the Swiss Cheese model and accident analysis: a comparative systems analysis of the Grayrigg train derailment using the ATSB, Accimap and STAMP models. Accident Analysis and Prevention. • Le Coze, JC. 2008, Disasters and organisations: from lessons learnt to theorising. Safety Science. 46. 132-149. • Mémento technique d'enquête après accident RAPPORT D'ÉTUDE 06 / 04 / 2011 N° DRA-08-95321-15486B

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