Safety Management System and Safety Culture Working Group (SMS WG)

GUIDANCE ON HAZARDS IDENTIFICATION

Authors:
Ilias Maragakis, EASA
Stephen Clark, NATS
Michel Piers, NLR
Capt Dave Prior, easyJet
Carmela Tripaldi, ENAC
Michel Masson, EASA
Clément Audard, EASA

EXECUTIVE SUMMARY

Safety risk assessment is one of the functions in a Safety Management System and an important element of safety risk assessment is the identification of hazards.

A hazard can be considered as a dormant potential for harm which is present in one form or another within the aviation system or its environment. This potential for harm may be in the form of a natural hazard such as terrain, or a technical hazard such as wrong runway markings.

This document develops the concept of 'the hazard' within a safety risk management framework which also defines risk, safety events, undesirable events, outcomes, consequences and risk controls (barriers or mitigations).

The basic concepts behind hazard identification methodologies (data-driven and qualitative) are described. It is acknowledged however that it is difficult to declare completeness of a hazards identification process, and hence hazard identification should be periodically reviewed. Moreover, it is further recognised that the aviation system involves a complex interaction between technical and human-centred sub-systems operated by a wide range of different stakeholders (Airlines, Airports, ANSP and MRO etc.). Each organisation should manage the hazards that fall within their managerial control, but should also co-operate with other stakeholders to help manage interactions and interfaces.

A number of specific tools and techniques for hazards identification are summarised and their advantages and disadvantages noted.

These tools and techniques include:

- Brainstorming
- Hazard and Operability Studies (HAZOPS)
- Checklists
- Failure Modes and Effects Analysis (FMEA)
- Structured What-if (SWIFT)
- Dynamic Models
- Future Hazards Identification through FAST method

Another key step in the safety risk assessment process is safety assessment documentation and the use of Hazard Logs to document the output of hazards identification is also described and an example hazard log template provided.

Some examples of hazards and information sources that could be used to identify hazards are also provided as annexes.

Contents

1 Introduction to Hazards Identification

Amendment 30 of ICAO Annex 6 requires organisations to establish Safety Management Systems (SMS) that, as a minimum:

- identifies safety hazards;
- assesses risks;
- ensures that remedial action necessary to maintain an acceptable level of safety is implemented;
- provides for continuous monitoring and regular assessment of the safety level achieved; and
- aims to make continuous improvement to the overall level of safety.

An SMS is a systematic and organised approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures. The component of SMS within which hazards identification takes place is safety risk assessment and this forms part of an overall safety risk management process.

Safety risk assessment can be performed on steady-state operations to provide assurance that the risks associated with day-to-day operations remain tolerably safe. It can also be performed on proposed changes to a system or operation to ensure that the risks from any additional hazards or any impacts on existing hazards, introduced by the change remain acceptably safe.

Safety risk assessment features 8 steps:

1. **System / operation description**
2. **Hazards identification processes**
3. **Consequence analysis**
4. **Causal analysis**
5. **Evaluation of risk**
6. **Mitigation of risk**
7. **Approval of residual risk**
8. **Safety assessment documentation**

This article focuses on Step 2 - hazards identification processes, but also touches on the other steps at a high level in so far as they relate to hazards identification in the wider safety risk management process.

2 Definitions

This section does not aim to contribute with new definitions related to safety management to the numerous ones already available, but rather to provide a better understanding of their use within this document. To this end the definitions below are provided as assistance in understanding the terminology within this document and not as a proposition for amending or enriching existing definitions established by other sources.

The use of the term **'hazard'** in the formal risk assessment context originated in the nuclear and chemical industries for which a wide range of different types of 'hazards' are present all of the time (e.g. nuclear material, flammable gases, toxic chemicals etc.). The 'control' of these hazards (containment, separation etc.) and the 'mitigation' of their consequences (gas detection, plant shutdown etc.) should a failure condition arise is the subject of safety risk assessment and safety risk management processes.

In the aviation domain, a hazard could be considered as a dormant potential for harm which is present in one form or another within the aviation system or its environment. This potential for harm may be in the form of a natural hazard such as terrain, or a technical hazard such as wrong runway markings.

EUROCONTROL (Ref. 1 – ESARR 4) defines a hazard as any condition, event or circumstance that could induce an accident.

Hazards identification is the act of recognising the failure conditions or threats (Safety Events), which could lead to Undesirable Events and defining the characteristics of theses undesirable events in terms of their potential Safety Outcomes and of the magnitude of these safety outcomes' Consequences. This gives rise to the following definitions:

Hazard

A condition, object, activity or event with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function.

Safety Event

A failure condition, causal factor, threat or precursor event which in isolation or in combination with other safety events could result in an undesirable event.

Undesirable Event

A stage in the escalation of an accident scenario where the accident will occur, unless an active recovery measure is available and is successfully used.

Outcome

A potential end point of an accident scenario which can be assigned a consequence severity.

Consequence

The degree of injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function arising from an outcome. Consequences have a magnitude.

Risk Controls (Barriers and Mitigation)

A system, activity, action or procedure that is put in place to reduce the risks associated with a hazard. Mitigation may include:

- elimination of the hazard (preferred),
- reduction in the frequency of the hazard (barriers),
- reduction in the likelihood of the outcomes of the hazard (outcome mitigation),
- reduction of the severity of the outcomes of the hazard (consequence mitigation).

Risk

The combination of the predicted frequency and severity of the consequences of hazard(s) taking into account all of the potential outcomes.

Safety Risk Management

The identification of hazards associated with the day-to-day operations of an organisation, or associated with changes to the operations of an organisation; the assessment of the risks associated with those hazards; and the implementation and management of measures to reduce those risks to an acceptable level (hazard removal; or the application of barriers and/or mitigations – i.e. risk control).

The above definitions are illustrated diagrammatically in Figure 1 which is referred to in some literature as a **Bow-Tie diagram**. 'Bow-tie' also refers to the **methodology** used to build such diagram. Some examples of the use of the terminology are also provided in Tables 1 to 4.

The method for building a bow-tie involves asking a structured set of questions in a logical sequence. The completed Bow-Tie illustrates the hazard, the undesirable event, the safety events and potential outcomes, and the risk controls put in place to minimise the risk.

Risk management is about controlling risks. This is done by placing barriers to prevent certain undesirable events from happening. A control can be any measure taken that acts against some undesirable force or intention, in order to maintain a desired state. In the Bow-Tie methodology there are preventive or proactive barriers (on the left side of the Undesirable Event) that prevent the Undesirable Event from happening. There are also corrective or reactive controls (on the right side of the Undesirable Event) that prevent the Undesirable Event from resulting into unwanted Outcomes or reduce the consequence severity of the Outcomes.

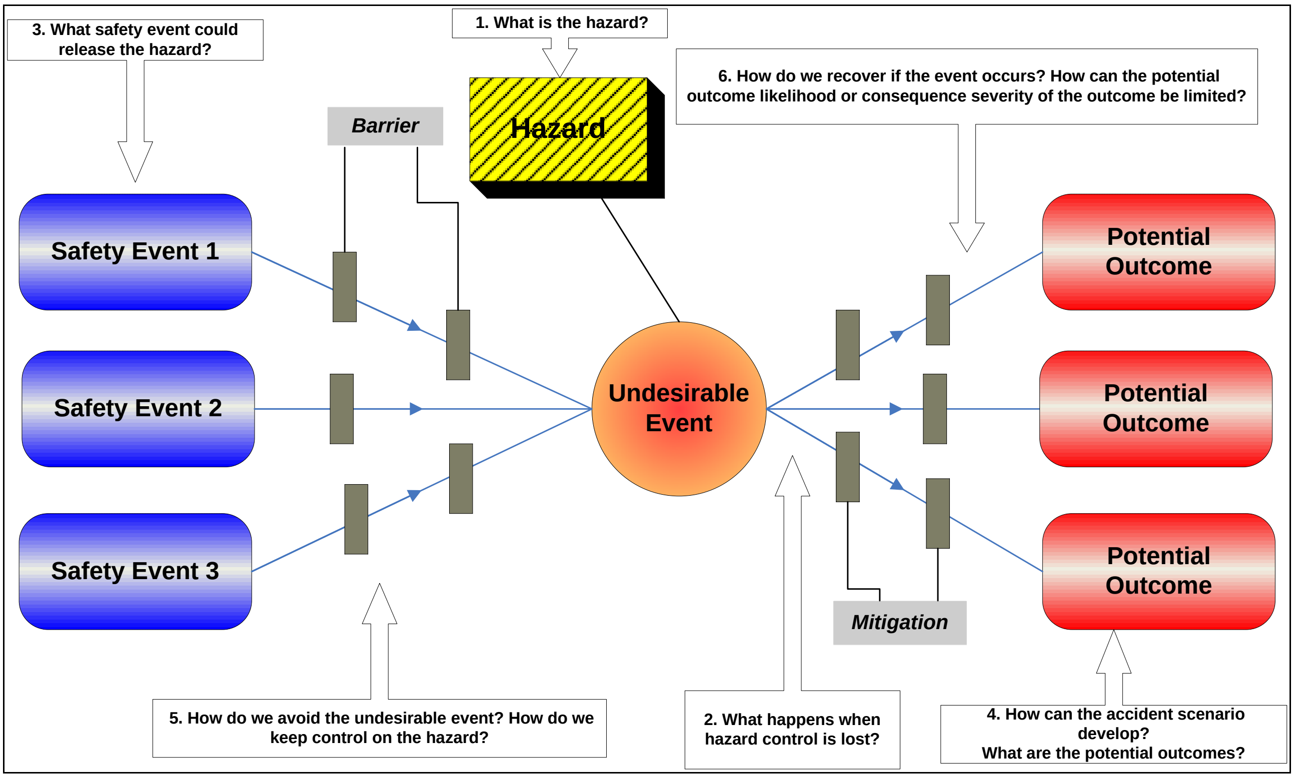

Figure 1: 'Bow-Tie' Diagram illustrating definition of terms

HAZARD: WORN RUNWAY MARKINGS					
Safety Events	**Safety Barriers**	**Undesirable Event**	**Mitigations**	**Potential Outcomes**	***Consequence Severity***
Improper snow removal process (damaging runway)	Runway Inspection	Pilot misinterprets/ cannot see runway markings	Taxiway Markings	Runway Incursion by vehicle	*Aborted landing*
Poor quality of material used for marking	Aerodrome Manual		Taxiway signage	Runway Incursion by aircraft (undetected)	*Multiple fatalities/Aborted landing*
Inadequate runway marking maintenance	Pilot reporting scheme		Taxiway lighting/stop bars	Runway Incursion by aircraft	*Aircraft go ground - delay*
	ATC reporting scheme		Runway lighting	Loss of location awareness by crew	*Aircraft / ground movement delay*
	Scheduled maintenance		Ground surface radar		

Table 1: Example of using hazard related terminology for worn markings on a runway

HAZARD: WRONG TAKE-OFF CONFIGURATION					
Safety Events	**Safety Barriers**	**Undesirable Event**	**Mitigations**	**Potential Outcomes**	***Consequence Severity***
Improper aircraft loading	Ground handling staff training	Pilot attempts to take-off with the aircraft wrongly configured	Stall Warning	Aircraft mush/stall	*Multiple fatalities*
Mis-configured flap setting	Aircraft centre of gravity detection systems (if available)		Aural Mis-configuration Warning	Runway Excursion	*Multiple fatalities*
Improper aircraft trim configuration	Check-list items		Simulator training on aborting a take-off	Aborted Take-off	*Aircraft / ground movement delay*
	Pilot training				
	Cockpit ergonomics				

Table 2: Example of using hazard related terminology for wrong take-off configuration

HAZARD: FLAMABLE CARGO MATERIAL					
Safety Events	**Safety Barriers**	**Undesirable Event**	**Mitigations**	**Potential Outcomes**	***Consequence Severity***
Improper cargo labelling	Ground handling staff training	Ignition of flammable cargo in the cargo hold	Smoke and fire detectors	Fire is uncontrolled	*Aircraft disintegration/ Multiple fatalities*
Improper cargo packaging	Dangerous Goods training		Emergency procedures	Fire is controlled and extinguished after some time	*Significant repair and off line service costs*
Improper cargo combination	Cargo dispatching procedures		Simulator training on aborting a take-off	Fire is extinguished	Aircraft diversion
	Cargo labelling procedures		Pilot training		
	Dangerous goods reference material (incl. software)		Fire extinguishing agents		

Table 3: Example of using hazard related terminology for flammable cargo

HAZARD: AIRCRAFT ICING (EN-ROUTE)					
Safety Events	**Safety Barriers**	**Undesirable Event**	**Mitigations**	**Potential Outcomes**	***Consequence Severity***
Failure of anti/ de-icing system	Aircraft anti/ de-icing system design	Accretion of ice on airframe or engines	System failure warning	Aircraft mush/stall	*Multiple fatalities/loss of aircraft*
Failure of ice detection system	Outside air temperature indicators		Ice accretion warning	Reduced aircraft performance	*Significant repair and off line service costs*
Failure of crew to detect ice on the aircraft	Maintenance procedures		Pilot training for cold weather operations	Engine flameout	Aircraft diversion
	Pre-flight check				
	Pilot training				

Table 4: Example of using hazard related terminology for aircraft icing encountered en-route

3 Hazards identification in Practice

Hazards may be identified through a data-driven (quantitative) methodology or qualitative process such as discussions, interviews and brainstorming.

3.1 Data Driven Methodologies

In a data-driven approach, hazards are identified and recorded through a systematic process which allows for traceability and further analysis.

There are various types of recorded observations which may be used to identify hazards. Sources for hazards identification can be **Flight Data Monitoring (FDM), company audits, staff surveys, hazard reports** and others. Investigation and reports of **past occurrences** may provide rich material as to existing hazards as well as, alternative to these, hazards which may arise. For example, an occurrence report may identify the hazard of standing water affecting the integrity of landing aid equipment at an airport, but through this report other hazards which may affect this equipment may also be identified.

Furthermore, real-time and non real-time **simulations** may be used to identify likely hazards and their interactions (Ref. 2 - FAA-EUROCONTROL Toolbox). Using simulation modelling it may be easier to identify potential hazards and their potential outcomes.

3.2 Qualitative Methodologies

Hazards may be identified through a qualitative process, either formal (part of safety assessment) or informal based on discussions, interviews and brainstorming. Informal qualitative methodologies are heuristic processes based on expert judgement. They often allow identifying hazards that other approaches can't detect. Using both approaches in combination will provide better and more comprehensive results.

Within published literature, it is recognised that hazards identification must be done methodically in order to ensure that all areas of operation where hazards may exist have been identified. It is recommended that among others; design, organisational, work environment factors, as well as procedures and operating practices are taken into account in the identification process (Ref. 3 - ICAO SMS Training Manual; Ref. 4 - ICAO Safety Management Manual).

Existing material should be reviewed with the aim of identifying gaps or hazards. The UK CAA (Ref. - UK CAA CAP730) suggests a brainstorming exercise, which will allow participants to identify hazards within the organisation. The FAA-EUROCONTROL Toolbox (Ref. 3 - Section 4: Overview of Safety Assessment, p.7) suggests that the identification of the hazards may be done by individual or group-based assessors.

The main challenge for individual and group-based brainstorming sessions involves the identification of hazards which exist but are difficult to think of. Some approaches have been developed to cover what might be termed 'unimaginable hazards'.

<u>Individual Approach</u>

The individual-based approach entails one or two assessors conducting identification of hazards across all aspects of a system. These assessors assume the responsibility for identifying the majority of hazards within the organisation. This particular method may be appropriate for an initial and high level identification of hazards.

Examples of questions which may assist in identifying hazards are:

- What would possibly go wrong?
- What could lead to something possibly going wrong?

Group-Based Approach

The group-based approach involves a group of experts conducting the identification exercise. It is suggested that this group consists of selected managers and staff. For small organisations it is suggested that departments participate in this exercise in their entirety. For example, for small operators, all Flight Department staff could participate in the hazards identification process.

Unimaginable Hazards

One of the most common ways of identifying hazards other than from occurrence reports is to conduct functional hazard assessments. In such functional hazard assessments, failures of prescribed or intended system functions or operational procedures, the operational consequences of these failures, and the potential effects on the safety of the operation are identified. It is however a well established fact that some hazards are hard or even impossible to identify using functional hazard identification sessions. Such hazards are called (functionally) unimaginable hazards.

One reason why not all hazards may be identified through a functional approach is that there may be hazards associated with a system functioning well, for example when operators become overly reliant on a well-functioning alerting system. Another reason is that some hazards may not be associated with functional failures, such as those associated with situational awareness problems. Also, sometimes functions relevant for the safety of the operations are implicit and go unnoticed, or the available description of the system or operation involved is otherwise not complete.

This means that, in order to get a complete picture of the relevant hazards, "logical thinking" from the functional failure point of view must be enhanced by creative input of operational experts. Such input is obtained through hazard identification brainstorming sessions that are designed, organised and conducted in a specific manner. Guidance for such hazard identification brainstorming sessions may be found in (Ref. 6 - EUROCONTROL Safety Assessment Methodology Guidance Material on Planning and Conducting FHA Sessions. SAF.ET1.ST03.1000-MAN-01-01-03-A) and (Ref. 7 - NLR-CR-2004-094 Guidelines for the Identification of Hazards - How to make unimaginable hazards imaginable?).

Getting an as complete as possible overview of the relevant hazards is essential of course, as the risks associated with hazards that go unnoticed, cannot be managed.

3.3 Hazards Identification Documentation and Review

It should be recognised though that it is very difficult to declare a hazards identification process as complete. For this reason, **hazard identification should be periodically reviewed**. If there is a significant change in the operations, the organisation or its staff; the process should be repeated. Also, it is recommended that hazards identification be repeated when mitigation measures have been identified in order to detect unforeseen interactions between mitigation measures and other elements of the system or in the light of the outcomes of internal investigations.

The outcome of the hazards identification process should be documented in the form of a list of hazards or hazard logs. Hazards logging is useful for subsequent analysis (see Section 5).

3.4 Interfaces between Systems and Stakeholders

The aviation system involves a complex interaction between different technical and human centred sub-systems operated by a wide range of different stakeholders (Airlines, Airports, ANSP and MRO etc.). Each organisation must manage the hazards that fall within their managerial control, but should also co-operate with other stakeholders to help manage interactions and interfaces. In this complex hierarchy of systems, a safety outcome in one system could cause hazards in another system.

It is therefore important that hazards identification involves representatives from all relevant stakeholder organisations where appropriate.

4 Specific Tools and Techniques for Hazards Identification

This section provides a summary of a number of tools and techniques that can be used for hazards identification. The various techniques are described below together with a brief overview of their advantages and disadvantages.

It should be remembered that any system or operation comprises:

- people;
- procedures;
- equipment; and
- an environment of operation

All these elements must be considered during hazards identification.

Hazards identification techniques require a definition of the System / Operation, its environment of operation and its interactions to have been completed prior to undertaking the task (safety risk assessment Step 1: System/Operation description). This System / Operation definition may take different forms depending on the specific technique and type of system. The definition may be:

- Functional
- Operational
- Process
- Scenario based

4.1 Brainstorming

Brainstorming is an **unbounded** but **facilitated** discussion within a **group of experts**. A facilitator prepares prompts or issues ahead of the group session and then encourages **imaginative thinking** and discussion between group members during the session. The facilitator initiates a thread of discussion and there are no rules as to what is in or out of scope from the subsequent discussion. All contributions are accepted and recorded and no view is challenged or criticised. This provides an environment in which the experts feel comfortable in thinking laterally.

Advantages

- Good for identifying new hazards in novel systems.
- Involves all key stakeholders.
- Relatively quick and easy to undertake.
- Can be applied to a wide range of types of systems.

Disadvantages

- Relatively unstructured and therefore not necessarily comprehensive.
- Depends on the expertise and profile of the participants
- May be susceptible to the influence of group dynamics.
- Can rely heavily on the skills of the facilitator for success.

4.2 Hazard and Operability (HAZOP) Study

HAZOP is a systematic and structured approach using parameter and deviation guidewords. The technique relies on a very detailed system description being available for study and usually involves **breaking down the system into well defined subsystems and functional or process flows between subsystems**. Each element of the system is then subjected to discussion within a **multidisciplinary group of exp**erts against the various combinations of the guidewords and deviations.

The group discussion is facilitated by a Chairman and the results of the discussion recorded by a Secretary together including any hazards identified when a particular guideword and deviation combination is discussed. Where a particular guideword and deviation combination does not produce any hazards, or is not thought credible, this should also be recorded to demonstrate completeness.

The guidewords and deviations must be prepared in advance by the HAZOP Chairman and may need to be tailored to the system or operation being studied.

In an aviation context, typical guidewords might include:

- Detection
- Co-ordination
- Notification
- Transmission
- Clearance
- Authorisation
- Selection
- Transcription
- Turn
- Climb
- Descend
- Speed
- Read-back
- Monitoring
- Signage
- Handover
- Supervision

Typical deviations might include:

- Too soon / early
- Too late
- Too much
- Too little
- Too high
- Too low
- Missing
- Twice / repeated
- Out of sequence

- Ambiguous
- Reverse / inverted

Advantages

- Systematic and rigorous.
- Involves interaction of views from multidisciplinary experts.
- Can be applied to a wide range of types of system.
- Creates a detailed and auditable record of the hazards identification process.

Disadvantages

- Requires a considerable amount of preparation.
- Can rely heavily on the skills of the HAZOP Chairman
- Can be time consuming and therefore expensive.
- Can inhibit imaginative thinking and so certain kinds of hazards.

4.3 Checklist

Checklists are **lists of known hazards or hazard causes** that have been derived from past experience. The past experience could be previous risk assessments of similar systems or operations, or from actual incidents that have occurred in the past.

This technique involves the systematic use of an appropriate checklist and the consideration of each item on the checklist for possible applicability to a particular system.

Some example checklists are provided in Annex II: Examples of Hazards.

Checklists should always be validated for applicability prior to use.

Advantages

- They can be used by non-system experts.
- They capture a wide range of previous knowledge and experience.
- They ensure that common and more obvious problems are not overlooked.

Disadvantages

- They are of limited use when dealing with novel systems.
- They can inhibit imagination in the hazards identification process.
- They would miss hazards that have not been previously seen.

4.4 Failure Modes and Effects Analysis (FMEA)

FMEA is a ‘bottom up’ technique that is used to **consider ways in which the basic components of a system can fail to perform their design intent**. This could either be at an **equipment level** or at a **functional level**. The technique relies on a detailed system description and considers the ways in which each sub-component of the system could fail to meet its design intent and what the consequences would be on the overall system.

For each sub-component of a system an FMEA considers:

- All the potential ways that the component could fail.
- The effects that each of these failures would have on the system behaviour.
- The possible causes of the various failure modes.
- How the failures might be mitigated within the system or its environment.

Behaviours at the system level arising from the sub-component failures which have a safety consequence are thus identified as hazards. The system level at which the analysis is applied can vary and is determined by the level of detail of the system description used to support the analysis. Depending on the nature and complexity of the system, the analysis could be undertaken by an individual system expert or by a team of system experts acting in group session.

Advantages

- Systematic and rigorous.
- Creates a detailed and auditable record of the hazards identification process.
- Can be applied to a wide range of types of system.

Disadvantages

- Only really considers hazards arising from single point failure modes rather than combinations of failures.
- Relies on people with detailed system knowledge.
- Can be time consuming and expensive.

4.5 Structured What-if (SWIFT)

The SWIFT technique was originally developed as a simpler and more **efficient alternative technique to HAZOP**. Like HAZOP, SWIFT involves a multidisciplinary team of experts under the facilitation of a Chairman. It is a facilitated brainstorming group activity but is typically **carried out on a higher level system description**, having fewer sub elements, than for HAZOP and with a reduced set of prompts.

Ahead of the group session the Chairman prepares a suitable list of prompts such as:

- What if…?
- Could someone…?
- Has anyone ever…?

The Chairman uses the prompts to initiate discussion within the group.

Advantages

- Creates a detailed and auditable record of the hazards identification process.
- Is less time consuming than other systematic techniques such as HAZOP.

Disadvantages

- Careful thought is required in preparation for the application of the technique.
- Relies heavily on the expertise and experience of the team members.
- Relies heavily on the skills of the Chairman.

4.6 Dynamic Methods

A number of techniques widely used across the industry such as the FTA and FMEA described above are static techniques which are not very good at capturing hazards related to the dynamic interaction aspects of complex systems and operations involving multiple actors. Some hazards related to timing, sequencing and mutual dependency can be identified using such methods, and also using the various brainstorming approaches described in the previous paragraphs, but other techniques are sometimes needed to ensure an adequate capture of hazards related to the dynamics of complex systems and operations. The complexities involved with employing these techniques, most of which involve some form of simulation, are such however, that their use is beyond the scope of most operational organisations and therefore requires expert assistance. Their description is also beyond the scope of this document. Nevertheless, experience shows that where these dynamic methods are applied, they often identify relevant hazards that were not –or could not be – identified using static approaches. It is therefore wise, when conducting hazard identification for complex and dynamic operations and systems, to give conscious consideration to the possible need to employ dynamic methods in addition to the methods described above.

4.7 Future Hazards Identification through the FAST method

Identification of future hazards often relies on expert judgement and some sort of ‘instrumented’ brainstorming.

There are only few methods available for future hazards identification. The method developed by the Future Aviation Safety Team (FAST) is one of these. This team created by the JSSI is now associated to ECAST, the commercial aviation safety team of the ESSI.

The FAST method (Ref. 8 - FAST method) is a **“prognostic” or “predictive” approach aimed at discovering future hazards arising as a consequence of future changes** introduced inside or outside the global aviation system and of their interaction, and subsequently develop and implement mitigating actions.

The FAST team has built and maintains a list of 200+ Areas of Changes (AoCs) affecting the *global* Aviation and ATM system. This list is used for identification of future hazards.

This list can be augmented by a more specific list of changes identified by the method user (airline, ANSP, maintenance organisation, manufacturer, authority, etc.) that *specifically* affects its activities. A list of local changes is likely to feature proprietary information regarding for instance new market strategy, new organisation, new staff policy, opening of a new route, etc., depending on the method user’s profile.

5 The Hazard Log

The 8th step in the safety risk assessment process is safety assessment documentation. A key element of this process step is the documentation of the hazards identified in Step 2.

Organisations should wherever possible maintain a centralised log of all identified hazards. The nature and format of such a log may vary from a simple list of hazards to a more sophisticated relational database linking hazards to mitigations, responsibilities and actions (as part of an integrated safety risk management process).

As a minimum, it is recommended that the following information be included in the hazard log:

- Unique hazard reference number against each hazard
- Hazard description
- Indication of the potential causes of the hazard (safety events)
- Qualitative assessment of the possible outcomes and severities of consequences arising from the hazard
- Qualitative assessment of the risk associated with the possible consequences of the hazard
- Description of the risk controls for the hazard
- Indication of responsibilities in relation to the management of the risk controls

In addition, organisations may wish to consider the following information for inclusion in the log.

- A quantitative assessment of the risk associated with the possible consequences of the hazard
- Record of actual incidents or events related to the hazard or its' causes
- Risk tolerability statement
- Statement of formal system monitoring requirements
- Indication of how the hazard was identified
- Hazard owner
- Assumptions
- Third party stakeholders

An example Hazard Log template is given in Table 5 below.

<table>
<tr><td>Operation / System</td><td colspan="3"></td></tr>
<tr><td>Hazard No.</td><td colspan="3"></td></tr>
<tr><td>Hazard Description</td><td colspan="3"></td></tr>
<tr><td>Safety Events
(Causes or Threats)</td><td colspan="3"></td></tr>
<tr><td>Potential Outcomes
(and Associated
Consequence
Magnitudes)</td><td colspan="3"></td></tr>
<tr><td colspan="4">Risk Controls (Barriers and Mitigations)</td></tr>
<tr><td>No.</td><td colspan="2">Description</td><td>Responsible</td></tr>
<tr><td>1</td><td colspan="2"></td><td></td></tr>
<tr><td>2</td><td colspan="2"></td><td></td></tr>
<tr><td>3</td><td colspan="2"></td><td></td></tr>
<tr><td>4</td><td colspan="2"></td><td></td></tr>
<tr><td>5</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="4">Risk Assessment (Worst Foreseeable Scenario – i.e. Highest Risk)</td></tr>
<tr><td>Hazard Frequency</td><td colspan="3"></td></tr>
<tr><td>Outcome Likelihood</td><td colspan="3"></td></tr>
<tr><td>Consequence Severity</td><td></td><td></td><td></td></tr>
<tr><td>Risk</td><td></td><td></td><td></td></tr>
<tr><td>Management Approval</td><td>Name:</td><td>Post:</td><td>Signature:</td></tr>
<tr><td>Relevant Previously
Reported Incident Data</td><td colspan="3"></td></tr>
<tr><td colspan="4">Safety Performance Monitoring Requirements</td></tr>
<tr><td>No.</td><td colspan="2">Description</td><td>Responsible</td></tr>
<tr><td>1</td><td colspan="2"></td><td></td></tr>
<tr><td>2</td><td colspan="2"></td><td></td></tr>
<tr><td>3</td><td colspan="2"></td><td></td></tr>
</table>

Table 5: Example Hazard Log Template

Annex I: Abbreviations and References

List of abbreviations

ATC	Air Traffic Control
AD	Airworthiness Directive
ANSP	Air Navigation Service Provider
EASA	European Aviation Safety Agency
ECAST	European Civil Aviation Safety Team
ESARR	EUROCONTROL Safety Regulatory Requirement
ESSI	European Strategic Safety Initiative
ETA	Event Tree Analysis
FAST	Future Aviation Safety Team
FHA	Functional Hazard Analysis
FMEA	Failure Modes and Effects Analysis
FMS	Flight Management System
FTA	Fault Tree Analysis
FODA	Flight Operations Data Analysis
FOQA	Flight Operations Quality Assurance
FDM	Flight Data Monitoring
HAZOP	Hazard and Operability (Study)
ICAO	International Civil Aviation Organisation
IOSA	ITA Operational Safety Audit
JSSI	JAA Safety Strategy Initiative
LOSA	Line Operations Safety Audit
MRO	Maintenance and Repair Organisation
NAA	National Aviation Authority
OEM	Original Equipment Manufacturer
SIE	Safety Information Exchange
SMS	Safety Management System
SWIFT	Structured What-If Technique

List of References

1. EUROCONTROL, ESARR 4, Risk Assessment and Mitigation in ATM.
2. FAA - EUROCONTROL (2007), ATM Safety Techniques and Toolbox.
3. ICAO (2008), SMS Training Material.
4. ICAO (2008), Safety Management Manual.
5. UK CAA, CAP 730.
6. EUROCONTROL Safety Assessment Methodology Guidance Material on Planning and Conducting FHA Sessions. SAF.ET1.ST03.1000-MAN-01-01-03-A.
7. NLR-CR-2004-094 Guidelines for the Identification of Hazards - How to make unimaginable hazards imaginable?
8. FAST, Future Aviation Safety Team method.
9. FAA, Safety Management System Manual.

Annex II: Examples of Hazards

Example Hazards by **Hazard Type**:

Natural
- Severe weather or climatic events: Hurricanes, major winter storms, drought, tornadoes, thunderstorms lighting, and wind shear.
- Adverse weather conditions: Icing, freezing precipitation, heavy rain, snow, winds, and restrictions to visibility.
- Geophysical events: Earthquakes, volcanoes, tsunamis, floods and landslides.
- Geographical conditions: E.g.: adverse terrain or large bodies of water.
- Environmental events: wildfires, wildlife activity, and insect or pest infestation.
- Public health events: epidemics of influenza or other diseases.

Technical, deficiencies regarding:
- Aircraft and aircraft components, systems, sub-systems and equipments. This includes Failures, inadvertent or erroneous functioning of Systems.
- An organisation's facilities, tools, and related equipment.
- Facilities, systems, sub-systems and related equipment external to the organisation.

Economic
- Major trends related to: Growth, Recession, Cost of material or equipment, Fuel cost, Environmental issues, etc.
- Diverging interests: operation vs. shareholder

Ergonomic
- Deficiencies in the environment the front line employees have to operate
- 24-hour operation with impact on individual's performance (circadian cycle)

Organisational
- Complex organisational structures resulting in unclear responsibilities
- Re-organisation.

Example Hazards by **Organisation**:

Airport Operator
- Worn Runway Markings
- Unclear ramp marking for vehicle holding point
- Fuel Spillage
- Not well lit parking position
- Partial failure of weather monitoring devices (e.g. anemometer)

Ground Handler
- Jet Blast
- Noise
- Understaffing
- Misinterpretation of Load-sheet
- Wet surfaces/ equipment
- Improper application of anti-icing fluid

Aircraft Operator
- Load-sheet errors
- Lack of sleep during off duty
- Partial failure or loss of navigation systems
- Error in FMS database
- Loss of radio communication

- Wrong reed-back of ATC clearance
- Expired Aeronautical information
- Loss of transponder transmission

ANSP

- Loss of communication
- Loss of aircraft separation
- Improper flight handover
- Improper clearance
- Use of wrong call sign
- Adverse weather conditions
- Diversion of multiple aircraft
- Loss of transponder transmission

Maintenance Organisation

- Use of outdated procedure
- Delayed implementation of AD
- Use of non-OEM certified parts
- Improper handover of remaining work to next shift
- Improper application of paint or other chemicals
- Chemical spillage
- Repair of wrong system/component

Annex III: Examples of Sources for Identifying Hazards

1. Flight Operations Data Analysis (FODA) / Flight Data Monitoring (FDM)
2. FODA-Campaigns (subject specific in-depth analysis)
3. Flight Reports
4. Cabin Reports
5. Maintenance Reports
6. Confidential Safety Reports
7. Operations Control Reports
8. Maintenance Reports
9. Reports of the NAA
10. Crew Surveys
11. Crew Observation (LOSA)
12. Investigations & Hearings
13. Partner Airline Assessments
14. Quality Assurance Programme (Quality Audits acc. EU-OPS)
15. Training records (e.g. crew periodic checks, simulator checks and training, line checks, etc)
16. Manufacturers reports and SIE safety information exchange programs
17. Safety Reporting
18. Observation of Maintenance operations (if applicable)
19. Safety (& Quality) Audits / Assessments
20. Safety Culture monitoring through surveys
21. Internal safety investigations
22. Ad-hoc questionnaires on chosen Safety Issues
23. Internal safety workshops
24. External safety information
25. Training records
26. Company voluntary reporting system
27. Audits and surveys
28. Ground Handling Report
29. Disruptive Passenger Report
30. Captain's Special Report
31. Flight and Duty Time Discretion Report
32. Flight Operations Monitoring
33. Accident reports
34. State mandatory occurrence system
35. Organisation's partners
36. Assessment of partners
37. IOSA reports