Guidelines for Preparing a Training Toolkit in Event Investigation and Dynamic Learning

ESReDA

European Safety, Reliability & Data Association

Guidelines for Preparing a Training Toolkit in Event Investigation and Dynamic Learning

European Safety Reliability and Data Association (ESReDA)

ESReDA Project Group on Dynamic Learning as the Follow-up from Accident Investigations

These Guidelines are also available for free downloading from the ESReDA website: www.esreda.org

PREFACE

by the President of ESReDA

Learning from experience or operating experience feedback is recognised to be one of the pillars of safety management. In theory, it helps to reveal “failures” in the socio-technical system, which can be remedied so that - according to the standard phrase – such events "can never happen again". This is why investigations are seen as important sources of safety information, as they demonstrate how things can go wrong. Lessons to be learned should be implemented and not forgotten. This requires actors from those systems to be trained to investigate after events and to learn the lessons adequately. The ambition of these guidelines is to provide some support to designers who have to prepare their training toolkit. By formulating these considerations, the intention is to support a learning process across sectors, and to improve the quality of investigations.

These guidelines have been written by a project group within the European Safety, Reliability and Data Association (ESReDA). ESReDA is a non-profit association of European industrial and academic organisations concerned with advances in the safety and reliability field. The association always welcomes comments and contributions concerning their publications and invites all to submit ideas for further developments.

These guidelines would not have been possible without substantial individual effort of the ESReDA project group members who come from different companies, research institutes, universities and authorities. They have produced its contents without any financial support and have devoted considerable free time to the task. This publication collects considerable experiences from several industrial sectors (transportation, energy, petrochemical, manufacturing…) and countries in Europe. ESReDA is proud to present the results of their work and hopes it will benefit many organisations and individuals worldwide concerned with safety investigation of accidents and learning from experience.

ESReDA would like to thank the authors for their contribution and also the member organisations for allocating time and for funding travel expenses for its members. In particular special thanks are due to those organisations that have allowed working group members to participate in this work including giving free access to their extensive in-house expertise and experience. We record our appreciation and grateful thanks to:

- EDP – Gestão da Produção de Energia, S.A., Portugal;
- Électricité de France, EDF R&D, France;
- European Commission, DG-Joint Research Centre, Institute for Energy and Transport, The Netherlands;
- European Commission, DG-Joint Research Centre, Institute for the Protection and Security of Citizen, Italy;
- Fondation pour une Culture de Sécurité Industrielle (FonCSI), France
- Institut de Radioprotection et de Sûreté Nucléaire, (IRSN), France;
- Kindunos Safety Consultancy Ltd, the Netherlands;
- SRL HSE-Consulting, Norway;
- TNO Innovation for Life, The Netherlands
- The Finnish Safety and Chemicals Agency (Tukes), Finland;

We hope these guidelines meet the expectations of members of the public and organisations who have shown interest in the work of the group in this important field.

Porto, May, 2015

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President of ESReDA

PREFACE[1]

by the Chairperson of the ESReDA Project Group on Dynamic Learning as the follow-up from Accident Investigations

These guidelines are the result of a joint effort by experts, in the fields of accident investigation, accident analysis, learning from experience, safety management, organisational analysis and resilience engineering, from several countries in Europe across almost every industrial sector. **The question they address with this effort is "*what should be in a training toolkit*?".** They attempt to represent a general approach to the training in event investigation and dynamic learning across sectors and national borders in Europe. **Safety investigation of events** (incidents, accidents, near-misses) is a field which is improving and expanding, as well as the ability to learn the lessons from internal and external events, while keeping memory of past events. The ambition of these guidelines is to provide support and guidance **for the trainers or designers of a training toolkit in event investigation and dynamic learning.** It was found important and challenging to balance the need for referring to the scientific background and theoretical framework with the objective of formalising practical guidelines for the future users of the guidelines. The contents of this publication are summarised below.

- Chapter 1 presents the main motivations for these guidelines, their objectives and scope;
- Chapter 2 addresses the scoping tasks to be done before delivering the training;
- Chapter 3 addresses guidelines and recommendations to designers of a training toolkit on the content of event investigation training;
- Chapter 4 focuses on the training content of how to learn "dynamically", starting from the results of the event investigations when designing corrective actions, then disseminating lessons to be learned and to keep in memory and also looks at barriers to learning.

1 The opinions and concepts expressed by the authors are solely their responsibility and do not reflect the policy or opinion of their company or organisation.

All members of the project group have been actively involved in preparing these guidelines. An overview of the group's participating members with names and affiliations is given after the prefaces. The ESReDA project group *"Dynamic learning as a follow-up from accident investigations"* (DLFAI), which was a follow-up of the former working groups on *"Accident Investigation" (2001-2008)* and *"Accident Analysis" (1993-2000)*, has been active between 2009-2014.

The ESReDA project group DLFAI produced **5 deliverables** published in 2015 on www.esreda.org :

- *"Case study analysis on dynamic learning from accidents"* ESReDA report,
- *"Barriers to learning from incidents and accidents"* ESReDA report,
- this ESReDA report *"Guidelines for preparing a training toolkit on event investigation and dynamic learning",*
- an ESReDA website webpage *"Dynamic learning from Accidents"*, and
- an essay by Professor Stoop *"Challenges to the investigation of occurrences. Concepts and confusion, metaphors, models and methods"*.

The PG DLFAI also organised **2 ESReDA Seminars** on these subjects, both in Portugal and both with the support from EDP:

- The 45th ESReDA Seminar on *"Dynamic Learning from incidents and accidents: Bridging the gap between safety recommendations and learning"*, in Porto, 23 and 24th of October 2013.
- The 36th ESReDA Seminar on *"Lessons learned from accident investigations"*, in Coimbra, 2nd and 3rd of June 2009.

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The ESReDA Project Group on Dynamic Learning as Follow-Up from Accident Investigations has been chaired by John Stoop (2009-2010), Yves Dien (2011-2012), and Tuuli Tulonen (2013-2014).

Earlier publications from the ESReDA working groups "Accident Analysis" and "Accident Investigation":

- Directory of accident databases (1997)
- Accident databases as a management tool (1998)
- Guidance document for design, operation, and use of safety, health, and environment (SHE) databases (2001)
- Accident investigation practices – results from a European study (2003)
- Shaping public safety investigations of accidents in Europe (2005)
- Guidelines for safety investigations of accidents (2009)

In addition, the ESReDA Working Group on Accident Investigation has organised **two ESReDA Seminars on accident investigation with 2 special issues in scientific journals:**

- in 2003 jointly with JRC-IE in Petten (the Netherlands): a special issue with some papers of the seminar edited in the Journal of Hazardous Materials (n°111, 2004)
- in 2007 together with JRC-IPSC in Ispra (Italy): a special issue with some papers of the seminar edited in the Safety Science Journal (n°50, 2012) on "Industrial Event Investigations"

All the papers/contributions from these seminars are collected and printed in proceedings which are available from the ESReDA secretariat.

Acknowledgements

We would like to thank the following people who have reviewed some of the draft reports, hosted us, and provided valuable feedback: Ludwig Benner (Starline Software, USA), Tarja Valvisto (Tukes, Finland), Thomas Gell (MSB, Sweden) and John Kingston (NRI Foundation).

SUMMARY

These guidelines have been **prepared especially for designers of a training toolkit that targets specialists and generalists** to be trained in event investigation and in learning from experience analysis, engineering, management and auditing. **It answers to the question: "what should be in a training toolkit?"** for **safety** investigation and dynamic learning from events and as a follow-up from accident investigations. It could therefore be **valuable for**:

- investigators to be trained, investigation managers who should define the training level of their staff, people who order investigation trainings,
- learning from experience (or operating experience feedback) analysts, engineers, managers, auditors, and
- responsible persons who will have to learn from events (safety engineers and managers, inspectors and auditors, regulators and policy makers, workers), but also victims, citizens and researchers.

These guidelines provide a minimum, current and recognised cross-sectorial best practices oversight to prepare a training toolkit for **conducting and managing investigations** related to industrial, technological and organisational **events (accidents, incidents, near-misses)** and for **the dynamic learning** of lessons as a follow-up from event investigation. These guidelines give practical and theoretical advice related to different stages of event investigations and of learning process, along with the related barriers and limits faced.

More specifically, the guidelines attempt to provide guidance to training toolkit designers on:

- **How should we organise to prepare a training toolkit?** What are the objectives? Who should participate? Who could deliver it? **What are the trainees' categories and needs?**
- What is the **basic knowledge** a generalist should have in event investigation and in learning management (e.g. concepts, processes)?
- What are the **basic methodologies and skills** an investigator or a group should possess?
- What are the pitfalls, **barriers and enablers in learning?**
- What type of **case studies** should or could be developed to test the methodologies, acquire the concepts and discover some know-how?

Any aspiring investigator can develop skills and know-how through practice, but carrying out an effective accident investigation is a difficult task. The quality of the outcome is influenced by the investigator's quality of a priori knowledge or initial models. Specific methodologies have been developed to facilitate some key investigation tasks (what, how and why it happened, and what is recommended to avoid its recurrence). Organisations should take stock of these methods to define their protocols and train their investigators before the event occurs in order to be ready to undertake **collectively** the investigation of an event in an effective way. The training toolkit has been designed to address this challenge.

Organisations should also invest resources in improving learning. When operating a system, regularly, **learning opportunities** can be recognised, with some of them which are provided by the occurrence of events. Learning starts after the lessons identification. **How should the lessons be learned?** Turning investigation findings into recommendations, then into corrective measures, are specific tasks that require specific knowledge on dynamic socio-technical system behaviour interconnected at several levels (macroscopic, meso, micro). **Managing the changes** (adaptation, optimization, innovation) of an organisation can be an arduous ordeal requiring a systematic follow-up and monitoring to be put in place, especially within a safety management system. Learning should be engineered as a process that is supported by models within an organisation. However, **many barriers to learn lessons need to be overcome by organisations**. The training toolkit also addresses this other challenge.

In addition to the above-mentioned principles, the training toolkit **advocates and provides suggestions for the use of case studies**.

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1 INTRODUCTION

1.1 Motivation and aim of these guidelines

The main motivation to preparing these guidelines was to provide a minimum, current and recognised cross-sectorial best practices oversight **to prepare a toolkit for people to be trained in event investigation and dynamic learning.**

At the same time, this set of practices provides the foundation for further work to harmonise investigative and learning practices within the European countries. Hence, the primary aim of these guidelines is to share knowledge and experience about methodologies and principles for **safety investigation of events and learning dynamically from experience** across different sectors and application areas.

The development of these training guidelines builds on the ESReDA *"Accident Investigation" Working Group (WGAI) study on investigative practices in Europe (2003)* where we noted certain deficiencies, in particular a lack of use of formal methodologies and a lack of proper investigation management. This fact motivated the work that resulted in this training toolkit, designed by the **project group *"Dynamic learning as the follow-up from accident investigations*"** *[*DLFAI*] (2009-2014).* It also emerges from the work carried out by the previous ESReDA project group *"Accident Investigation" (2001-2008).* **In particular, to frame its basis, it extracts some key ideas from two former deliverables** (www.esreda.org):

- ESReDA book "*Shaping public safety investigations of accidents in Europe"* (2005), which focused on the political and organisational axis (at societal level) of accident investigation**.**
- ESReDA "*Guidelines for Safety Investigations of events"* (2009), which focused on a methodological and organisational axis (at managerial level) of accident investigation.

Indeed, after focusing on necessary conditions to improve the quality of investigations and lessons that could be learned, the PG found it necessary to address several issues about the quality and efficiency of learning.

At the end of the DLFAI PG mandate, **5 deliverables** were produced and published in 2015 on www.esreda.org :

- *"Case study analysis on dynamic learning from accidents"* ESReDA report,
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Consequently, these guidelines **aim to provide some guidance to the designers of training toolkits, so as to prepare their toolkits for further training sessions**. Some organisational issues are addressed for preparing the toolkit, especially the need to establish a multidisciplinary team, to balance the use of different communication formats and to develop case studies articulated with principles.

These guidelines are intended to give **both practical and theoretical advices** appropriate to each stage of event (accident, incident, near-misses) investigation, and by this, contribute to the improvement of investigations performed within companies and by public authorities. Such advices are directed at the investigators, their trainers and at those who order and specify what shall be investigated. Similarly, advice on efficient learning processes, pitfalls and barriers to learn should be part of the training in order to develop more robust and dynamic learning.

Safety investigation of events and learning from experience (operating experience feedback) are some fields that are currently improving, expanding and receiving new attention due to the lessons learned from their limits and their strategic role in safety management. The ambition behind these guidelines is to reflect the state of the art, providing some latest insights, as well as addressing future challenges. By formulating these considerations into the guidelines, the intent is to support a learning process across sectors, and to enhance improvement in the quality of investigations.

1.2 Scope of the Guidelines

The scope of these guidelines is to cover the **training needed to enhance the whole learning process**. The **two major questions** addressed are:

- How should we organise ourselves to deliver such training?
- What should be the training content and the toolkit used?

In order to dynamically learn the lessons, this starts with the efficient identification of **relevant lessons** to be learned. This is the reason why the event investigation remains a foundation. However, this focus should be widened to the whole learning process, as lessons may not be **"dynamically" learned**.

Safety investigations of events aim to support learning, in order: to improve safety, to prevent, to better mitigate effects of future potential accidents. They differentiate from inquiries carried to determine responsibility and allocate blame (e.g. judicial or regulatory).

Investigations are seen as important **sources of safety information**, as they demonstrate how and why things go wrong or could have gone wrong in other circumstances. Investigations can be a good knowledge base for improving safety in sociotechnical systems, its oversight by regulators and the governance of the high-risk system. They can **help to diagnose knowledge deficiencies**. By choosing the term "safety investigation," this aspect is emphasised.

However relevant **lessons to be learned** are only the required input, but not the final targeted output, which still remains to be the development of **changes** in the new system at different sociotechnical levels. These changes should be lasting or dynamically used to sustain a high safety level. They can require the system to be optimised, adapted or to look for innovation.

The scale of severity of events is considerably wide, ranging from equipment failures or minor injuries to major disasters, industrial and natural catastrophes with severe effects on people, environment and property. **Although, the resources would be rather different, especially the range of skills and the level of expertise required, most of the principles for investigating and learning remain the same.** The term "event investigation" is generally used in these guidelines, but it can also be applied to the study of near-misses, incidents, accidents and other events indicating safety problems such as weak signals.

These guidelines for the design of a training toolkit could also **be applied across a wide industry spectrum**. They are generic and cover, in large part, most types of activities and systems in which events can occur. **The principles are meant to be generic** and could as well be applied in non-profit-organisations (such as community services). In a number of industrial branches, specific guidelines have been developed to which references are given. Benefits of cross-industry fertilisation are advocated by ESReDA but may face some limits too (Grote and Caroll, 2013).

These guidelines are mainly based on a **sociotechnical system perspective**, including how technical, human, organisational and socio-political levels interplay or malfunction (e.g. Rasmussen (1997) and Rasmussen and Svedung (2000)). To simplify, we will sometimes use levels such as macroscopic, mesoscopic and microscopic. Specialities like forensic techniques, technical investigations, interviewing techniques, etc., are less addressed here. However, there is a plethora of literature available, which covers these subjects.

1.3 Target groups

The initial and **direct target group** are not only the **trainers** who will deliver the training but mainly the **designers** of a training session and toolkit:

- Their purpose could be for **"professional"** training within the professional arenas or **"initial education"** training in universities;
- Therefore, it concerns **trainers and training designers** who are professionals and **practitioners** in charge of a training session, **teachers** in charge of a course, and **managers** or directors that want to enhance the skills of their staff and managers;
- Those trainers and designers of the training toolkit can **come from their organisation or from other organisations** (e.g. other professional organisations, consultants, professors, professional investigators, etc.)
- The level of the training and the expected skills transferred that are targeted are **ranging from generalist to specialists**. Therefore the **depth of the knowledge** content and theories, the **duration** of the training session, the level of **practice** of methodologies for example with case studies, are **variables** within their hands, to adapt to their needs. The structure and the general objective can be part of a **common framework** which is the objective of these guidelines.

The final and **indirect target group are the trainees**:

- **People who conduct the practical event investigations**; it could be practitioners in companies, (National/Federal) bureau investigators, authorities or consultants. These are a key target group but they are not the only actors who shape the context in which investigations are performed and the quality of the lessons to be learned; An example of training guidelines have been developed by ICAO (2003) for aircraft accident investigators;
- **Someone who orders an investigation**, giving more or less clear instructions and quality demands on the outputs;
- **Responsible persons who are supposed to learn from the investigation**, and consider and decide about the measures proposed (e.g. managers, designers, consultants);
- **Learning from experience or operating experience feedback analysts** who should be able to consolidate the lessons from several events, animating the use of memorised events in databases or any operational actor in operations;
- **Assessors** (auditors, inspectors, regulators) and **designers** (managers, engineers, policy makers) of the learning system, which should develop guidance to assess the performance of the learning loops and their sustainable and dynamic character;
- **Victims** of an event and other directly affected persons or organisations have an interest in a fair and correct investigation and lessons learning process. They could use the guidelines to find out what is considered as good practice for an investigation and lessons learning.

An **indirect target group could be researchers** in accident investigation, learning from experience (operating experience feedback) and safety that may find insights from this cross-sectorial best practices oversight.

1.4 Disclaimer

It should be noted that issues of terminology and definitions will not be addressed in these guidelines as it is rather specific to the various sectors.

These guidelines use commonly applied notions, such as the medical metaphor depicted in Haddon's "agent-host-environment" model, the "Swiss Cheese" metaphor, which reflects Reason's school of thinking on hazards, defences, triggering events, proximate and remote causal factors and linear sequencing of events. Although these models could be criticised for their oversimplification of a complex reality, they reflect the state-of-the-art for investigating the majority of frequent accidents and incidents, with an emphasis on human error and/or organisational failure. For further reading (see Prof. Stoop's essay on Challenges to the investigation of occurrences).

1.5 Copyright issues

We have done our best to get specific agreements where necessary.

2 DEFINING THE SCOPE BEFORE THE TRAINING DELIVERY

The concept of "just-in-time training" is developing due to the competitive environment and also because, the duration between the training and the use of the skills should be narrowed to get a more efficient transfer from the training.

However, with events, especially serious incidents or accidents, their timing is not mastered. Skills might be needed immediately. As we have written in the "*Guidelines for Safety Investigation of Accidents*" (2009), some investigation preparation (or readiness to investigate) of the organisation and staff is needed. This remark can be downplayed by systems that provide frequent events to investigate and require daily learning activities (database and trend analysis, etc.).

Whatever the situation is, training is an investment for the future. But instead of, or before buying, a ready-made training on the shelves of a training entity, we advocate for a **demand (or term of reference) analysis** time that is spent to define the scope of the training, which takes on board the objectives or the needs of trainees.

Chapter 2 addresses these preliminary and basic issues that will provide **criteria to adapt the training content to the needs** in four stages:

- Defining the scope, the objectives, the framework of the training;
- Our targets : investigation and learning knowledge and skills;
- Criteria for being a trainer or part of a training session design team;
- Defining categories of training and level of training.

2.1 Defining the scope, the objectives, the framework of the training

One can assume that the readers of these guidelines have been mandated to or that they are interested in preparing some form of training or thinking back to possible improvements of their on-going training. A good practice for these trainers or training designers is to make a demand analysis. It requires asking their decision-makers and/or their targeted customers a **few questions to define the framework**, the scope, the objectives or some performance criteria about the training that will shape the design of such training:

- What is the **main purpose of the training**? What are the numerous secondary purposes? e.g.
  - Investigation and learning skills are our main targets (see §2.2);
  - foster a safety culture, or an effective safety management;
- Who are the **targeted users** of this training? What are the different **categories of trainees**? e.g.
  - **"Specialists"** who have to conduct investigations (as a full time or part time investigator) and analyse several events to identify the lessons to be learned; other specialists who have to define operational actions;
  - **"Generalists"** who have to launch event investigation, assess the quality of findings, defeat the learning barriers and implement the success factors for learning and effective safety management and culture; (see §2.4)
- What are the **performance criteria** for investigating and learning? What are the event types, **scale** of investigations and learning?
  - Risk levels, severity of accidents, learning potential of events, timing to report to control authorities, impact of the potential changes (e.g. regulation changes). All may modulate the scale of investigation required;
  - Do principles of investigation and learning remain the same? What changes in practice and for whom?
- What are the **trainees' needs or requests**? Are these coming from informal feedbacks or has a **formal enquiry** been performed? Do you know their **background**?
  - informal sources coming from investigation practitioners, from experiences of analysis of events databases, from auditors of learning from experience processes;
  - formal sources coming from a dedicated survey within the organisation;

  - formal and external sources, such as the ESReDA inquiry (2003) on investigation practices in the EU;
  - a training application file with background, career, expectations about training.
- In **which situations** do users claim a need? **Which skills do trainees require?** Does it highlight a lack of methodology, a lack of practice, a lack of expertise and/or a **lack of knowledge** (e.g. on learning theory)?
  - e.g. lack of data collection in particular context (e.g. forensic techniques); lack of investigation management; lack of root cause methodologies practices; lack of competencies for the analysis of human and organisational factors; lack of view of the overall implications of a global learning process; lack of concepts in organisational learning; lack of understanding of barriers, biases and pathologies to learn which will hamper the efforts for changes, etc.
- **What are the training outcomes, knowledge and skills targeted?** What are the **choices** between the different levels of skills to be transferred? What are the **key messages** to be transferred?
  - e.g. Among the previous list, what are the most important request to meet or the outcomes expected?
- How much **resources** are available for trainees? How much resources are available for the training team to prepare and deliver the training? What are the **criteria to proportionate** the resources? (see §2.4)
  - e.g. days available per category of trainees; budget granted to the design of the training session and toolkit;
- What **skills should the training team combine**?
  - e.g. multidisciplinary in investigation, learning, human and organisational factors with external experts requested for additional training… (see §2.3)
- How many exemplary **case studies** (investigation and/or learning) can be used? What other deliverables should be prepared for trainees?
  - e.g. internal case within the organisation, or external case available publicly; (see §3 and §4 and ESReDA report on case study analysis on dynamic learning from accidents (2015)). etc.

2.2 Our targets: investigation and learning skills

With the training objectives, the constraints and the resources, training sessions can be framed. The expected **learning outcomes** would address some knowledge and skills and would be formulated throughout verbs. Some final exams could be used to check its efficiency. To our experience, we propose to divide the training in **two sessions**:

- **Investigation knowledge and skills**, in the first session of the training:
  - What is an event? What are the regulatory definitions? What are the mandatory requirements from public authorities, incl. the EU agencies, concerning reporting of unwanted events?
  - How often do events occur in your organisation and reportable events in your industry?
  - How to prepare the organisation to investigate?
  - Who should investigate within the internal staff? On what criteria? What system knowledge base is required to be selected?
  - How to train investigators? How to request external expertise?
  - What has to be investigated? Scope, term of reference, a priori mandate and updates
  - How to investigate? With which investigation protocol? How to transfer a proper investigation knowledge base? How to select methods to be used? And with what resources and which skills?
  - How to deal with investigation results or findings? How to recommend?
  - How to select accident case studies according to the application purposes: overall investigation stages, principles, fault tree methodologies, etc.
- **Learning knowledge and skills**, in the second session of the training:
  - What is learning?
  - What and how to learn efficiently from an event?
  - How often should you learn from internal and external events?
  - How to learn the lessons to be learned? Shifting from lessons learnt to lessons to be learned?
  - How to implement lessons, recommendations, and corrective actions?

- What is the range of possible changes (adaptation, optimisation, innovation)? What are the difficulties in conducting changes?
- What are barriers for learning? How to detect barriers? How to overcome barriers?
- How to implement good learning practices? At individual, collective and organisational levels?
- How to store and memorise the lessons? What are the benefits and limits of databases?
- How to select learning case studies according to the application purposes: lessons to be learned from accidents, audits showing failures to learn, successful redesign of a learning process.

2.3 What are the criteria for being a trainer or part of a training session design team?

Some question a (safety) manager should address could be:

- Who is relevant to deliver which training and to be nominated as a trainer in which field? On which stage of investigation and learning process? On which method or tool?
- Does he/she combine enough practical experience and theoretical insights?
- Who should be the designer in charge of the training session framing?
- Are there some competence criteria or minimum knowledge criteria for those positions?
- Is one person able to handle all of those skills? How efficient or risky is it for the training delivery?
- **How should a multi-specialist team be set-up?** How complex does it become to handle (one location with several trainers? etc.)?
- Could we benchmark?
- Should we request external expertise (consultant, professor, researcher, etc.) for the global design and delivery of the training? In which specific domain? Which adaptation work should be performed (e.g. translation into the context?)
- etc.

According to our experiences, the **basic skills required for the training design team and trainers** are the following:

- Expertise and experience in event investigation,
- Expertise and experience in learning from experience (e. g. operational experience feedback manager and analyst),
- Technical aspects (engineering sciences, reliability methods),
- Human and Organisational Factors (human and social sciences),
- Trained for training (pedagogic skills).

Experiences and skills to be transferred should be at least generic in their principles across sectors and if possible applied in your industry or your organisation.

Members of a training session design team could have background/occupations such as:

- Accident investigator, experience feedback analysts, learning from experience managers and engineers, change manager, human and organisational factors specialist,
- Safety analysts, managers, inspectors, auditors, design, operations, maintenance engineer and technician on systems or equipment,
- Researcher, university professor, consultant teaching in some of the fields,
- Someone who knows a valuable case to study or witness.

2.4 Defining categories of trainees and level of training

Firstly, **within the common framework** defined all along these guidelines, the level of learning is quite dependent from of the targeted trainees and their needed uses. It is therefore useful to start to **proportionate the training scenarios** to be designed for specialists from those that will be designed for generalists:

- **“Specialists”** (in our words), are responsible persons who will be **in charge on the main process of investigation and learning, taking in charge the input and delivering the output**: full time investigator or part time investigator in charge of an investigation after an event, using databases and analysing several events, animating the learning from experience process, designers, engineers and managers of the learning from experience system, change consultant or manager. They need theory and practice during the training.

- **"Generalists"** (in our words) are **customers, users and assessors of the output but also resources providers of the processes of investigation and learning**, implying that they are more remote than the "specialists" who are in charge of the investigation, but in interaction with: some may be involved as witness or only because the event occurred in their technical or managerial accountability, safety analysts integrating and cross-analysing lessons to be learned with other safety information to derive new lessons, production and safety managers and engineers, auditors, inspectors, policy makers and any actor potentially contributing to an investigation and learning loop. They need at least theory during the training.

The classification proposed is rather simple and may show some limits. Any taxonomy is to some extent arbitrary. In our exchanges (2014) with Benner, he would distinguish five categories of trainees and training needs, rather connected to their position towards the learning process:

1. Managerial and supervisory individuals who establish and oversee investigation policy and programs, provide investigation resources, and assess the value produced by the investigations.
2. Individuals who develop the explanatory description of what happened, who perform the functions of historians researching past events.
3. Analysts who utilize the explanatory descriptions for predictive purposes, to identify issues with planned or ongoing system operations, problems, and lessons learned, to identify options for resolving the problems or issues, to prepare proposals for implementing the best amelioration options, and propose measures for determining the effectiveness of implemented actions.
4. Users of the investigation work products who must actually act to resolve the reported problems or issues in their systems.
5. Trainers, for each of the previous four categories.

Expert training on some method, as described in the table 1 (see hereafter), would reasonably be considered as advanced training in each category. Another key dimension to consider for a classification effort is whether the trainees are rather internal to the company framework (including subcontractors) or rather external with stakeholders, such as public authorities, consultancy firms, external auditors/inspectors, researchers (see table 2). **Whatever the classification of trainees needs**, roles and responsibilities referred, **each category requires distinctive knowledge, methods and skills to perform their functions for successful learning from accidents. However, some basic knowledge is common and is targeted here in the training sessions (see table 1).**

Several parameters could influence the level of training (see Ch. 3.1): the level of risk, the size of the organisation, the scale of investigation and learning especially towards regulatory requests, the history of the sector, the individual background...

According to our experience, in table 1 are a few guidelines of what is practised in constrained organisations and environments in many industries and public institutions. It does not mean that it is sufficient to address some skills or know-how, but some basic knowledge (foundations, principles, models and grid of analysis) are better than nothing! **At least some information is needed**. It could be understood as **resources baselines for basic training achievements for a global view**. Indeed, some engineering courses take several years as well as in social sciences, and getting experience and little know-how may require a few cases and sometimes years under the umbrella of experienced colleagues, and being acknowledged as an expert by peers may take a decade. Some further distinctions could be developed on **more narrow domains of skills and some dedicated methodologies.** Being trained on one root-cause methodology or some forensic methods may require similar time and resources than the estimates provided here for the generic principles!

Table 1: Level of training according to the proposed category of trainee.

Categories of trainees	Jobs of trainees	Level of training
"Generalist" *customers, users and assessors of the output but also resources providers of the processes of investigation and learning*	Safety analyst, manager, engineer, inspector, auditor, policy maker, any potential contributor to investigation and learning process	Theory ; in classroom; ranging from 1,5 hours to 1 or 2 days in professional context to 2 days in education context ; average 3 to 6 hours module
"Specialist" *in charge on the main process of investigation and learning, taking in charge the input and delivering the output*	Investigator, incident and experience feedback analyst, learning from experience manager, database designer, human and organisational factors expert, learning/change agent	Theory and practice; mostly in classroom + homework + field; ranging from 2 to 5 days in professional context to few days and even few weeks in education context; average 3 days
"Expert" in some specific method, tool	e.g. forensics, data collection tools, chronology methods, analytical tools (fault tree), root cause methodologies, database use and classification	Half to an hour for basic information on or concepts of a tool; 2-3 hours for some practice per tool and basic application case

Nota Bene: The resources for training mentioned here may be totally different for professional full-time investigators such as in independent investigation boards or forensic techniques specialists in police investigations.

3 TRAINING SESSION CONTENT IN EVENT INVESTIGATION

3.1 Framing the organisational and trainees context for event investigation and learning

The training introduction in section 3.1 is common for most parts to the investigation (Ch. 3) and learning sessions (Ch. 4).

Introduction: recalling the training objectives to the trainees and introducing the issues

Despite the diversity of background and work context of trainees within their organisation, some basic goals within the common framework can be recalled. It can be done:

- by recalling the **targeted knowledge, skills and training outcome**, e.g.;
  - specialist: to conduct an investigation, to identify lessons to learn,
  - generalist: to contribute to an investigation, to assess its quality.
- by recalling the **content of the training** (see detailed lists in Ch. 2.2);
  - Role of accident analysis and learning from events in the learning from experience process, and safety management,
  - Designing the learning policy and implementing the system and processes: investigation and learning are processes with important and critical stages.
- by **raising some issues** of investigation and learning with a few questions addressed to trainees;
  - e.g. Importance of a learning from experience system for safety management: is there an issue or problem with learning in your organisation? What are the risks of deficient learning?
  - What types of events are required to investigate? How often is it requested in your organisation or job? etc.

The answer to these introductory questions can be useful for the trainer, especially an external trainer, to assess the level of a priori knowledge and know-how of the trainees. (Nota bene: For a generalist course of a couple of hours, time is short: trainees' background and learning needs may be collected before the course through questionnaires).

Adapting the training to the risk context

It should be kept in mind that the scale of needs, risks, stakes, resources and industrial applications, is wide (ranging from small to medium-sized enterprises/SMEs to large scale companies with several units over the world, and from low to high risk Industries). Therefore at this stage the training designer(s) and trainer(s) will start to **adapt and proportionate the principles** to risk levels and means. The **generic training** available in these guidelines should have specific features from the users' context of application. It is clearly a needed and useful exercise for the trainer, especially for an external trainer. Trainers should collect and analyse some safety indicators before the training: to design it (Ch. 2) and to set the global picture in the introduction which could address a few issues, e.g.:

- What are the major risks of the system where the trainees work?
- What have been the accidents, major accidents and disasters of that industrial sector?
- What were the lessons learned and kept in memories?
- Is it possible to compare event and accident statistical data with other industrial risks?

Adapting the training to the scale of investigation and learning

Although these issues should have been addressed during the design of the training (Ch.2), it is valuable to settle the context of work of the trainees during the introduction phase:

- How often do events (incidents, near-misses, reportable events) occur in your organisation?
- What are the reportable events? And the associated investigation and learning regulatory requirements?
- How often is an internal investigation launched? For which reasons? What are the means involved?
- What is usually done with the lessons learned? How is it followed up? Why? By whom? Are there any regulatory impacts?

Adapting the theoretical framework to the trainees

Trainees have different experiences, careers, positions, responsibilities and backgrounds… and expectations!!! This information should be collected or estimated during training design (Ch. 2) and at the latest at the early beginning of the training session to provide answers during the training.

Before addressing investigation and learning theories and practices, it might be needed to recall some basic notions or concepts and terminology of risk and safety management in various sectors (energy, transport, process) and countries, e.g.:

- Safety, reliability, availability, maintainability; Risk, danger, risk analysis, criticality, safety function, defence-in-depth and barriers;
- Risk management cycles (prevention, precaution, mitigation, crisis);
- Accident prevention in industrial safety (and occupational safety).

It could last a few minutes for safety practitioners or experienced professionals, and several hours for novice students.

Short history of accident investigation and learning

Although the harmonisation trends are strong at EU, international or some business and research levels, the ESReDA working group on accident investigation (WGAI) found a lot of discrepancies in accident investigations practices (see ESReDA publications in 2003, 2005, and related collective articles; Roed-Larsen et al., 2003, and Dechy et al., 2012). For further information, especially on methods, see also, Sklet, 2002, 2003.

Therefore, before sharing and transferring the latest best or new practices, a short history of the practices might be useful to the trainer and trainees. It can be in general, or more specifically within the country, the industrial sector (e.g. aviation, nuclear,…) and the organisation of the trainees.

Regulation of event investigation and learning from experience

Although the harmonisation trends are strong at the EU, international or some business and research levels, the ESReDA WGAI found a lot of discrepancies in accident investigations regulations (see ESReDA book Shaping public safety investigation of accidents in Europe, 2005).

Some regulatory requirements are often defining the performance criteria of the input and outputs of event investigation and learning from experience. Some key important distinctions could be the level of regulatory requirements:

- **for public accident investigation or conducted by an independent accident investigation bureau:** their legal mandate to have access to plants, to key evidence with potential jurisdictions conflicts between authorities;
- **incidents reportable to the control authority:** criteria are regulatory defined for events to be notified and investigated with some request on the content and quality of investigations;
- **internal procedures of organisations:** criteria for internal recording, data collection and analysis, with internal procedures and guidelines for investigating, communicating the lessons and implementing corrective actions and assessing the efficiency of the follow-up.

Institutional framework, stakeholders and relevant actors

Although the harmonisation trends are strong at EU, international (e.g. in aviation) or some business and research levels, the ESReDA WGAI found a lot of discrepancies in accident investigations institutional framework (see ESReDA publications in 2005, 2009 and Dechy et al., 2012). Although traditionally there are overlaps between administration territories, some accident investigation bureaus do exist in several sectors and several countries in Europe and the world that are playing a key role in the investigation of major accidents. For other events, the context will probably depend mostly on regulation.

In the ESReDA Guidelines for safety investigation of accidents (2009), we have also recalled the impact of different standpoints (Rasmussen, 1994) and defined three basic categories of stakeholders which shape the investigation and learning framework: companies, control authorities and external parties.

Table 2: A general classification of accident investigation stakeholders.

Type of stakeholders		
A) Operating Companies	**B) Control Authorities**	**C) Public Parties**
• Company and the corporation • Internal department in charge of Health, Safety and Occupational Conditions/ Environment • Health, Safety and Occupational Conditions committees • Sub-contractors and customers • Insurers	• Local control authorities • Control authorities of local control authorities • National control and regulatory authorities, Ministries and Government • Police and justice (litigation and court) • Labour inspectorate • Fire and rescue services	• Third party-expert • Independent investigation board • Victims' labour associations • Parliament and political parties • Mass media • Non-Governmental Organisations • Trade unions

Although the different stakeholders have different aims for investigations, achieving an effective and credible investigation relies on recognition of these different requirements and frameworks:

- Participation in an investigation will be affected by individuals' and companies' perceptions of the investigation and its goals;
- Corporate requirements will be to protect company reputation and liability;
- Political requirements will be to satisfy key stakeholders without attracting blame to senior figures and without recommendations which prove to be politically unattractive or excessively costly to implement;
- Societal requirements will be to find someone (individual or company or both) responsible who will take action to ensure "*it can never happen again*";
- All will require the investigation to be thorough, to find out what happened and to be transparent;
- All will require the output to be perceived to be independent and seen by all as highly credible and as an authoritative statement.

In addition to this institutional framework that shapes the performance criteria, it is necessary to map the organisational layers in order to adapt the training to the needs of the trainees according to their (future) roles and responsibilities in the learning process (see table 1): e.g.

- Who should investigate what?
- Who should learn what, from whom and communicate to whom?

3.2 How to prepare the organisation and the trainees to investigate?

Preparing an organisation to investigate events not only the people

Training people to investigate and learn is necessary but not sufficient. Organisations should be prepared too! **Readiness** to investigate and learn requires the trainee and its managers to address the organisational and work conditions of the future investigations:

- Preparing procedures, protocols, organisation, structure:
  - Develop willingness to investigate among participants and stakeholders;
  - Define requirements and criteria within internal guidelines for an investigation;
  - Prepare an incident response plan;
  - Identify basic elements of the investigation response and prepare an investigation activation plan; e.g. setting rules for establishing an investigation team on short notice, with their roles, competencies and mandate.
  - Achieve the level of readiness for initiating an investigation;

- Develop readiness to manage the investigation;
- Verify readiness to investigate;
- Plan how to select people for the different positions and with what criteria.

It should be kept in mind that the scale of needs, risks, stakes, resources, applications, etc. is wide (ranging from SMEs to large corporations, from low to high risk industries). More suggestions can be found in the ESReDA Guidelines (2009), in the DORI report (NRI Foundation, Kingston et al., 2005), and in the proceedings of ESReDA seminars (e.g. 2007).

Define the training for contributors to investigation and learning process

Trainees following your course are may be the first from their organisation to receive one. For instance, in some organisations, some specialists are trained externally (during initial education or professional context) on some generic skills in investigation and learning. They can be in the position to develop a toolkit that is in-house and adapted to the tools, the procedures, the organisation, and the skills of their colleagues. At least, the trainees should receive the following messages in order to communicate them to their management and colleagues.

The participants of an investigation should be appointed according to their competencies or according to other criteria, such as being a witness, an independent assessor or as a person being involved in the event causation. They should be trained in the field they will be responsible to investigate or learn. There are several actors that can be involved (see table 1).

In-house roles in investigation and learning should be identified with required information or training:

- What generic skills do the contributors have? (e.g. someone who notifies an event, or who has to register and code the learning file, or who has to implement the corrective action, etc.)?
- What generic skills are required for investigators?
- What specific skills are needed for learning specialists?
- What skills are needed for experts in some tools for particular tasks of the investigative process (such as assessing damages, interviewing, reconstructing a chronology, performing a causation analysis, analysing engineering work in design and manufacturing, daily operations management, human, organisational, societal factors)?
- What is the system knowledge base required to be selected?

Usually few people are trained internally on all of these investigative skills and external expertise is often requested. An investigation facilitator or mediator might be useful to assist the internal staff in conducting an investigation. **Investigation should not be a one person process but a collective process** to overcome biases and individual knowledge limits.

3.3 What to investigate? Event, accident causation model, concepts…

Whatever the contributor position in the learning and safety management system, he/she should receive a theoretical background on models of events and basic concepts. This worldview or grid of analysis will guide the analysts in interviewing, in the causal analysis and in the stop rules applied (e.g. “old view on human error”, see Dekker, 2008, and Dien et al., 2012). In the ESReDA guidelines for safety investigation of accidents (2009), some content is provided to support the following recommendations in the training tool-kit guidelines.

What is an event?

“Event”, “incident”, “near-miss” and “accident” have many definitions depending from regulatory context, industrial sectors and academia. An accident or an event is a materialised risk. But what is important to remember is that they are characterised by many parameters (e.g. organisational, procedural, spatial and temporal). It is also important to bear in mind that an event is usually interlinked with other events and is merely a point in a timeline when symptoms of prevailing conditions make sense. According to Barry Turner, it is this moment when we understand that our beliefs regarding safety and ways to manage it were inadequate (Turner, 1978).

An investigation can be triggered by the observation of visible effects (i.e. from near misses to disasters). However, an analysis (i.e. an audit or a review) can also be triggered by a change of perspective, or faith, or degree of reliance on the safety status, or its dynamics, by an expert of the system - even in the absence of an event.

As a reminder, in all sectors, event and accident definitions are provided in procedures or regulations along with criteria for reporting or triggering an investigation. **In the ESReDA Guidelines for safety investigation of accidents (2009)** (available on www.esreda.org), **a definition of what is an event** is provided (Dien, 2006). It recalls that it is linked to the “worldview” or knowledge of safety which has evolved during the last decades especially after disasters: from technical failure and human error to more sociotechnical and inter-organisational understanding (Wilpert and Fahlbruch, 1998).

Basic concepts and theories

Several metaphors, concepts and models related to some accident theories should be more or less mentioned developed according to the audience and level of skills targeted (generalist, specialist, expert):

- Domino theory (Heinrich, 1931), energy transfer (Haddon, 1973), epidemiological (Suchman, 1961), etc.
- Direct-immediate (technical failure, active human error) and root causes (latent failure, human and organisational factors) in connection with causalities models: mechanistic, complex,
- Defence-in-depth, Swiss Cheese (Reason, 1990),
- Human errors classifications and taxonomies (Reason, 1990, Rasmussen, 1983), active failure, latent error or deficiency, resident pathogen (Reason, 1990),
- System Failure (Bignell and Fortune, 1984), Normal Accident Theory (Perrow, 1982, 1984, 2011, Hopkins 1999, 2002),
- Organisational Accident and factors (Reason, 1997), Pathogenic Organisational Factors (Dien and Llory, 2002, Dien et al, 2004, 2012), Resilient Organisational Factors (Dien, 2006),
- Near-misses (several definitions according to the sectors and literature),
- Weak signals, incubation period (Turner, 1978, Vaughan, 1996, Llory, 1996),
- Whistleblowers (Chateauraynaud and Torny, 1998),
- Normalisation of deviance (Vaughan, 1996), etc.

Some other useful models are safety models, related to sociotechnical system and organisational view of safety (Wilpert and Fahlbruch, 1998):

- Sociotechnical levels in operations (Rasmussen, 1997), and design (Stoop, (1990) and Leveson (2002)), organisational network (vertical, transversal) and time analysis (Dien, 2006),
- Safety management systems (MORT, Johnson, 1973), Integrated Management Systems, Safety Culture (INSAG 4, 1990, Guldenmund, 2000),
- Highly Reliable Organizations: Roberts (1988, 1990, 1993), Rochlin (1987), La Porte and Consolini (1991), Schulman (1993, 2004), Weick and Sutcliffe (2001, 2007), Roe and Schulman (2008), Amalberti (1996), Hopkins (2007, 2009), etc.,
- Resilience Engineering (Hollnagel et al., 2006, 2010…),
- Limits of safety (Sagan, 1993, Starbuck and Farjoun, 2005), etc.

3.4 How to investigate?

A wide range of events and investigations

All sectors have encountered major accident and disasters. It is useful to give the trainees a view of those that have occurred in their industrial sector and country. After the disaster, large scale investigations are performed, especially by public authorities, the parliament, the regulators, and independent investigation boards. Some information is usually made public; nowadays hundred-pages reports are available on the Internet. In the ESReDA book on Shaping public safety investigation of accidents in Europe (2005), we have given some details about the institutional conditions of those investigations.

The resources for these disaster investigations are unusual and extensive. A professional independent investigation board can require dozens of professional investigators to collect data on the damaged site for an airplane or train crash or the group can be even larger for independent commissions when it comes to collecting damages of the space shuttle Columbia over the state of Texas. It requires to study hundreds or thousands of pages of documents, and to interview tens or a few hundreds of people (e.g. Paddington train collision in 1999 in U.K. inquiry chaired by Lord Cullen, Columbia Accident Investigation Board in 2003, and the US Chemical Safety Board for Texas City in 2005). These investigations appointed external experts in several fields of engineering, human and social sciences.

On the other side, incidents, near-misses, anomalies, and reportable deviations happen regularly (if not daily) in every industrial sector. For example, in the aviation and nuclear sector, it means several hundred per year to thousands when globalised for several high-risk systems on a scale of very large companies, countries or the European scale. **Detecting, reporting, investigating, learning, implementing corrective actions are daily activities** for the system, and for some people of the system but are far less frequent for the others.

A key message to be given to trainees is that **whatever the scale of the investigation, their basic principles remain the same.**

Basic assumptions, generic approaches and protocols to investigate

In the ESReDA Guidelines for safety investigation of accidents (2009), we have recalled a few generic principles for event investigations, especially some "**basic assumptions on safety investigations**":

- an investigation should be a **fact-finding activity to learn from the experience** of the accident, **not an exercise designed to allocate blame or liability**,
- the emphasis in conducting investigations should be on providing an explanatory description of what happened, on identifying the underlying causes in a chain of events, the lessons to be learned, and on ways to prevent and mitigate similar accidents in the future.
- Worth mentioning are also the defined protocols for conducting investigations, the coordination mechanisms, the competencies required, the data and evidence to be collected, the formalisation and expected reporting, the follow-up of investigations, and communication.

Goal of an event investigation

Trainees should have a clear idea about the fundamental objectives of an investigation, which are to answer the following key questions:

- **WHAT did happen?** Collect evidence, identify the facts, in particular define the chronology of events with the goal of providing an explanatory description of what happened;
- **HOW did it happen?** In particular, identifying circumstances and conditions explaining the causal relationships (mostly mechanistic with regard to this objective with so-called direct causes) between events; it implies an assessment of the plausibility (proving or invalidating) of hypotheses generated based upon the sequence of events, to challenge the various scenarios with available evidence, to validate the most probable scenario taken from observed consequences and track back to its direct causes;
- **WHY did it happen?** In particular, understanding, making sense and recognising a rationale for actors' actions, decisions, operations, design of systems and organisation, in order to identify and highlight the complex causal relationships with the so-called root causes; it is useful to add a sub-question here **"why it was not prevented"** and this enables to have other lines of investigation with barriers or lines/layers of defence in-depth that failed;
- **WHAT is recommended to prevent the recurrence of similar events** here and elsewhere?

Phases of accident investigation and background knowledge

Whatever the scale of the event, an event investigation includes several main phases or tasks: data collection; hypotheses generation; analysis; findings; recommendations.

The allocation of effort per phase is not constant (see figure 1).

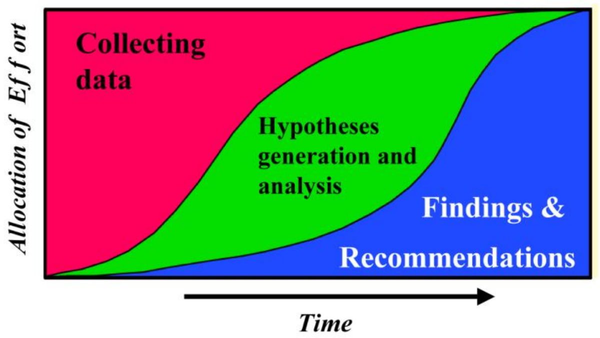

Figure 1: Progressive allocation of effort to investigation phases (adapted from US DOE, source NRI Foundation).

Every analyst acquires skills and know-how, so accident investigation is influenced by 'initial knowledge' (i.e. *a priori* knowledge, worldview or reference models from the analyst's earlier experiences). Additionally, connections between investigation phases are not a linear process, but rather an iterative one. This iterative process and the relationships between the various phases can be seen in figure 2.

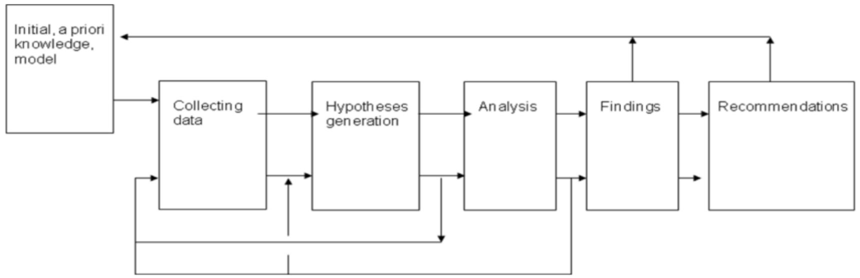

Figure 2: Initial knowledge and accident investigation (ESReDA, 2009).

Indeed, an analyst or an investigation team member is not naïve regarding event analysis. He/she has a set of knowledge - previously acquired – that frames its worldview and know-how - and related to:

- Methodologies for fact-finding regarding technical, human and organisational factors;
- A set of chief findings and lessons learned from other accident or incident investigations;
- Techniques that can be used to identify certain root causes or to uncover facts "hidden" in the past or by the situation.

This body of knowledge helps the analyst to set up hypotheses that make up the skeletal framework for the analysis, i.e. to establish a general framework for (field) analysis, **but it can also bias the analysis that are guided by the principle that, *"You can only find what you are looking for*.**" (e.g. Lundberg et al, 2009).

Models and methodologies for investigating accidents

When carrying out an accident investigation, a relevant accident model is useful. Many are available as earlier described but are not designed for the same level or scale.

The general principle of accident causation models encompasses all aspects ranging from consequence(s) to cause(s).

When starting the investigation, the entrance gate to the investigation process is usually the unwanted consequence and effects on the targets or vulnerable stakes (near-miss, incident, accident, disaster).

However, the investigation in industrial sectors should address all sociotechnical levels (see Rasmussen, 1997) which may be involved in the accident causation or influence. Although this model is relevant for a system in operation, other authors have since made the link with the design phase (Stoop, 1996, Leveson, 2002).

In our experience, we find useful (ESReDA, 2009) the following framework to structure the investigation with the **4 main level model and investigation/causation paths** (Reason, 1997):

- The main elements of an event: hazard source, energy transfer, barrier, target;
- That are produced by three levels: the person (unsafe act); the workplace (error-provoking conditions); the organisation.
- The direction of causality (top-down from organisation to unsafe acts) is the opposite of investigation steps from consequences to direct and root causes.

As a reminder, **analysing human and organisational factors' influence** require to consider:

- Organisational and social level :coordination, complexity, decision-making, subcontracting, resources, culture, power, production pressures, human resources management, change management, policy-making, regulation, governance, communication with stakeholders…
- Human level: activity, tasks, man-machine-organization interfaces, skills and know-how, professionalism…

Several kinds of competencies, levels of expertise are required to analyse those different dimensions of an event, and they are related to several disciplines (engineering, ergonomics, psychology, sociology, anthropology, management, and organisation science, decision-aiding, etc.) (Rasmussen, 1997).

Table 3 summarises some of the various parameters and main characteristics that influence the methods used in accident investigation.

Table 3: Example of criteria to classify methods (ESReDA, 2009).

Purposes of the investigation and its conclusions are about	Levels and/or phenomena to be addressed; type of data	Phases of the investigation; tasks to be performed	Type of approach	Methods employ different forms of logic or processes	Underlying accident model
- What happened - Why it happened - What is recommend-ded to prevent the recurrence of similar accidents	-The main elements of an event (hazard source, energy transfer, barrier, loss) that are produced by: The person; The workplace; The organisation.	- Data collection - Hypotheses generation - Analysis - Findings - Recommenda-tions	- Quantitative - Qualitative, - "Data that should fit the model" - "Model that should fit the data"	- Deductive - Inductive - Morphological - Non-system oriented	- Causal-sequence model - Process model - Energy model - Logical tree model - SHE-management models

For additional discussion on investigation methods: see Sklet (2002, 2003), Frei et al. (2003), Energy Institute (2008), Ziedelis and Noël, (2011), Dien et al (2012). Another interesting classification of investigation methodologies and tools was provided by Frei et al. (2003) that combined three separate criteria of characteristics: phases of investigation, scale of investigation (severity of event) and level of abstraction. **The main idea is to choose the accident investigation methodologies according to their context of use**. (For additional discussion, see "*Tools in context*", Frei et al., 2003). As a reminder, **tools and methodologies are 'servants' and not 'masters'**.

In the ESReDA guidelines for safety investigation (2009), several tools and techniques have been mentioned and **training on investigation should basically mention some of these methodologies** as done here, even for generalist training. For specialist training, at least one method per investigation phase or skill seems a basic requirement:

- **For data collection**: photographs, interviews of witnesses and victims, and actors of the system, documents, recording on the system state, geographical information, damages;
- **Chronology**: immediate-direct causes (technical failure and active human error), to latent errors, root causes described and analysed by timeline, STEP (Hendrick and Benner, 1987), ECFA, ECFA+ (NRI Foundation)…;
- **Consequences** (damages on structures, effects on people and environment) assessment: chemical, physical, ecological models to assess the observed or potential effects…
- For **direct causes** and analysis of the **barrier** that failed: causal-tree, bow-tie, ETBA…
- **Analysis of human errors and human factors**: several methods analysis in ergonomics, e.g CREAM (Hollnagel, 1998), psychology; human reliability analysis (Kirwan, 1994), etc.
- For **root causes and beyond**: MORT (Johnson, 1973), TRIPOD (Reason, 1988), SOL (Wilpert and Fahlbruch, 1998), Accimap (Svedung and Rasmussen, 2000), STAMP (Leveson, 2004), Organisational Analysis (Dien et al., 2004, 2012, Rousseau et Largier, 2008, Dien et Llory 2010, Llory et Montmayeul, 2010, Dechy et al., 2011).

To conclude, the main point is that a variety of methodologies and tools are available to investigators. **All methods were designed for some purposes and have some limits.** Some internal specialist could be trained, or the other option is to rely on external expert help.

Biases affecting investigator(s) and investigations

The investigator (or team) cannot be regarded as neutral to the investigation outputs. We have already mentioned how the background knowledge, worldview, experiences and models influence assumptions, data collection and analysis. There are - at least - two aspects regarding investigators that could have an impact on the investigation results:

- Position of investigators towards the event;
- Role of investigators regarding investigation results.

Results (report) of an investigation have to be read and interpreted with the knowledge of the position and role of the investigator(s). A few issues should be mentioned during the training, more details are given in the Guidelines for safety investigation of events (ESReDA, 2009):

- Several stakeholders can conduct an investigation (see table 2) on the same event. Analysis of A. Hopkins (2003) carried out for the Longford accident (1999) had shown how the findings can be different according to the investigations (e.g. safety investigation versus judicial inquiry).
- Investigators can belong to the plant where the event occurred (in case of process event), to the corporate level of the group, or be an outsider (e.g. consultant, researcher). Whatever its position, an investigator may have difficulty to imagine some causes that affects processes unknown to him, for example phenomenon beyond its work or the organisation boundaries. He could therefore face difficulty to grasp the “big picture” with the entire set of possible causes. In addition, he could attribute the responsibility to some involved actors according to its position (see Mbaye, 2009).
- In addition, epistemological barriers (Llory, 1996) can be faced by some actors, especially by technicians and engineers who still have a behaviourist worldview about human error.
- A “culture of efficiency” could lead investigators to emphasise the controllable and manageable causes for which corrective measures exist within the organisational boundaries available to the investigator(s). Inspectors can tend to report only deviations they are sure to win the case. Several kinds of stop rules could be mentioned (Hopkins, 2003). Investigators have a tendency to limit themselves in their investigation; so it’s not necessary to be too strict in the framing of an investigation.
- Investigators can be seen as political actors (Dien et al., 2012). Sagan (1994) mentioned some “taboo” subjects that cannot be discussed. Usually an authority asks for the investigation, sets the term of reference and may filter some of the data or results. Technical findings are seen as more neutral (Bourdeaux and Gilbert, 1999). This is the

reason why independence, such as given to the independent investigation boards, is a key factor for the confidence in the findings. The role of Cassandra or whistleblower remains costly for an investigator (Dien and Pierlot, 2006).

Conducting an investigation requires several choices

To conclude this chapter on how to investigate, the key message for trainees is that conducting an **investigation is a complex process** to be managed that implies a lot of choices: investigation scope, people (expertise, witness or independent), adequate methods, resources, time constraints, assumptions and causes to be deeper analysed, findings disclosed, hierarchy of recommendations. The findings and quality of lessons identified are quite dependent from those choices and from the conditions in which they are made.

Although, group biases should be challenged too, another key message is that, **to manage this complexity, investigation should be a collective process**, in order to provide more skills, richer worldview, more assumptions, reduce individual biases, more debate about choices and findings..

3.5 How to identify findings

The findings must express the conclusions of the causal investigation process. They should highlight the major factors that contributed to the event sequence.

The pre-findings have been assessed in the analysis phase and some conclusions (the preliminary findings) were reached. Findings can be facts that have been verified, presumptions that have been proven to be true or false (based on the available facts or analysis), or judgements beyond reasonable doubt when dealing with human and organisational factors.

Based on the established findings, a summary of the event sequence and major causes helps to understand quickly WHAT and HOW it happened and WHY it happened and was not prevented. The established findings provide a robust foundation to identify and design recommendations.

3.6 How to establish recommendations

Recommendations should flow directly from the analysis and findings and contain applicable corrective action(s). **Recommendations should be formulated to address the following goals** to:

- Prevent similar accidents/events from happening again here and elsewhere; mitigate the consequences should such an event happen again in the future;
- Address knowledge deficiencies revealed during the investigation;
- Identify weaknesses in the processes (human, technical or managerial) with special focus on the interfaces (human-technical, human-managerial, technical-managerial), as these potentially could be the weaker parts of the processes within the system;
- Focus on strengthening these weaknesses;

As mentioned previously, the definition of different types of recommendations **requires various types of expertise** of the socio-technical system design, construction, daily operations management.

Turning findings into recommendations can be interpreted simply as analysing the learning experiences of those involved and transforming them into meaningful recommendations. Please notice that some independent investigation safety boards (e. g. US CSB) developed **a specific team and set of procedures to deal with recommendations**. Indeed, the recommendation process is not as simple as it might appear. During this process it is important to **bear in mind the following good practices**:

- Recommendations need to be clear and unambiguous;
- The accident investigation report needs to clearly set out the reasoning applied, based on evidence of what happened, and forming the basis of the recommendations;
- Making meaningful recommendations requires a thorough understanding of the system;
- It is essential to involve the stakeholders (those controlling the risks in the system) whilst developing recommendations. This process (of discussing options) leads to more credible recommendations and

greater understanding of what needs to be done by the stakeholders; Consultation with system owners (i.e. involved parties) on draft recommendations before publication leads to more practicable recommendations and a better likelihood of a more positive response;

- It may be appropriate to include a reasonable time limit for responding to a recommendation if this is not already mandatory by regulation. This may be seen as a way to indicate the investigator's ranking of priorities, however skill and caution is needed if this technique is used. Recommendations are proposals for the design of corrective actions, which can become mandatory when a safety authority turns them into objectives to comply with.
- The integrity and credibility of investigators is crucial to securing acceptability of findings. This is mainly achieved by professional reputation based on actual behaviour. Codes of conduct covering such matters can be especially helpful (see §3.7).

Corrective actions to be designed according to the recommendations can be **categorized according to**:

- ***Their position with regard to the risky phenomenon:*** from preventing the occurrence of the hazard to reducing the vulnerability for those people, systems or environments at risk;
- ***Their position with regard to the socio-technical level***: e.g. re-engineering the process, redesigning the human-machine-organization interfaces, reorganizing the work at the shop-floor or management level(s), or the structure and power relationships, changing regulations and procedures.
- ***The degree of renewal*** or change to the sub-system or whole system: optimise, adapt, and innovate (see ESReDA-Cube in figure 8 in Ch. 4 on learning). For example, coping with deficiencies in the system's design and operation. Safety enhancement can be achieved by timely adaptation of the system characteristics and primary working processes. The system will adapt its operating parameters to enable changes in the operating environment. Another example is closer to the "resilience" approach that requires coping with deviations from a normative level of performance based on optimal operating conditions, and restoring the situation and/or system state to what it was before the disruptive event.

3.7 Code of ethics, do's and don'ts in terms of communication

The investigators should possess several qualities and capabilities, including a high standard of competence and knowledge, professional behaviour, a strong commitment to the objectives of the investigation, impartiality and thorough training in the disciplines aimed at safety promotion and risk control/management. Some communication procedures are developed by independent safety boards (see ESReDA, 2009).

Table 4: Examples of principles for codes of conduct.

Integrity	At all times the activities should be in accordance with the high standards of integrity required of the role, profession or position held by the individual.
Objectivity	While collecting, analysing, describing or communicating facts, the main emphasis should be on objectivity.
Logic	Facts should be applied in a logical manner.
Prevention	Facts and analysis should be used to develop findings and recommendations that will improve safety.
Independence	The investigative body, its investigators and staff should be independent of the national judicial system, other authorities and of all other actors and parties involved.

3.8 Report content

In many cases, the scope of the investigation and the complexity of the accident itself will dictate the report's size/volume, depth and content. As earlier described, some disaster investigation report are hundreds of pages long, while some event files recorded in a database are less than a page of text! Based on a number of international sources, the **main chapters** in the report should be based on the following headings:

1. Summary;
2. Background and purpose;
3. Organisation and mandate;
4. Factual information (e.g. chain of events, consequences);
5. Analysis/method used;
6. Results (e.g. findings, direct and root causes);
7. Conclusions (e.g. most probable scenario);
8. Urgent recommendations to immediate measures;
9. Safety recommendations;

Appendices (to supplement the content and information of the main report), which, for instance could be key evidence (e.g. damage pictures, transcription of hearings or (part of) witnesses interviews).

3.9 Defining case studies to be used for the training on event investigation

It is time address some **pedagogic issues** that shape the training design.

Most of the training sessions proposed here are expected to be delivered in **classroom**. It is especially efficient for courses on theory and principles, both for generalist and specialist training. Trainers should choose the best ways for delivering the messages: presentation from a trainer, an accident video, an investigation guideline, a procedure, a newspaper extract, examples and a stories they know well. In this configuration, from a pedagogic point of view, the **trainee is mostly passive**. Therefore, a known good practice is to use some **questioning method** at some stages (e.g. introduction) to **stimulate participation from the trainee**.

For specialist training, in order to transfer not only knowledge or grid of analysis but basic skills, some **active approaches** should be targeted. Still, some of those sessions will likely mostly occur in classroom too **with practical exercise, case studies, or working group debates** (e.g. analysing an event). Other methods such as **computer simulation, role play, field exercise out of the classroom** could be part of the tools used by trainers. In addition some **homework** might be necessary (e.g. on some case study). Finally, some **exams** can be scheduled to assess the efficiency of the training and the effective learning of the trainees. Furthermore, training should continue after the session with real cases and responsibilities under the supervision of experienced colleagues (**companionship**).

Because the ESReDA PG has gathered several **case studies** in the deliverable “case study analysis on dynamic learning from accidents (2015)”, a few guidelines are proposed to the training designers:

- It should be a **contextual choice** made by the training design team as it is a key part of the training toolkit and should be adequate to the trainees, the trainers and the training time frame,
- There are two main options for the case selection according to its adaptation to trainees context:
  - **use up-to-date events** adapted to the operational context of users; some group of trainees can propose their investigation case, recently done;
  - or to step back from the **cultural background, historical reference cases** (such as a well-documented disaster investigation) can be valuable; some case studies are provided by the ESReDA PG in the case study report (2015) that address different industrial sectors and scales of events.
- We can distinguish 2 kinds of cases used for application:
  - **simple** accident case studies, discovered during the training, **to test some investigation phase tools in a few hours** (e.g. analysis with fault tree, bow-tie, ECFA, MORT, etc.), the trainee might be alone or paired with 2 or 3 trainees per exercise ;
  - and there are more **complex** cases that should be worked and tested in larger groups, possibly with **homework** study.
- It could be useful to develop a connection between first part (investigating) and second part (learning) cases (see chapter 4.8).

4 TRAINING SESSION CONTENT IN DYNAMIC LEARNING

4.1 Framing the organisational and trainees' context for dynamic learning

Introduction: recalling the training objectives to the trainees and introducing the issues

Despite the diversity of background of trainees, some basic and generic goals can be recalled. Although, some of those issues have been introduced in the first part of the training on event investigation (Ch. 3), it can be valuable to recall the focus of this second part on learning:

- by recalling the targeted skills (e.g. generalist versus specialist);
  - **specialist**: to transform lessons to be learned into effective changes, to design, operate the learning system and audit it,
  - **generalist**: to see the bigger picture of the learning process, its barriers within the safety management system, production management and decision-making.
- by recalling the content of the training;
  - Role of accident analysis and learning from events (from one and many) in the learning from experience process, and safety management,
  - Designing learning policy and implementing this into systems and processes,
  - Integrating learning at multiple levels within the organisation (operational, systemic, managerial), some features of learning efficiency, recommendations for learning,
  - Barriers, hindrances, pathogens, symptoms, facilitators;
- by raising some issues of investigation and learning with a few questions addressed to the trainees;
  - e.g. What is learning? Why should we learn? Who should learn? At what level? For which reasons? From whom?
  - e.g. Importance of a learning from experience system for safety management: is there an issue or problem with learning in your organisation? What are the risks of deficient learning?
  - Do you know some barriers, hindrances for learning in your organisation? etc.

The answer to these introductory questions can be useful for the trainer, especially an external trainer, to assess the level of a priori knowledge and know-how of the trainees.

Adapting the generic training on learning to several parameters

In chapters 2 and 3.1, in order to frame the design of the training session on accident investigation and learning, several questions addressing **several parameters** have been raised. Chapter 3.1 introduces and frames the content of the two sessions on investigation and learning and provides some suggestions to **proportionate the training**.

The idea for the trainer, the training designer is not to repeat those issues, but to introduce the course according to the trainees' framework. Some parameters that should lead to some adaptations from the generic training are recalled with a focus on learning.

- **Adapting the theoretical framework to the trainees**: most of the notions and concepts to be recalled should have been done in the general introduction of the course during the event investigation session; some recalls could be specifically done on safety management systems, in order to locate the input and output of the learning loops.
- **Adapting the training to the risk context and scale of investigation and learning**: according to the trainee's context in its organisation (small, medium and large companies, low or high-risk industry), the requirements of the learning process on reportable events (by regulation) or events to learn from will be different, as well on the input (frequency and scale of events or lessons to be learned), as on the output; historical view of the learning system development in the organisation can be useful too.

- **Recalling the regulation on learning, institutional framework and stakeholders of the learning system**: the regulation have been recalled before especially on reportable events to learn from, but the content of the training should focus now on the detailed regulatory request on the learning system (are there any? Or are they only specifying the objectives such as "learning the lessons" and "implementing corrective actions"). We have distinguished 3 categories of events to learn from: public accident investigation, reportable incidents to the control authority, events treated through internal procedures. What are the changes of scale and content of the learning? Who are the different stakeholders involved and responsible for the learning? This visualisation will help to introduce further issues (e.g. on learning loops,…).

4.2 Who wants to know, who needs to learn?

Before developing the features, processes and barriers to learn during the training, an important issue to clarify is who should learn?

Indeed, every accident investigation is an opportunity to learn and increase the cumulative knowledge available to improve safety and accident management. Before sharing lessons and issuing recommendations, it is essential to be aware of the roles of participants and stakeholders concerning the learning process. Some may want to know and learn, but are they the same as those who need to learn? The trainer could ask answers from the trainees on these two questions.

- Many different audiences want to know what happened (e.g. the bereaved, public, police) but these are not always the same as the ones who need (and hopefully want) to learn the safety lessons. E.g. after some accidents the police will want to know what happened and who was to blame. Their main goal is not necessarily to learn the safety lessons to be applied to the system. Others will need to learn why and how it happened in order to identify improvements in the way the risks are controlled;
- Those who truly need to learn the lessons are those who are in a position to make improvements and changes (i.e. turning the lessons into actions) to the systems (i.e. organisational and technical processes) for controlling risks. However, there are many organisational layers and depth of learning. According to the layer and depth, there will be corresponding stakeholders involved;
- Controlling risks is not just in the hands of experts and the system managers. In some circumstances changes in public behaviour is a key aspect of controlling the risks;
- Many will claim they want to learn the safety lessons: politicians, safety professionals, senior managers and workers, for example. However, it is paramount that they follow through with their claims by putting the lessons into actions;
- It is of utmost importance that lessons are communicated in the right way and at the right time to the right people in a manner that they can understand.

Asked differently, who is the target of this training on learning: the people or the organisation?

Although this training focuses on people, to change their knowledge and critical thinking on learning processes and their know-how to manage better the learning activities they are involved in, the ultimate changes targeted are on the organisation, institution, regulation. They will in turn support collective and individual change in practices, in worldview, and will support the memorisation of lessons of their employees.

4.3 What is learning? Features of learning

After an introduction of the learning issues, recalling the objectives of the training part on dynamic learning, framing the generic training to the context of trainees (in terms of regulations, risk, parties to involve in the learning process), this chapter is generic as it addresses some theories, models on learning, especially from incident and accidents.

Some basic concepts, models, ideas, and messages are extracted here to form the basis of the training. More details are given in the two ESReDA reports (2015) *"Barriers to learning from incidents and accidents"* and *"Case study analysis on dynamic learning from accidents".*

Individual learning and knowledge – organisational learning and knowledge management, learning loops

What is learning? At this basic question, an Oxford dictionary definition can be given as an introduction: *"In general, learning is the acquisition of knowledge or skills through study, experience, or being taught"*.

Learning from events implies that skills and knowledge are acquired through study and experience. However the knowledge acquired through some lessons can differ in type, depth and use. It makes sense for prevention if lessons and recommendations are applied through corrective actions. In other words, *"learning means change"* (Koornneef, 2000).

In the definition, the knowledge acquisition is individual, but at some point it should be collective and organisational, which requires transfer of knowledge between people and organisational features, and connects it to the field of knowledge management and organisational learning.

A trainer can pick the following definitions (see ESReDA "Barriers", 2014).

- *"**Organizational learning** is seen as a dynamic process based on knowledge, which implies moving among the different levels of action, going from the individual to the group level, and then to the organizational level and back again* (Huber, 1991; Crossan etal., 1999)" [Jerez-Gomez 2005].
- An important distinction is made between learning loops (Argyris and Schön 1978, 1996): ***"single loop"***, ***"double loop"*** referring to depth of causes addressed, and the concept of "learning to learn", called **deutero learning**.
- Nonaka and Takeuchi (1995) identified four types of ***transfer of knowledge*** from individuals to groups (socialisation, externalisation, internalisation, combination), based on the distinction of two key types of knowledge: ***tacit*** *knowledge* and ***explicit*** *knowledge*. They are relevant as a background on learning from events. Among those, socialisation is important for the skills and experience transfer.

Other frameworks are available in literature, especially on triple loop learning. In safety, one can mention the one from Svedung and Radbö (2006), when the lessons to be learned and change were above the company and concerned the regulation of an industrial sector. Notions of loops will be discussed again in the chapter on levels of learning.

Learning from events versus normal operations, learning from success versus failure

As the Oxford dictionary definition recalls, this acquisition of knowledge and skills can be based on experience feedback and study. To simplify, the feedback can be a success or a failure.

Both kinds of experiences (positive and negative) provide lessons to be learned. However those lessons might be of different nature and are complementary.

Some researchers (especially Highly Reliable Organizations, Resilience Engineering streams) advocate for the study of normal operations (as they estimate normal operations are not as studied as accidents), seeking best practices, especially relevant to explain how success is obtained in adverse conditions, in order to grasp **features of reliability and resilience**.

Other researchers are advocating for the study of events, of failure and accidents (as they consider, not enough attention is given to those events compared to normal operations) in order to highlight **features of vulnerability**. Some researchers as Wilpert (quoted by Carroll and Fahlbruch, 2011) considered that undesirable incidents and events, serious and disturbing as they may be, are a ***"gift of failure"***. In short, events offer an opportunity to learn about safe and unsafe operations, generate productive conversations across engaged stakeholders, and bring about beneficial changes to technology, organization, and mental models (understanding). Llory (1996) argues that accidents are the ***"royal road"*** (referring to Freud's metaphor about dreams being the royal road to access the unconscious) to access to real functioning of organisations (especially hidden phenomena, dark side of organisations as defined by Vaughan (1999)). They add that these accident' lessons can be capitalised in the form of a Knowledge of Accidents and transferred as a Culture of Accidents to balance the safety culture too much focused on best practices (Dechy et al., 2010, 2011, 2013, Dien et al., 2012).

From accident investigation to learning from many events

The first part of the training has focused on event investigation, especially accident investigation. However, **analysis is not learning**. Several new issues arise on top of the event investigation process, when one addresses the objective of learning from events. Each one could be developed according to the needs and the context of the trainees, its future work.

- Instead of investigating one accident with higher resources, many events should be investigated with comparatively much less resources: how efficient can it be?
- Lessons to be followed-up are not coming from one accident, but from several events affecting several sub-systems, at different times and pace. The lessons are sometimes complementing, repetitive, cumulative, and sometimes are contradictory or hard to synthesize.
- **Databases** recording thousands of events have been operated for more than 20 years (see ESReDA reports during the 1990's). Learning from experience analysts (often engineers, sometimes human factors specialists) who have to analyse tens, hundreds, thousands of events in complex and large systems, have to establish connections, identify trends, and make assumptions for further analysis. Today, they can be helped by automated/natural language-processing tools (IMdR, 2013, Blatter and Raynal, 2014) and statistical treatment of "big data" (IMdR, 2013, Jouniaux et al., 2014).
- The lessons to be learned should be cross-analysed with other inputs from operations (e.g. maintenance data), safety management system (e.g. audits) and external inputs (e.g. lessons from others), and from the accumulated knowledge of accidents (Dechy et al, 2013).

Learning from others

The "hard lessons" one faces directly are easier to remember and have been a key factor motivating people and organisations to take some actions to avoid similar events from recurring.

Another driving force for learning has been to learn from others "hard lessons" (Llory, 1996, 1999, Dien et al., 2004, Hayes and Hopkins, 2012, Paltrinieri et al., 2012). It can be seen as "observational learning" (Bandura, 2004), that is learning that occurs through observing the behaviour of others and can be called "vicarious learning" from indirect sources.

Exchanges of lessons on accidents have been promoted across several industries for a long time: e.g. in aviation in the early 1900 (see the ESReDA book on Shaping public safety investigation of accident in Europe (2005)). Some international databases are shared in aviation (ADREP) and nuclear industry (under the umbrella of IAEA, WANO, EU), or in Europe for chemical industry (MARS and eMARS databases at Joint Research Center).

This kind of learning is inter-organisational, between countries, and sometimes between industrial sectors especially with disaster cases. This transversal learning (Dien et al., 2006, 2012, Dechy et al., 2007, 2013) has to cope with some challenges, of lessons sharing, and especially in the translation and the compensation of the loss of context (Koornneef, 2000).

Learning from the past, keeping that memory, learning for the future

Once an event occurs and is detected, a learning loop (or process) is triggered involving several stakeholders and especially several hierarchical levels in the vertical sociotechnical system. When an external event, is detected, another learning loop or process is triggered, this time in the transversal dimension (see figure 4).

Both these learning loops generate lessons to be transformed into actions. In addition, a follow-up should be done on the implementation of corrective actions, as not all actions are implemented in practice, and the effects they produce may be surprising or counter-productive. **The time dimension is important in learning**.

Indeed, several minor events are **recorded for the future** in order to carry out later some trend analysis. In the opposite direction, when an event occurs, it is valuable to track if other **events from the past** could be put in relationships (e.g. weak signals, precursors, near-misses) during an analysis in order to bring new insights of underlying phenomena. A third dimension of learning appears, the historical one (see figure 4).

Keeping memory of past events, lessons to be learned or not forgotten, and changes made is a key learning function. This should be addressed by organisations, although Kletz (1993) has warned that *"organisations have no memory, only people have"*. Although it is an interesting warning, it is partly false as organisation and engineering designs incorporate some form of memorisation (see Ferjencik and Dechy, 2013).

Is learning after events reactive or proactive?

Once an event occurs and is detected, a learning loop (or process) is triggered. Therefore, learning is often seen as a reactive process. It seems particularly true for events easy to detect, such as accidents, and where investigation is required by regulation.

For minor events, anomalies, deviations, near-misses and weak-signals, it requires a proactive attitude to consider some of them (but how to determine the most relevant beforehand is one of the key question?) as opportunity to learn, and to invest resources for investigating the underlying phenomena behind these early signals or symptoms that something has gone wrong.

Process/stages of learning

Several researchers (see more in ESReDA "barriers to learning from incidents and accidents" report, 2015) have described learning from events or operating experience feedback as processes. The learning process is modelled in several steps or stages, and depending on the authors between 5 to 13 steps.

At this stage the trainees should receive the message that the number of steps is not of primary importance, as these are only models. What is important to keep in mind is the idea of the process, and to connect it with the difficulties found at each stage of the learning process.

The trainer can pick among the examples the one which fits the most with the trainee's context or its key messages:

- reporting, selection of incidents for further investigation, investigation, dissemination of results and the final step is the actual prevention of accidents (Lindberg et al. 2010);
- data collection and reporting, analysis and evaluation, decisions, implementations and follow-up (Jacobsson et al., 2011);
- Learning process in 5 phases and 13 steps (Drupsteen et al., 2013), emphasising the impact of weaknesses in one step on all consequential steps in the process

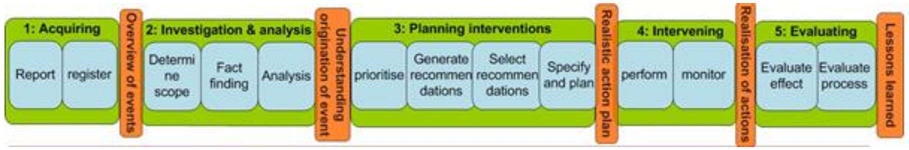

Fig. 3: Analytical framework of learning from incidents process (Drupsteen et al., 2012).

- 3 learning processes of 9 steps in 3 organisational dimensions with deficiencies and failures found in major accidents at all steps and in the 3 organisational dimensions an in the common dimension of information formalisation an communication (Dien et al., 2006, 2012, Dechy et al., 2008, 2011);

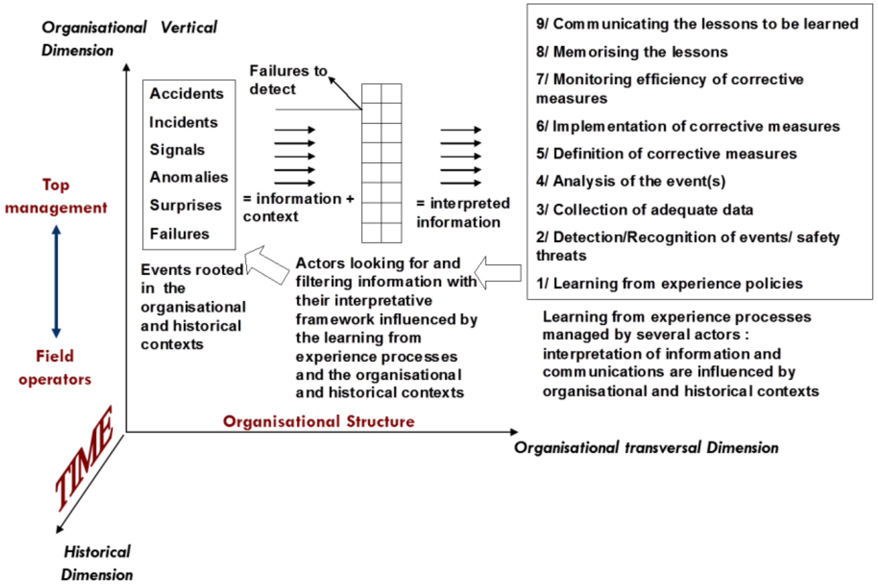

Fig. 4: The learning from experience processes issues to manage/sources of failure (Dechy et al., 2008).

Level of learning, learning loops and impact of learning

In addition to the concepts of learning loops conveyed by organisational learning researchers that addressed the depth and extent of learning, several researchers have identified multi-level learning (Rasmussen and Svedung, 2000, Dechy et al., 2004, Svedung and Radbö, 2006, Cedergren and Petersen, 2011, Hovden et al, 2011, Tinmannsvik et al., 2013).

Rasmussen (1997) defined mainly 6 levels for the sociotechnical system (the process, the work by the operator staff, the management of the staff, the company, the regulators and the government). Several authors have simplified it into three levels, micro-meso-macroscopic, as is used in the ESReDA-Cube model (2015, see fig. 8). Each level may be the location of contributing factors to the event, the target of recommendations, and impacted by the effects of safety measures.

"Dynamic" and "static" learning

"Dynamic" learning is a wording proposed by the ESREDA project group on dynamic learning as the follow-up from accident investigations to address the issue of an everlasting process with new inputs and new outputs expected. It acknowledges the complexity of organisation, of interactions, its dynamic character with new data, lessons… Safety requires continual adaptation to new data, lessons and to changes.

It is a way to avoid "static learning", seen as one-time learning. Learning is not a one-time phenomenon, but is an ongoing process in which one continually improves and adapts the organization (and society, culture, etc.). It also includes the unlearning of the former ways of work, procedures, processes and behaviour.

4.4 Symptoms of failure to learn

In the ESReDA report on *"Barriers to learning from incidents and accidents"* (2015), three categories of phenomena and factors influencing the quality of learning are defined:

1) symptoms of learning deficiency or disease,

2) their root cause such as learning pathologies and other causes,

3) enablers aiming at improving the quality of learning or correcting its deficiencies.

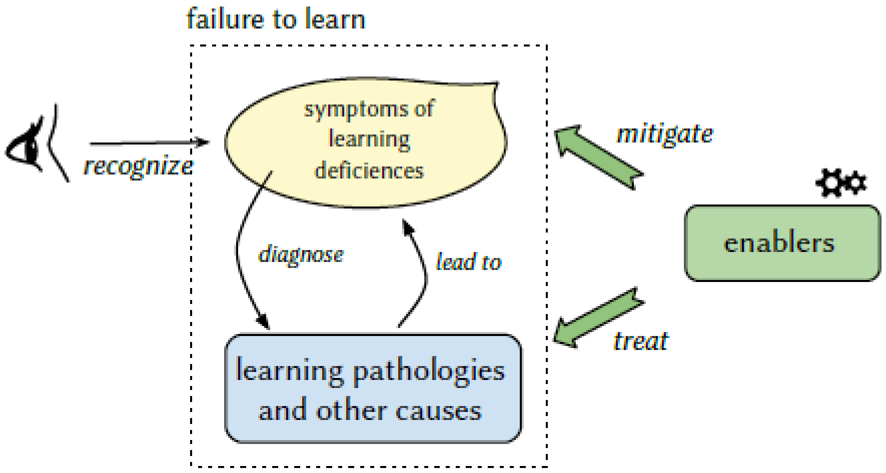

Figure 5: Categorising influence factors of the quality of learning (ESReDA, 2015).

In the ESReDA report on *"Barriers to learning from incidents and accidents"* (2015), several symptoms of failure to learn have been identified and could be recognised by the trainees in their organisations. It would be valuable to question the trainees about them and write them on a blackboard.

Symptoms of learning deficiencies should be mentioned in the training course (as a list at least in the generalist training). They are recalled hereafter, shortly defined and further details are provided in that report. For specialist training, more details should be provided:

- To take on board some of the explanations or causes of the learning deficiency described for each symptom in that report, based on the audience and the objectives of the training.
- Practical suggestions are made in that report about ways to diagnose the symptom.
- Examples of accidents are often mentioned in that report; they might be valuable to explain some deficiencies. Other examples are available in the ESReDA case study report.

Underreporting, underlogging

Voluntary incident reporting systems often suffer from chronic under-reporting, in which incidents are simply never reported.

Poor quality of reports

Some reports or one page fact sheet recorded in databases provide little help in identifying safety improvements. The data collected may be incomplete (facts missing, unclear sequence of events, and superficial description of the context of the event). In any case, we have to keep in mind that as good report could be, there will always be remaining grey zones about the event and its (underlying) causes.

Analysis stops at immediate/direct causes

In some learning systems, the analyses of the causal factors contributing to events tend to be superficial, and are limited to the identification of the direct (or immediate) cause(s) (such as the technical failure of a piece of equipment, or the behaviour of an operator who skipped a step in a procedure).

The underlying contributing factors (often called "root causes"), which allowed the direct cause(s) to exist, and which are generally organizational (for instance, insufficient budget for maintenance leading to corroded equipment; high production pressure and supervisor tolerance of "temporary shortcuts") and related to the management of operations and safety, are not identified.

According to the terminology from the organizational learning literature, we can say that recommendations are limited to single-loop learning (immediate fixes), and do not include double-loop (underlying values) or deutero-learning ("learning-to-learn" capability). Using the notions of multi-level learning, top levels of the sociotechnical system (company management, regulators, regulations) would not be addressed by the investigation into the root causes.

Self-centeredness (deficiencies in external learning)

Insufficient sharing between sites, firms and industry sectors: there are many institutional and cultural obstacles to the sharing of information on events and generic lessons between sites from a same firm, firms in the same industry sector, and (even more) between industry sectors. Several factors contribute to this difficulty.

Ineffective follow-up recommendations

Certain recommendations or corrective actions are not implemented, or are implemented very slowly.

No evaluation of effectiveness of actions

In order to ensure that the learning potential of incidents is used and effective, organizations should ensure that the effectiveness of corrective actions is evaluated. Did the implementation of recommendations really fix the underlying problem that triggered the initial event?

Lack of feedback to operators' mental model of system safety

In addition to organisational learning, learning should occur at individual level, especially by revisiting the mental model of its actors, stabilised over time (supported by the confirmation bias), of the system's operation, of the types of failures which might arise, their warning signs and the possible corrective actions. If events are not presented with new information which challenges their mental models, such as feedback from the reporting/learning system, then the learning loop will not be completed. If the organizational culture does not value mindfulness or chronic unease, then people's natural tendency may be to assume that the future will be similar to the past.

Loss of knowledge/expertise (amnesia)

There is a natural tendency that memory fades over time. People forget things. Organizations forget things. The lessons learned from incidents and accidents are slowly lost if no measures are taken to make them alive.

Bad news are not welcome and whistleblowers are ignored

A number of major accidents have been preceded by warnings raised by people familiar with the system and who attempted, unsuccessfully, to alert people with an ability to change the system of the nature of the threat that they perceived. The message of these whistleblowers was not heard by the organization, because of a culture in which bad news was not welcomed and contrarian voices are frowned upon.

Ritualization of experience feedback procedures or of accident investigation

Ritualization, or a compliance attitude, is a feeling within the organization that safety is ensured when everyone ticks the correct boxes in their checklists and follows all procedures to the letter, without thought as to the meaning of the procedures. This kind of organizational climate is not conducive to learning.

4.5 Pathogens causing learning deficiencies

Some pathogenic organizational factors (see Dien et al., 2004, 2006, 2012, Rousseau and Largier, 2008) which hinder the effectiveness of the event-learning process have been identified in the ESReDA report on *"Barriers to learning from incidents and accidents"* (2014).

These underlying characteristics, or pathogens in the medical metaphor used in this framework of learning deficiencies, are generally more difficult to detect or diagnose at an operational level than the symptoms, and may be responsible, to various degrees and possibly in combination with other problems, for a number of symptoms.

Those pathogens could be recognised or assumed by the trainees in their organisations. It would be valuable to question the trainees about them and write them on a blackboard.

The pathogens should be at least mentioned in the training course (as a list for the generalist training). They are briefly recalled here, briefly defined, and should be further discussed in the specialist training:

- To take on board some of the explanations on the pathogen origins, according to its audience and the objectives of the training.
- Some examples of accidents are often mentioned in the barriers report; they might be valuable to explain some pathogens. Some other examples are available in the ESReDA report, "*Case study analysis on dynamic learning from accidents*".

Denial

Denial can be related to the idea that "it couldn't happen to us". At an individual level, denial is related to cognitive dissonance, a psychological phenomenon in which people can intellectually refuse to accept the level of risk to which they are exposed. At an organizational and institutional level, group-think phenomena or commitment biases can lead to denial (rationalization of decisions).

Failures indicate that our existing models of the world are inadequate, requiring a search for new models that better represent reality (Cyert and March, 1963). This challenge to the status quo is expensive, which can encourage people not to look too closely into warnings that something is not exactly as one would like it to be.

Resistance to change

At an individual level, resistance to change may be caused by mistrust, lack of information, lack of ability or lack of sufficient incentives. Note however that "resistance to change" is a complaint often made by managers concerning resistance of shop-floor workers to a proposed reorganization, which when analysed in detail may be due to workers having identified that the proposed change will lead to degraded working conditions or lower safety.

At an organizational level, resistance to change means that trying new ways of doing things is not encouraged. It is well known that organizations have a very low level of intrinsic capacity of change, and often require endogenous pressure (from the regulator, from changes to legislation) to evolve. For more information see e.g. De Boer, 2012. However, on the other side, companies implement too many changes which generate turbulences (e.g. NASA before Columbia in 2003).

Inappropriate organizational beliefs about safety and safety management

In mature industries dealing with hazards, accidents too often act as a trigger which shows us that our worldview is incorrect, that some fundamental (but sometimes unstated) assumptions we made concerning the safety of the system were wrong.

Overconfidence in the investigation team's capabilities

The investigation and analysis teams may lack certain skills necessary for quality investigations, or have inadequate knowledge of the system's functioning and elements responsible for its safety, leading to substandard investigations and little learning.

Anxiety or fear

Accidents and incidents often arouse powerful emotions, particularly where they have resulted in death or serious injury. On the positive side, this means that everyone's attention can be focused on improving prevention (awareness). On the negative side, however, the same emotions can also cause organizations and individuals to become highly **defensive**, leading to a rejection of potentially change-inducing messages. This is natural and understandable but needs to be addressed positively if a culture of openness and confidence is to be engendered to support a mature approach to learning.

Another area for fear or anxiety is the effect of reporting a negative event on the company's (or a colleague's) **reputation**.

Corporate dilemma between learning and fear of litigation/liability

Due to legal context, organizations may wish to avoid the accumulating of what can be seen as incriminating knowledge. Indeed, the incident reporting database may contain information concerning precursor events, which demonstrate that managers “knew” of the possible danger in their system, but had not yet taken corrective action. However, suppressing the safety lessons which can be derived from this information can create an organizational learning disability (Hopkins, 2006).

Lack of psychological safety

In the absence of psychological safety (Edmondson, 1999), people will hesitate to speak up when they have questions or concerns related to safety. This can lead to under-reporting of incidents, to poor quality of investigation reports (since people do not feel that it is safe to mention possible anomalies which may have contributed to the event), and to poor underlying factor analysis (it is easier to point the finger at faulty equipment than at a poor decision made by the unit’s manager).

Self-censorship

In many workplace situations, people do not dare to raise their concerns (they choose silence over voice, withholding ideas and concerns about procedures or processes which could have been communicated verbally to someone within the organization with the authority to act). They have developed self-protective implicit voice theories, socially acquired taken-for-granted beliefs about the conditions in which speaking up at work is accepted, which they have internalized from their interactions with authority over many years (Detert and Edmondson, 2011).

Subjectivity and attribution bias

The data may also be biased, since a person reporting an incident will have a natural tendency to include some subjective information on the event. In addition, whether the investigator or reporter is an employee or manager may bias his judgment towards the responsibility of similar colleagues and others involved in the event (see Mbaye et al. 2009 for further discussion about attribution bias).

Cultural lack of experience of criticism

In some national cultures, there are strong obstacles to producing and addressing criticism or suggestions for improvement (which can be seen as implicit criticism of the people who designed or manage the system).

Drift into failure, migration, normalisation of deviance

Performance pressures and individual adaptation put systems in the direction of failure (Rasmussen and Svedung, 2000), and thereby gradually reduce their safety margins and take on more risk.

This migration (Rasmussen, 1997, Amalberti, 2006), and the associated erosion of safety margins, tend to be a slow process, with multiple steps which occur over an extended period of time. Because each step is usually small, the steps often go unnoticed, a “new normal” is repeatedly established (“normalising deviance” Vaughan, 1996), and no significant problems may be noticed until it’s too late.

Inadequate communication

Lessons sharing and organizational learning requires communication between the people and organisational entities (transversal and vertical dimension of the organisational network, Dien et al., 2006, 2012).

Communication is often impaired by the organizational structure, the policies, the conflicts of power between departments and relationships between people.

Conflicting messages

When there is some disconnect between management’s “front-stage” (according to Erving Goffmann distinction during the 50’s) slogans concerning safety (such as “Safety first”) and the reality of decisions or actions on the “back-stage” (“let’s wait until the next planned shutdown to do this maintenance”), management messages lose their credibility.

Langåker (2007) has analysed the importance of compatibility between the front-stage and back-stage messages (management’s ability to “walk the talk", or commitment to the meaning of safety messages, as opposed to appearances) for the effectiveness of organizational learning.

Pursuit of the wrong kind of excellence

System/Industrial/Process safety is a complex phenomenon to monitor through safety indicators or key performance indicators.

Several organisations have made (e.g. see the Texas City refinery accident in 2005 (CSB, 2007)) and still make some confusions with occupational safety, where incidents occur more frequently and success or failure (or indicators) are easier to monitor (e.g. lost time injury rate), especially when communicating about their level of safety.

4.6 Enablers of learning

The "enablers of learning" are influencing learning positively either by mitigating the symptoms of deficient learning or by treating the pathogens causing learning deficiencies (see Figure 5). These enablers of learning have been identified in the ESReDA report on *"Barriers to learning from incidents and accidents"* (2014).

Enablers are ranging from underlying organisational conditions such as transverse mechanisms (e.g. culture), to organisational functions and specific measures that are working in practice.

The enablers of learning should be at least mentioned as a list for generalist training. They are briefly recalled here and defined. Then it is up to the trainer (especially for specialist training) to take on board some of the explanations and examples, according to the needs of the audience and the objectives of the training.

Enablers linked to climate of work and cultural factors

Learning can be enabled by several factors that are related to a good climate of work and supporting organisational culture. Although, well studied by researchers in prevention and safety science, they are not easy to lever or enforce efficiently despite management efforts or claims (e.g. safety culture INSAG 4 in nuclear industry).

They should be mentioned at least as a list, and can lead to more debates within a specialist training (see ESReDA report on barriers):

- Cooperation: it enables communication information and sharing of knowledge,
- Motivation: the belief that learning is important and necessary,
- Trust: it enables communication without fear of blame,
- Existence of shared language and concepts: organisation are not monolithic, many subgroups are developing their own words and way of viewing the system,
- Individual curiosity and vigilance: individual awareness and will to learn can be favoured,
- Ability to embrace new ideas and change, to see opportunities and risks,
- Supporting organisational (sub-)cultures ("learning culture", "reporting culture" and "just culture") as claimed by Reason (1997) and Dekker (2007: balancing safety and accountability).

Enablers related to operational measures

- Importance of appropriate accident models: several seem outdated, and not shared in practice in the field,
- Training on speak-up behaviour,
- Peer reviews: learning opportunities for participants through benchmark and cultural change,
- Learning agency: an organisational function recommended by researchers on organisational learning (Koornneef, 2000),
- Unlearning outdated safety procedures: a forgotten function of organisation, lessons should also help to remove and simplify, and reduce accumulation and complexity,
- Dissemination by professional organisations: of safety information and lessons from incidents, several examples per industry (e.g. CCPS safety beacon),

- Workshops: exchanges between academia, industry on learning (e.g. FonCSI, 2014, IMdR, 2015, ESReDA 2003, 2007, 2009, 2013),
- Standards: a way to accumulate knowledge, often slow, but include specifications developed in voluntary process with a minimum of consensus among parties involved,
- Role of regulators to enforce lessons, to disseminate lessons, to share databases,
- National inquiries and investigation boards: qualitative report providers,
- Real time response of databases and information systems: old databases not adapted to the needs.

4.7 How to learn efficiently and dynamically? A learning space for guidance

According to the previous developments, an effective learning approach would require:

- To mitigate the symptoms of barriers to learn,
- To treat the pathogens of learning,
- To implement the identified enablers of learning.

In addition, some guidance to question the effectiveness of learning should be addressed in the training (both for generalist and specialist). It questions the relationship between the lessons, the corrective action implementation and the effectiveness of the changes.

From applying the recommendations to the design and implementation of corrective actions?

Recommendations are operational translation of the main lessons drawn from the investigation by the investigators. Learning the lessons implies to change knowledge or to take some actions and implement some changes sometimes on broader scale such as an industrial sector. The role of those with authority (internal and external, including regulatory) to implement the recommendations can be considered using the following guidelines:

- It is for those with responsibility for the activities affected by the recommendations to take them into account and follow-through with appropriate action;
- In determining their response (either accept or reject) to the recommendations, the responsible party should consider all information relevant to manage and/or control the risk(s) involved;
- Responses to recommendations should be recorded: any rejected recommendation should be supported by a rationale; any accepted recommendation should be accompanied by an action plan;
- Actions taken in response to recommendations should be tracked through to their completion;
- Formal steps should be taken to preserve the lessons learned in the corporate memory (such as a database of recommendations and actions, a record of why changes are made to systems, etc.). Similarly, steps should be taken to ensure lessons are learnt across the industry sector and that industry memory is also preserved;
- Lessons must not rest only on individuals knowledge but on systems' change and knowledge storing mechanisms to ensure the lessons are not lost;
- A key challenge is in the proactive use of databases of lessons and/or recommendations. Only through the continual use of these databases to challenge safety management systems and develop refinements, will the full potential of the investigative process be realised. The goal is a 'living memory' that constantly informs of actions to be taken rather than a dormant listing residing is a rarely used black box.

A model of what needs to be learned

In the report on *"Case study on dynamic learning from accidents",* four aspects of learning (according to Stoop, 1990) have been chosen to simplify the multi-dimensions that the lessons to be learned could cover:

- ***Process*** (what is the work involved: what goes on in the primary processes). Operation is about what activities to deal with. How can the work be done safer and who is involved in organizing and executing these processes.

- ***Structure*** (what is the business system architecture and functionality). Structure is about (re)design of hardware, technology and (re)design of organization and processes.
- ***Culture*** (what are the values and norms, behaviour etc.). Culture is about several cultural aspects: organizational culture, learning culture and behavioural change.
- ***Context*** (what is the direct operations environment). Context is about business/change management organized (learning agent), political, social changes needed, supporting organization (e.g. safety board) and knowledge development needed.

Learning means change, but how deep is the change?

As recalled by Koornneef (2000, 2004) ***"learning means change"***.

In the ESReDA report on *"Case study analysis on dynamic learning from accidents" (2015),* the learning loops have been summarised in a scheme that underlines the level of change.

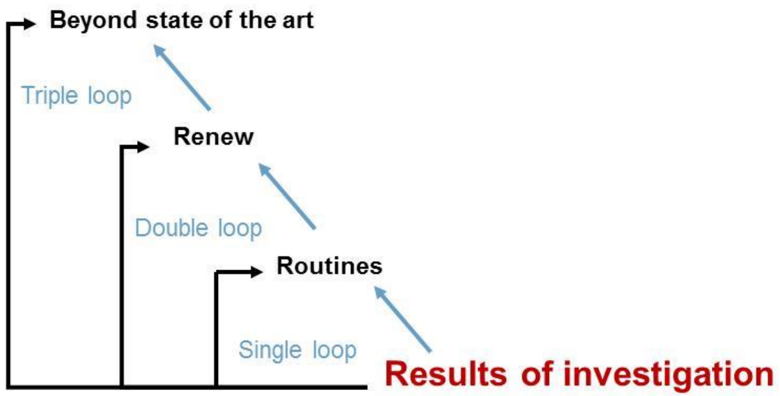

Figure 6: Depth of change according to the learning loops (ESReDA, 2015).

Changes sought by learning eventually depend on the level or depth of learning aimed at envisaged:

1. ***Single loop learning*** (change of rules). Change of rules lead to new behaviour and practices but only ***optimizes*** them.
2. ***Double loop learning*** (change of insight, norms and values). New insights lead to renewal and ***adaption*** of present practices.
3. ***Triple loop learning*** (learn to learn, introducing new principles, breakthrough of knowledge). This can be technological or organizational e.g. knowledge and science development. New principles lead to new developments and ***innovative*** practices.

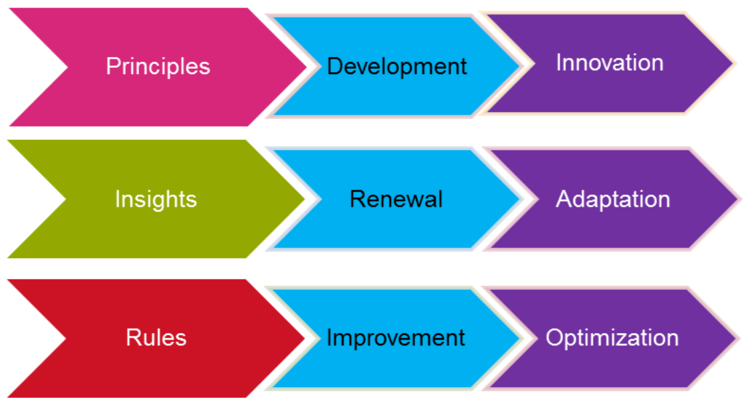

Figure7: Impact from dynamic learning depends on depth of learning (ESReDA, 2015)

Who should learn?

Learning is considered as a multi-actor phenomenon depending on stakeholders on several levels of the organization and sociotechnical system and throughout the various phases of the life cycle that is under analysis. Learning takes places in interrelated systems: designers, manufacturers, organizations, authorities, insurance companies etc.

In the ESReDA 2015 report on *"Case study on dynamic learning from accidents",* 3 levels have been chosen to simplify the analysis of the multi-levels of actors that could be involved in learning:

1. ***Macro level:*** industry network, transport system, government (e.g. regulator) and society (e.g. safety board);
2. ***Meso level:*** corporate holding, branch of industry;
3. ***Micro level:*** individuals, team, organization.

A learning space as a grid of analysis of learning: the ESReDA-Cube

Finally the combination of the three dimensions makes the ESReDA Cube © a frame and analysis grid, for describing a three dimensional space in which learning impact can be identified by a position in the Cube.

An empty space (or cell) in the Cube indicates the potential for learning as well as learning opportunities overlooked, e.g. when comparing results across similar events within a particular sector or across sectors. All learning opportunities being made explicit analysing results of several accident investigations can be categorized in this framework. Each solution may be indicated by coordinates in the cube, being more or less end points of a vector (e.g. Stoop and Van Der Burg, 2012). Examples of how to use the Cube in an accident analysis, are provided in the ESReDA 2015 report on *"Case study on dynamic learning from accidents".*

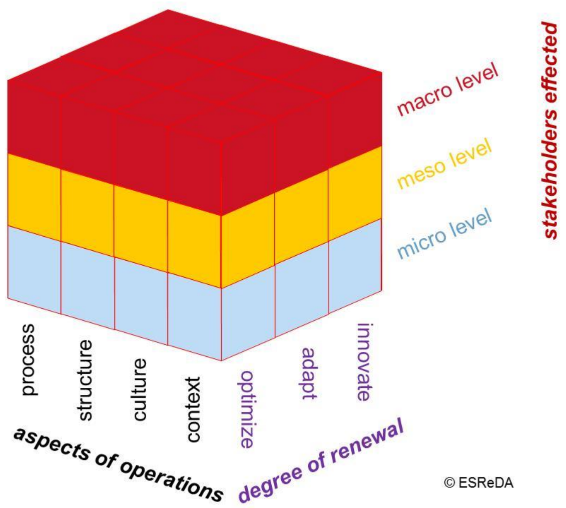

Figure 8: ESReDA Cube ©, solution space for designing recommendations from accident investigations (ESReDA, 2015)

4.8 Application cases: lessons to be learned, failure to learn

First, the **pedagogic comments** made in chapter 3.9 still apply for this session. Most of the training session is designed to be delivered in **classroom**, with the use of slides, videos, guidelines, procedures, accident reports, newspaper extracts, personal examples and well known stories especially for the principles, either for generalist and specialist training.

As quoted by The US Wildland Fire Lessons Learned Center: *"Tell me and I forget. Teach me and I remember. Involve me and I learn."* -Benjamin Franklin

Therefore and especially for specialist training, **application exercises** should be developed for instance with **learning tools** (e.g. recording an event in a database and discovering the difficulties of recording events in databases and classifying the causes) **and simulating learning protocols** (e.g. simulating an engineering and management meeting to design and decide about the corrective action plan; preparing an audit on the efficiency of the changes implemented).

Similarly, because the ESReDA PG has gathered several **case studies** in the deliverable "case study analysis on dynamic learning from accidents (2015)", a few guidelines are proposed to the training designers:

- It should be a **contextual choice** made by the training design team as it is a key part of the training toolkit and should be adequate to the trainees, the trainers and the training time frame,
- For this training session on learning from events, the **cases should be more detailed on the learning part in the aftermath of the event rather than event investigation** as such (which was adequate for the training session on investigation). The cases should be analysed and summarised in such way that is easy to identify the lessons to be learned on event or missed ones; and on cases of failure to learn. It seems more appropriate to use cases that provides the connection between the first session of the training (investigating) and second session (learning). The ESReDA accident and learning case studies have been worked in this aim (available in the "case study analysis on dynamic learning from accidents (2015)". However some other cases might be valuable to explain the use of some models or some phenomenon (e.g. failures to learn).
- Two main options for the case selection according to its adaptation to trainees context:
    - **use up-to-date events and their learning outcome** adapted to the operational context of users; some group of trainees can propose their learning case, recently done;
    - or to step back from the **cultural background, historical references cases** (such as disaster investigation and learning well documented) can be valuable; some case studies are provided by "case study analysis on dynamic learning from accidents (2015)" and address the different industrial sectors and scale of events and learning.
- We can distinguish two kinds of cases used for application:
    - **simple** learning from event case studies, discovered during the training, **to test some tools or concepts** (e.g. some barriers to learn) in a few hours, the student might be alone or paired with 2 or 3 students per exercise ;
    - and there are more **complex** cases that should be worked and tested in larger groups, possibly with **homework** study.

Each training design team can and should prepare its own dedicated **documents** to support the generic principles of investigation and learning process: guidelines, procedures, example of reports, slides, videos, examples,…

Some of these principles can be taught and learned through case studies. The US Wildland Fire Lessons Learned Center developed some case study approach to support the lessons learning from some accidents (e.g. fatalities among the fire fighters) during the operations. They delivered some report called the "Facilitator's Guide for the Saddleback Field Learning Review". It is designed as a tool for learning with questions and exercises proposed to the trainer and trainees.

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Annex 1 ESReDA, Goals – Membership – Seminars – Reports

ESReDA aims and goals

- Focus the European experience in the fields of security, safety, reliability, maintainability, lifetime and management of technological and human risks
- Harmonize and facilitate European R & D on these techniques;
- Promote the setting-up, development, operation and maintenance of data banks concerning these techniques;
- Provide expert opinion in these fields, to the European Commission and other national, European or international organisms;
- Improve the communication between researchers, industry, university, databanks owners and users, and government bodies;
- Contribute to Safety & Reliability education, its integration with engineering disciplines and in arriving at international definitions, methods and norms;
- Contribute to national, European and international efforts in field of standardization and methodological guides' elaboration;

ESReDA Membership

Effective Members are legal entity or individuals. They have the right to vote and are eligible for the various functions of the Association. They pay an annual membership fee or render services, conform with the internal rules, to the Association.

Associate Members can be legal entity or individuals. They participate to the project groups and are invited to join the General Assembly as mere observers. They are not entitled to voting rights and are not eligible.

Sponsoring Members can be legal entity or individuals. Sponsoring Members are expected to contribute to the funds of the Association with free services or assets. They may attend General Assembly as mere observers. They are not entitled to voting rights and are not eligible.

ESReDA Seminars

ESReDA organises 2 seminar per year. All ESReDA proceedings are available on request through the secretariat of ESReDA:

1. London (UK), October 1991: *The use of expert systems in safety assessment and management*;
2. Amsterdam (NL), April 1992: *Safety of systems relying on computers*;
3. Chamonix (FR), October 1992: *Equipment ageing and maintenance*;
4. Huddersfield (UK), April 1993: *Safety in transport systems*;
5. Lyon (FR), October 1993: *Operational safety*;
6. Chamonix (FR), April 1994: *Maintenance and system effectiveness*;
7. Ispra (IT), October 1994: *Accident analysis*;
8. Espoo (FI), May 1995: *Reliability data analysis and use*;
9. Erlangen (G), November 1995: *Learning from accidents investigations and emergency responses*;
10. Chamonix (FR), April 1996: *Rotating machinery reliability and maintenance*;
11. Oxford (UK), October 1996: *Communicating safety*;
12. Espoo (FI), May 1997: *Decision analysis and its applications in safety and reliability*;
13. Paris (FR), October 1997: *Industrial applications of structural reliability theory*;
14. Stockholm (SW), May 1998: *Quality of reliability data*;
15. Antwerpen (BE), November 1998: *Accident databases as a management tool*;
16. Oslo (NO), May 1999: *Safety and reliability in transport*;
17. Garching (GE), September 1999: *Work & Results from ESReDA Working Groups*;
18. Karlstad (SW), June 2000: *Risk Management and Human Reliability in Social Context*;
19. Lyon (FR), October 2000: *Operation Feedback Data & Knowledge Management for New Design*;
20. Rome (IT), May 2001: *Decision Analysis*;
21. Erlangen (GE), November 2001: *Lifetime Management*;
22. Madrid (SP), May 2002: *Maintenance Management & Optimization*;

23. Delft (NL), November 2002: *Decision Analysis; Methodology & Applications for Safety of Transportation and Process Industries*;
24. Petten (NL), May 2003: *Safety Investigations of Accidents*;
25. Paris (FR), November 2003: *Lifetime management of structures*;
26. Tampere (FI), May 2004: *Lifetime management of industrial systems*;
27. Glasgow (UK), November 2004: *Assembling evidence of reliability*;
28. Karlstad (SW), June 2005: *On The Geographical Component of Safety Management: Combining Risk, Planning and Stakeholder Perspectives*;
29. Ispra (IT), October 2005: *System Analysis for More Secure World: Application of system analysis and RAMS to security of complex systems*;
30. Trondheim (NO), June 2006: *Reliability of Safety-Critical Systems*;
31. Smolenice (SL), November 2006: *Ageing*;
32. Alghero (IT): May, 2007: *Maintenance Modelling and Applications*;
33. Ispra (IT), November 2007: *Future challenges of accident investigation*
34. San Sebastian (SP), May 2008: *Supporting Technologies for Advanced Maintenance*.
35. Marseille (FR), November 2008: *Uncertainty in industrial practice – Generic best practices in uncertainty treatment*;
36. Coimbra (PO), June 2009: *Lessons learned from accident investigations*;
37. Baden (SW), October 2009, Asset Optimization and maintainability
38. Pecs (HU), May 2010, Advanced maintenance modelling
39. Coimbra (PO), October 2010, Challenges in Structural Safety and Risk Analysis
40. Bordeaux (FR), May 2011, Risk Analysis and Management Across Industries
41. La Rochelle (FR), October 2011, Advances in Reliability-based Maintenance Policies
42. Glasgow (UK), May 2012, Risk and Reliability for Wind Energy and other Renewable Sources
43. Rouen (FR), October 2012, Land Use Planning and Risk-Informed Decision Making
44. Porto (PO), May 2013, RAMS impact on Asset Management Stakeholders and Risk Assessment Methodologies
45. Porto (PO), October 2013, Dynamic learning from incidents and accidents Bridging the gap between safety recommendations and learning
46. Torino (IT), May 2014, Reliability Assessment and Life Cycle Analysis of Structures and Infrastructures
47. Otwock-Świerk (PL), October 2014, Fire Risk Analysis
48. Wroclaw (PL), May 2015, Critical Infrastructures Preparedness: Status of Data for Resilience Modelling, Simulation and Analysis (MS&A)
49. …

ESReDA Working Group Publications

ESReDA publications are available through ESReDA secretariat (www.esreda.org):

- Communicating Safety (1996).
- Guidebook on the Effective Use of Safety and Reliability Data (1996).
- Directory of Accident Databases (1997).
- Industrial Application of Structural Reliability Theory (1998).
- Handbook of Safety and Reliability Data (1999).
- Guidance Document for Design, Operation, and Use of Safety, Health, and Environment (SHE) Databases (2001).
- Handbook on Maintenance Management (2001).
- Accident Investigation Practices – Results from a European Study (2003).
- Decision Analysis for Reliability Assessment (2004).
- Lifetime Management of Structures (2005).
- Shaping Public Safety Investigations of Accidents in Europe (2005).
- Ageing of Components and Systems (2006).
- Uncertainty in Industrial Practice: A Guide to Quantitative Uncertainty Management (2008).
- Structural Reliability Analysis into System Risk Assessment (2010)
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