Learning from incidents and accidents

Eric Marsden

<eric.marsden@risk-engineering.org>

“Human beings, who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so.

— Douglas Adams, author of The Hitchhiker’s Guide to the Galaxy
Most companies with high-hazard activities have a formalized process for **analyzing incidents** and **learning from experience**.

Terminology used depends on the industry sector:
- chemical industry: incident reporting, event analysis
- nuclear industry: operational experience feedback
- railways: learning from operational experience
- military: lessons learned analysis

This activity is often a requirement imposed by the regulator

A complement to the accident investigation process
Operational experience feedback

- Operational experience feedback is a structured process aiming to **learn from past events** in order **better to control the future**
  - collect information on anomalies, deviations, near misses, incidents and accidents
  - analyze the sequence of events and their causality
  - extract new knowledge or learning from the analysis
  - implement corrective actions or action plans
  - share the learning with all interested parties
  - record the learning so that it can help people in the future

- It’s related to the idea of **continual improvement**
  - identify improvements based on day-to-day operations
  - PDCA / Kaizen / 6σ ...
The experience feedback loop

identify incidents, anomalies, accidents
transfer information to the local manager
classify anomalies, analyze causes, define corrective measures, plan their implementation
manage implementation of corrective measures
communicate lessons learned to people potentially impacted
change procedures, design, attitudes, safety behaviour, ...

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Implementation at the site level

▷ **Reporting system** (paper forms or computer tool) to declare incidents, anomalies and accidents
  - specify the severity of consequences affecting people, the environment, production, process equipment
  - specify the severity level: for example catastrophic / high / medium / low

▷ For industrial sites that belong to a corporate entity:
  - monthly reporting to the corporate level on number of incidents affecting people, process, transport
  - immediately inform corporate level of events of high or catastrophic severity

▷ People on the site will also have **informal experience sharing practices**
  - safety discussion during team meetings
  - discussions at the water cooler
Sample reporting form used by the Aviation Safety Reporting System run by NASA for the US FAA, for incidents in civil aviation

Page 1: information on the person reporting and technical details of the incident
Sample reporting form used by the *Aviation Safety Reporting System* run by NASA for the US FAA, for incidents in civil aviation

Page 2: free-form description of the event, of contributing factors, of possible corrective actions

Source: asrs.arc.nasa.gov/docs/general.pdf
Implementation at the corporate level

▷ Consolidate reported data into indicators on a monthly basis (often automated)

▷ Indicator results and analysis discussed at executive committee meetings

▷ Publish a “safety bulletin” which is disseminated to industrial sites
  • displayed on noticeboards on industrial sites, distributed by email...

▷ When an accident occurs, prepare and disseminate a safety flash on the causes and lessons learned
  • for accidents within your group
  • for accidents from other firms in the same industry sector

▷ Statistical analysis to identify weak signals that could suggest a dangerous trend

▷ Based on the learning resulting from experience feedback:
  • improve operating procedures, design standards, organization of safety management
  • influence allocation of safety investments
Experience feedback as a formalized process was born in aviation
- *US Air Commerce Act* (1926): regulatory obligation to investigate accidents and incidents
- *Aviation Safety Reporting System*, managed since 1975 by FAA & NASA

Important procedure in the **nuclear power** sector since ≈ 1960

Process required by the European Seveso II regulation for hazardous establishments (1996)
- top tier sites must implement a Safety Management System (including OEF)

Process which is becoming common in the health care sector since 2000
A process which has multiple objectives

- Learn from errors
- Generate reliability data
- Feed into safety indicators
- Strengthen the safety culture

These objectives are not perfectly synergistic…
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Objective 1: learn from failures/errors

▷ *Errare humanum est, sed perseverare diabolicum*
  - to err is human, but to persevere down the wrong path is diabolical
  - aim to identify anomalies and errors and correct them as soon as possible
  - feed into people’s *sensemaking* process to improve their awareness of hazards

▷ Learning from one’s own mistakes is a natural way of learning
  - learning from the mistakes of *others* is more difficult
  - learning collectively (at the organizational level) is harder than at the individual level
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An OEF process which is designed purely around a rigid vision of safety as the absence of deviations from procedure is far from the reality of complex systems
Limits to the trial-and-error analogy

- Effective learning from trial-and-error
  - Possibility to experiment
  - Immediate & unambiguous feedback
  - Responsibility/ownership of actions

Can't experiment with loss of life!
Accidents are very rare
Incidents not always representative of situations that lead to accidents
Difficult to learn from other people's mistakes
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Objective 2: produce reliability data

- Operation of complex systems generates data on
  - failure modes
  - initiating event frequencies
  - availability and effectiveness of preventive and protective barriers

- Objectives:
  - improve the level of confidence in the quantitative reliability data which is used in risk analyses
  - improve the exhaustivity of the identification of accident scenarios

- Large databases + statistical analyses
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▷ Large **databases** + **statistical analyses**

An OEF process that only handles technical issues will miss all the organizational and human aspects of system safety
The locomotive division of SNCF maintains a database of undesirable events called Cecile

▷ created in 1980

▷ includes an official classification of reportable events

▷ 500 to 600 events reported per day

▷ 2,500 users of the database at the national level

▷ statistics are generated at the national, regional and site level

▷ allows analysis of correlations according to event type, severity, location, hour of the day, level of experience of the driver, driver’s work hours and shift

Source: *Le Retour d’Expérience à la SNCF*, Mortureux & Tea, Revue générale des chemins de fer, mars 2010
Objective 3: produce safety indicators

▷ Change in recruitment of managers: from people rising through the ranks to university graduates in management
  • less intimate knowledge of the real working of complex socio-technical systems

▷ Need to feed into performance indicators and management dashboards
  • allow safety level to be followed in a quantitative manner
  • use objective data to identify possible sources of improvement

▷ Need to design the OEF system as an information system
  • not only as a management process
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⚠️ An OEF system that only meets the strategic goals of management can lead to decreased engagement of sharp-end workers over time
**Illustration: indicators used by US NRC**

- **US Nuclear Regulatory Commission**: regulator for nuclear power plants in the USA

- Control activity based on audits and on following safety performance indicators (which are made public)
Objective 4: strengthen the safety culture

- OEF is a useful conduit for discussion on safety issues
  - bridging different hierarchical levels
  - bridging different trades and professions
  - between company personnel and contractors

- Helps to improve people’s awareness of hazards and risks
  - keep risks “in sight and in mind”
  - avoid the complacency that can develop over decades of operation without a serious mishap

- Some companies use “fake” accidents which combine the characteristics of several real incidents, to improve learning potential
Illustration: US CSB safety videos

- US Chemical Safety and Hazard Investigation Board, federal agency based in Washington DC
  - undertakes root cause investigations of chemical accidents at fixed industrial facilities
  - Web: csb.gov

- Publish pedagogical videos to disseminate the results of their investigations
  - 4 million views on their YouTube channel (June 2015)
  - also distributed in DVD format
Illustration: US FAA lessons learned site

Source: lessonslearned.faa.gov
Illustration: database of hydrogen accidents

An incident occurred when Ti-doped sodium alanate was exposed to air, apparently resulting in an unstable compound that experienced a rapid exothermic reaction.

The sample consisted of mechanically milled NaAlH₄ with 4% TiCl₃ dopant which was prepared in an argon atmosphere. The sample was sealed and placed in the probe head of an NMR magic angle-spinning (MAS) rotor and spun at approximately 9,000-13,000 rpm. During the process, the sealing cap dislodged and exposed the sample to ambient air for a little less than 24 hours. When discovered, the sample was visually inspected and showed no evidence of oxidation. The sample was re-capped and returned to an argon environment for removal. Most of the sample material was removed using a small stainless steel needle, but a residual amount, roughly 25 mg sodium alanate, proceeded to undergo a rapid exothermic reaction. No damage resulted to the tube, the glove box or the scientist.

The lab does not know the composition of the material after exposure to the ambient air or the ignition energy needed to initiate the reaction. However, it appeared that this material underwent a rapid exothermic reaction requiring very little ignition energy.

Aside from exposing this safety hazard, and the relatively minor incident, laboratory personnel pointed out the advantage of working with small samples.
Links between OEF and safety culture

**Informed culture**
System managers and operators have current knowledge about the human, technical, organizational and environmental factors that influence system safety.

**Reporting culture**
An organizational climate in which people are prepared to report safety lapses and potential safety hazards.

**Just culture**
An atmosphere of trust in which people are encouraged (even rewarded) for providing essential safety-related information, but in which they are also clear about where the line must be drawn between and acceptable and unacceptable behaviour.

**Culture of flexibility**
Organization is able to reconfigure in the face of high tempo operations or certain kinds of hazards, often shifting from the conventional hierarchical mode to a flatter mode.

**Learning culture**
Organization possess the willingness and the competence to draw the right conclusions from its safety information system and the will to address problems identified through the reporting system, and possibly implement major reforms.

Figure adapted from *Managing the risks of organisational accidents*, J. Reason, Ashgate, 1997
Links between learning and safety culture

▷ Safety culture can be seen as
  • one of the key “storages” for lessons learned
  • an important mechanism for transferring these lessons to new members of the organization

▷ Some “safety culture” programmes sold by consultants focus on canned “leadership in safety” messages for managers

▷ A more research-based viewpoint on safety culture examines the reality of work and decisions in the field
  • *theory-in-use* rather than *espoused theory*

Lack of authenticity tends to be detected by workers very quickly, and damages the credibility of all management messages.
Links between OEF and HRO principles

Highly reliable organization

HRO: an organization that manages to avoid catastrophes in an environment where normal accidents can be expected (hazards, complexity).

Body of research on system safety developed in the 1980s by a group of researchers at the University of California at Berkeley.

Five characteristics of HROs have been identified as responsible for the “mindfulness” that keeps them working well when facing unexpected situations.

Links between OEF and HRO principles

Preoccupation with failure
Active effort to learn from mishaps, near-misses, incidents and accidents. To enable this kind of organizational learning, structures or functions to report relevant events exist and are used. Relevant events are analyzed, integrating the knowledge and experience of people working at the “sharp end”.

Links between OEF and HRO principles

Reluctance to simplify
People within the organization recognize that it operates in a complex, unstable and partly unpredictable world. They reject overly simple models and question the assumption that past successes will necessarily lead to future success.

Links between OEF and HRO principles

Sensitivity to operations

Ability to obtain and maintain the big picture of operations and anticipate possible failures. HROS consult front-line staff in order to build a realistic picture of the status of operations and safety concerns within the organization.

Organizational learning takes into consideration the way in which work is really done in the field.

Links between OEF and HRO principles

Commitment to resilience

HROs develop an ability to cope with and bounce back from errors and unexpected events. The essence of resilience is the ability to maintain or regain a stable state, which allows the organization to continue operations after a major problem or during continuous stress. Organizations must be sensitive to warning signs, which may be signaled through the OEF system.

Deference to expertise during emergencies

Decision-making is hierarchical during routine operations, with clear allocation of responsibilities. In emergencies, decision-making moves to individuals with expertise, irrespective of their hierarchical position.

HROs value diversity since it helps them to notice more and to act properly. In the context of rigid hierarchies, errors at higher levels tend to couple with errors at lower levels, making the problem more difficult to understand and more prone to escalation.

What is learning?
What is learning?

▷ Some possible definitions:
   • knowledge or skill acquired by instruction or study
   • modification of a behavioral tendency by experience
   • responding to experience by modifying technologies, forms and practices

▷ Learning is a significant source of **competitive advantage** for a firm
   • in a dynamic world, performance cannot be sustained over time without learning

▷ Learning is a source of **increased safety**
   • better trained individuals produce fewer surprises (reduced variability)
   • organizations use rules, procedures and standard practices to ensure learning is transferred from old to new members (“routinization”)
What does it mean for an organization to learn?

Learning is often thought of as a process which only occurs within individuals’ brains.

“Organizations have no memory. Only people have memory and they move on.”
— Trevor Kletz
Organizational knowledge

- Most organizational scholars disagree with T. Kletz’s statement on absence of organizational memory

- Learning can be embedded within:
  - organizational beliefs and assumptions: culturally accepted worldviews about the system
    - what hazards are present, what risks are important, what is normal, what is taken for granted, what should be ignored
  - organizational routines, procedures and regulations (precautionary norms)
  - organizational structure and relationships
  - the design of equipment and implementation of technologies
  - the knowledge of people working within or interacting with the system
Learning and change

▷ People sometimes assume that learning has occurred once an event has been analyzed and lessons have been drawn

▷ Learning cannot be reduced to simply making a piece of information available to somebody
  • go beyond the “hydraulic” model of learning (the educator pours knowledge into the empty brains of the students)

▷ Learning also requires:
  • someone to internalize the new knowledge and “translate” it to their context
  • some form of change, in system design, in organizational structure, in behaviour...

▷ If new behaviours are not accompanied by new understandings, then learning cannot be robust and sustainable across time and ever-changing circumstances

Learning from catastrophes, incidents and anomalies

Learning potential is present in:

▷ **Catastrophes** and large accidents
  - instrument for learning: accident investigation
  - pressure to investigate, because of (incorrect) assumption that “a big accident can only have been caused by a big mistake”
  - significant resources available to implement change
  - few events (luckily!) from which to learn

▷ **Incidents**: analyze unwanted events, deviations from procedure, accident precursors, near misses in a systematic manner
  - instrument for learning: operational experience feedback, or lessons learned system
  - a larger number of events of this type is available for analysis

▷ **Anomalies**: minor deviations and quality-control issues, often recorded automatically by online monitoring equipment.
  - instrument for learning: statistical analyses of event databases, or quality analyses
Learning from both success and failure

▷ Learn from **what when wrong:**
  - search for underlying failures
  - attempt to eliminate their causes and improve safety barriers
  - safety seen as resulting from a reduction in the number of adverse events

▷ Learn from **what went right:**
  - study normal operations and the ways in which workers cope with varying performance requirements
  - develop a better understanding of system features that contribute to resilience
  - safety seen as the result of the ability to succeed despite varying performance demands and environmental variability
  - *cf.* research on “High Reliability Organizations” and “Resilience engineering”
What is success?

There may be more to learn from normal operation than meets the eye!
Knowledge and error

"Knowledge and error flow from the same source, only success can tell the one from the other."

— Ernst Mach

(Duality of expertise and error)

Source: Knowledge and Error: Sketches on the Psychology of Enquiry, E. Mach, 1905
Learning from others is more difficult than learning from one’s own mistakes

- “we do things differently (better)”, so wouldn’t have been affected by that accident
- “we aren’t concerned by that way of working”
"It wouldn’t happen to us..."
An attitude of denial is common after accidents.
### Accident BINGO

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>we work better than they do</td>
<td>our equipment is better</td>
<td>our people are better trained</td>
<td>we have a stronger safety culture</td>
</tr>
<tr>
<td>no the same industry as us</td>
<td>different regulation</td>
<td>we haven’t had an accident in the past</td>
<td>different national culture</td>
</tr>
<tr>
<td>our procedure requires a special check</td>
<td>stricter purchasing standards</td>
<td>we have our Golden Rules</td>
<td>they work like pigs over there</td>
</tr>
<tr>
<td>our operators don’t sleep on the job</td>
<td>different operating conditions here</td>
<td>we’re not that stupid</td>
<td>we’ve been doing it like this for 15 years</td>
</tr>
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- An attitude of denial is common after accidents
- Denial is contrary to the preoccupation with failure encouraged by HRO researchers

*More information: Distancing through differencing: an obstacle to organizational learning following accidents, R. Cook and D. Woods, 2006*
**Incremental learning**

- Adjust your actions to reduce the gap between desired and actual results
- Practice, feedback, improvement
- Underlying paradigm is that of control: increase predictability, minimize variations, avoid surprises

**Transformational learning**

- Change in perspective, defiance of complacency, conformity and norms
- Increases variation to explore new opportunities
- Is less smooth and more infrequent
- Threatens established control mechanisms and existing bureaucratic mechanisms

A natural tension exists between these two types of learning, somewhat related to the anticipation/resilience tradeoff described by [Wildavsky 1998]
It should not be necessary for each generation to rediscover principles of process safety which the generation before discovered. We must learn from the experience of others rather than learn the hard way. We must pass on to the next generation a record of what we have learned.

— Jesse C. Ducommun
Further reading

IAEA Specific Safety Guide SSG-50

Freely available from iaea.org/publications/
Further reading

ESReDA guidelines document *Barriers to learning from incidents and accidents* (2015)

Freely available from

Further reading

▷ Learning from incidents and accidents entry in OSHwiki, at oshwiki.eu/wiki/Learning_from_incidents_and_accidents


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