

INCIDENTS INVESTIGATION TOOLBOX

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1. Executive Summary

This document contains a compilation of tools and best practices at each stage of the investigation process. Each stage is briefly described before gathering the tools and best practices.

The intended audience are safety directors/SMS, safety investigators and supporting personnel in safety investigation and ATCOs/ATSEPs, where they can find a compilation of best practices and tools used in the investigation process (occurrence reporting, data collection, investigation, recommendations, human factors, monitoring, etc.).

2. Investigation process

2.1. Introduction

By definition, safety occurrences are events in which a system (aviation in our case) has drifted into an undesired state, which has led to a damage to people or property, or increased hazard exposure. According to Regulation (EU) 376/2014 'occurrence' means any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person and includes in particular an accident or serious incident, whereas, Regulation (EU) 996/2010 defines "incident" as an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

By definition according to ICAO Annex 13, Aircraft Accident and Incident Investigation, a safety investigation is a process conducted for the purpose of accident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and, when appropriate, the making of safety recommendations. In our context, the investigation process is well defined by its own purpose:

"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability." (ICAO – Annex 13).

This process, which aims to incident prevention, starts from the occurrence and terminates with safety recommendations and involves various actors:

- Front-line operator, the one who has experienced "first hand" the incident
- Investigator (or investigation team), the one who, with his expertise and skills, analyses what happened and why, finding out the circumstances which led, more or less directly, to the safety occurrence bringing light to areas of improvement, meaning those factors, that if revised would ensure a decrease in repeatability or a reduction in the impact of any future similar incident
- Any other actor (front line managers, back office, etc.) who has had an influence
- Managers, the ones who receive recommendations and are accountable for the appropriate implementation of remedial actions in order to mitigate or solve the issues revealed

Generally speaking, any process consists of a sequence of phases; each phase has an input and an output, which comply with its objective; the output of a phase acts as an input for the following one, and so on.

Therefore, the more effective are the single phases in producing intermediate output, the more effective is the whole process in achieving its goal, which corresponds to the final output.

Figure 1 illustrates the investigation process scheme based on the input/output simplification.

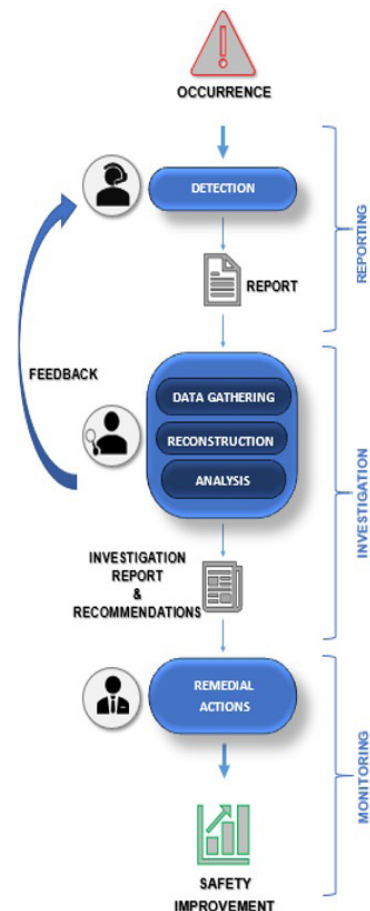


Figure 1

This document explores the process of incident investigation, from the initial input, being this the occurrence report to the final output, being this the investigation report with, when deemed necessary, its associated safety recommendations. Additionally, the document covers the occurrence reporting (as trigger to the investigation process) as well as the monitoring activities carried out inside the company's SMS.

2.2. Document structure

This document is intended to be a toolbox that collects best practices identified during the two meetings held at the CANSO Europe office in Brussels in 2018 and 2019, and where different European ANSP's presented their occurrence investigation processes.

The following chapters outline this process. Every chapter will have the following information:

1. A brief description of the different steps comprising the investigation process. A description of inputs and expected outputs for each step.
2. A set of regulatory references. Most of the time, these references are the same in every step.
3. A list of the best practices identified during the meetings (as they were logged in the minutes of meeting).
4. A list of high-level tools used to achieve the goals of every step. There will not be reference to specific tool names, but only a description. The reason behind this is that every user is able to choose the best choice for its purpose, which could even consist of in-house self-developed tools.

Additionally to the investigation process, this document will include four more chapters, focused in:

- Reporting of safety occurrences
- Safety monitoring process
- Human factors related aspects that could result in, or influence, an incident, namely fatigue, stress and, as far as practicable, psychoactive substances
- Involvement in the investigation process of other personnel not belonging to the investigation team.

2.3. Reporting: Introduction

The European Commission states in its Regulation (EU) No 376/2014 that "A high general level of safety should be ensured in civil aviation in the Union and every effort should be made to reduce the number of accidents and incidents with a view to ensuring public confidence in aviation transport". In order to achieve this goal, member states shall implement a system to allow front-line operators, and any other agent involved in the aviation industry, to report any safety related event.

Organisations shall collect, store, protect, exchange, disseminate and analyse this information, and should take appropriate safety actions based on this information.

The trigger of an investigation process, usually, is the report of any safety related event. The European Regulations establish two different types of reports, mandatory and voluntary, and it assigns this reporting responsibility to specific personnel.

It is compulsory to report any event, designated by the regulation as mandatory reporting, for any person who performs a function as a staff member of an air traffic service provider entrusted with responsibilities related to air navigation services, or as a flight information service officer, as well as any person who performs a function connected with the installation, modification, maintenance, repair, overhaul, flight-checking or inspection of air navigation facilities, for which a Member State ensures the oversight, i.e. ATSEP staff.

ANSP's shall establish occurrence reporting systems in the context of their SMS, according to European regulation (EC) No 2018/1139. Civil aviation shall promote a safety culture, facilitating the spontaneous reporting of occurrences, and thereby, advancing the principle of a Just Culture. Every ANSP shall have a robust Reporting Culture in place, as a component of the aforementioned safety culture (J. Reason, 1997).

2.3.1. Reporting: Applicable Regulation

REGULATION (EC) 2018/1139 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91.

REGULATION (EU) No 996/2010 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC.

REGULATION (EU) No 376/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on the reporting, analysis and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007.

2.3.2. Reporting: Best practices

- Daily logs processed by designated personnel at each unit to feed mandatory reporting system.
- Simplified templates available to report specific type of occurrences (meteorological, overloads, etc.)
- Availability of forms/templates at the CWP in order to allow ATCO's to take quick notes and facilitate the report writing afterwards
- Confidential electronic reporting system
- Designated professionals involved in a safety occurrence will focus on the description of the event, whereas other support personnel fills in report mandatory data fields
- Availability of fact findings questionnaires for involved staff, containing relevant info about personnel factors involved, license issues, workload perceived, detection and reaction to the event, etc
- It is advisable not to access radar replay and voice recording in order to avoid bias before filling the report
- Safety nets records processed as input for occurrence detection, feeding automatic reporting tools
- ANSP's also use ASRs coming from organisations as additional inputs to the reporting system.

2.3.3. Reporting: Used tools

- Paper Forms to take "quick" notes by the ATCO or ATSEP
- Paper templates to fulfil safety occurrence reports
- Dedicated Tools for electronic notification of safety occurrence reports (e.g. TOKAI)
- Specific reporting app for mobile devices

2.4. Information gathering: Introduction

Once a safety report arrives at the safety department, the first stage for investigators is to gather all the relevant information to begin with the investigation process.

¹ Regulation (EU) No 376/2014 amends Regulation (EU) N° 996/2010, but shall not interfere with it. Regulation (EU) No 376/2014 and (EC) No 2018/1139 should not give rise to two parallel reporting systems in any given State, and they should be seen as complementary.

In this stage, investigators should ask themselves what, where and when the occurrence happened. The goal is to find relevant facts, which in subsequent stages of the investigation will support the analysis.

In any investigation, sufficient factual data needs to be collected to ensure that a systemic analysis can be conducted.

Guidelines on the systemic occurrence analysis methodology, developed by EUROCONTROL, recognise that investigation teams should determine what evidence need to be sought, and what are the appropriate questions to ask to witnesses. The same document, also states that is useful to have a descriptive framework in order to better identify those evidences and questions. The document recommends the SHELL Model to provide such a descriptive framework.

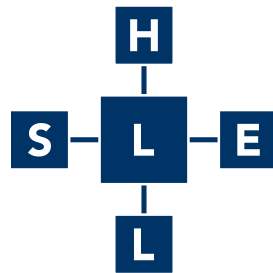


Figure 2: ICAO SHELL Model

The ICAO SHELL Model, as described in [ICAO Doc 9859, Safety Management Manual](#), is a conceptual tool used to analyse the interaction of multiple system components. According to the SHELL Model, a mismatch between the Liveware and other four components contributes to human error.

The SHELL Model can be adapted to incorporate a fifth element, recognising the influence of wider organisational factors on the basic human factors elements. This is often known as SHELL-O Model, including the organisational factors that could influence in the chain of events, or SCHELL Model including additionally the corporate culture. Data should also be collected on this fifth element, covering the broad areas in which organisational decisions and actions impact on people in the workplace.

While the data gathering and analysis phases in an investigation are typically depicted as distinct, and will be in different chapters within this document, they are actually part of an iterative process. After an initial data gathering phase, a preliminary analysis can be conducted, which could identify gaps that can be filled by further data gathering. This process will continue until the systemic analysis has eliminated unanswered questions and reached a logical conclusion.

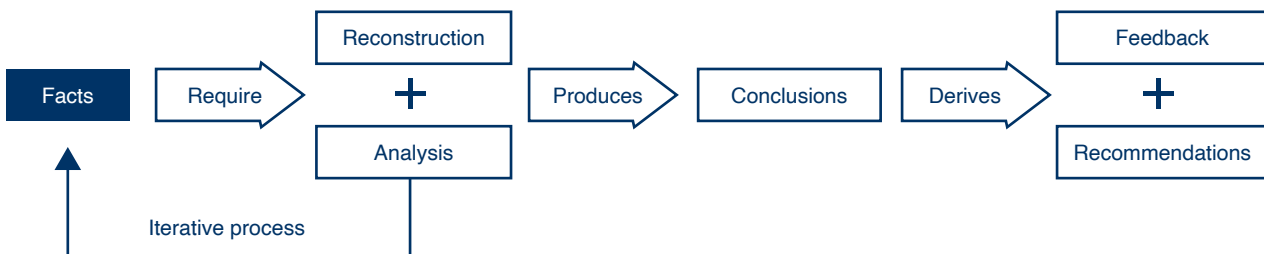


Figure 3: Phases in Occurrence investigation - Gather the Facts

There are two types of facts:

- Event: something that has already happened
- Circumstance: existing condition before, during or after the event

Regarding the facts, is necessary to have in mind the following:

- There should be evidences supporting these facts (Example: If a safety report states that a certain aircraft was cleared to a certain flight level, this fact should be supported by voice recordings, transcriptions or any other source of information). In the event of findings with no physical evidence, like verbal coordination, fatigue or stress, investigators should base their findings in the involved staff reports, or interviews.
- Investigators should avoid value judgement.
- Facts shall be relevant for the investigation. Investigators shall avoid facts without any relation with the occurrence events².

2.4.1. Information gathering: Applicable Regulation

REGULATION (EU) No 376/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on the reporting, analysis and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007.

Annex I of Regulation 376/2014 establishes the list of requirements applicable to the mandatory and voluntary occurrence reporting schemes, and as such provides a minimum set of information to be gathered in the investigation process.

2.4.2. Information gathering: Best practices

Identify the main sources of relevant information. There is a detailed list of mandatory items to be included in safety reports in Annex 1 of UE 376/2014 (flagged with an asterisk in the list below). Additional information about factual data gathering is available in the Guidelines on the Systemic Occurrence Analysis Methodology, chapter 4:

- Date of the occurrence;
 - Date and time of the day*
 - Duration of the event
- Geographical data:
 - FIR/UIR, ATS Unit, etc.*
 - Position*
 - If the location is an aerodrome, runway or taxiway*
 - Sectors involved*
- Traffic data, including ATFM information:
 - HEC
 - Occupancy
 - Demand vs. actual traffic load
 - ATFM Measures
 - Traffic typology (IFR/VFR, traffic in the holding patterns, emergencies, etc.)
- Meteorological data:
 - VMC/IMC conditions
 - Where these conditions relevant?*
 - Where the meteorological information available in a clear and timely manner?
- Data about involved aircraft

² In case of finding facts not related with the occurrence, but with an impact on safety, they should be addressed separately.

- Type of flight operations*
- Operator, call sign, type of aircraft*
- Origin, destination, flight segment, flight rules*
- Routes and procedures in force
- Any other special circumstance (emergencies, on board equipment failures, etc.)
- Data about involved personnel
 - Reports from ATCO's or any other concerned staff (e.g. Supervisor)
 - Interviews
 - Data about continuous time of operation, breaks, shifts, etc.
 - On the Job Training Instruction at the moment of the occurrence
 - Any other relevant personal circumstances (stress, fatigue, low attention due to low traffic load, perceived workload, etc.)
- Human factors related data
- Operational data
 - Operational documentation (Manual of Operations, LoA's, local SOP's, etc.)
 - Airspace classification*
 - Safety nets in place
 - Sector layout
 - Operations room layout
 - Aerodrome layout
 - Ergonomics of the CWP
 - Incident during takeover phase in control positions
 - Special events in course, like military exercises, aerial works, airport onsite works, etc
 - Active special areas (D/R/P)
 - NOTAM/SUP in force
 - Airspace design/issues
 - Availability of infrastructure and systems
 - Any other contextual, unusual or contingency situation
- Interview process
 - Done systematically or depending on type and severity of occurrences
 - The interview is a method to gather non-observable information to support the investigation process complementing factual information.
 - The investigation team should carry out interviews as soon as possible with ATCOs involved, whenever ATM contribution exists.
 - There is no homogeneity among participants on duration of interviews, and when they are allocated (not during rest or breaks vs on extended breaks or after the shift).
 - In order to avoid hindsight bias, some ANSPs do not grant access to radar replay and voice records to the interviewees or even to the interviewers prior to the interview.
 - Building trust is essential for successful interviews:
 - Explain reason for interview
 - Explain the investigation process and what can be expected
 - Explain the interview is confidential
 - Make the interviewee feel understood

- Use active listening
- Procure an undisturbed and quiet atmosphere
- Train the interviewer to consider the context surrounding the occurrence, adopting the point of view of the ATCOs involved
- Allow the interviewee to be accompanied by a peer
- Adopt questioning guidelines and techniques.
- In some cases, team representatives make the initial contact with controllers before the interview.
- Interviewees should read and agree upon the minutes of the interview (some Organisations do not record the interview and results are not directly highlighted in the report. In this case, Investigator sum up orally the results and ask the interviewee for confirmation).

2.4.3. Information gathering: Used tools

- Voice recorders
- Surveillance data recorders
- CHMI query
- Flight plan data

2.5. Occurrence Reconstruction: Introduction

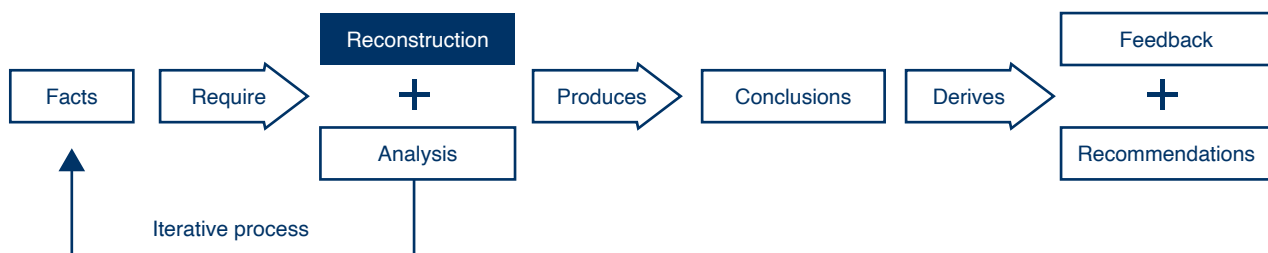


Figure 4: Phases in Occurrence investigation - Reconstruction

The reconstruction of an occurrence is a transition phase between data gathering and the subsequent analysis that identifies the causal factors which lead to the occurrence.

At this stage, taking as basis all the information gathered previously, the investigator (or investigation team) order and rebuild, in the most accurate and faithful manner, those facts that triggered the safety occurrence, finding out the possible related failures. The occurrence reconstruction implies that investigators will step themselves on the involved personnel's shoes³, considering for instance the information available for ATCOs and pilots during the incident, or those factors that may have influenced them (environment, human factors, etc.).

³ S. Dekker, The Field Guide to Human Error Investigations: "find how people's assessments and actions made sense at the time, given the circumstances that surrounded them."

During the reconstruction, the investigators should keep in mind that the occurrence is the result of facts (action or inactions) which took place in a specific contextual scenario. Changing contextual circumstances same facts could result in different outcomes.

The output of the reconstruction phase should be an organised set of events (chain) that agrees with recorded information and which unifies the views of the various persons who were involved in these events immediately before and after the occurrence. In other words, this should correspond to a sort of 3D model of the occurrence in which the investigator matches facts with contextual conditions, reconstructing the occurrence and its particularities.

It should be highlighted that, along the reconstruction process, investigators could find new matters that would make necessary to gather a set of not-previously considered pieces of information to clarify all facts of the incident.

2.5.1. Occurrence Reconstruction: Applicable regulation

No applicable specific regulation for this section.

2.5.2. Occurrence Reconstruction: Best practices

- Notifiers and contributors should participate the reconstruction process:
 - The reconstruction process can prompt controllers to remember significant events that might unintentionally have been omitted in the aftermath of an occurrence.
 - Their involvement during this stage has important psychological and motivational benefits and could help them to move away from any sense that they are the focus of an investigation.
- Occurrence reconstruction should not depend on the investigator or investigation team who carried it out. Investigators often have individual ways of conducting an investigation based on their expertise, past experience and local operating environment. However, without necessary guidance and training, many investigators develop their own methodologies and techniques. This can lead to inconsistencies that may bias the results of an investigation. It can also make it difficult to reproduce the results of any enquiry performed by different investigators or even by the same investigator. That’s way it’s suggested to use a method that is well understood and produces repeatable results.
- Occurrence reconstruction is useful to understand both what did happen during an occurrence and also what might have happened, this can help assess whether or not a recommendation has to be issued to avoid this worst case scenario.

2.5.3. Occurrence Reconstruction: Used tools

- Record and playback systems
- Simulation Tools
- EUROCONTROL SOFIA – Sequentially Outlining and Follow-up Integrated Analysis

2.6. Investigation analysis: Introduction

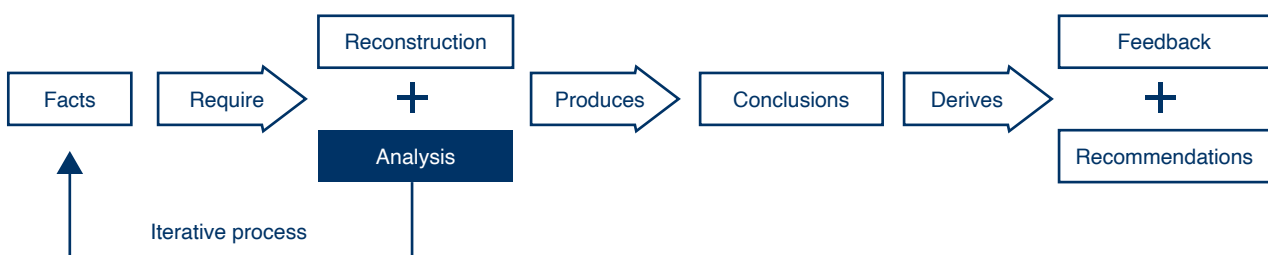


Figure 5: Phases in Occurrence investigation - Analysis

Through the information gathering and occurrence reconstruction phases the investigator should be able to understand what and how, the analysis phase will be then aimed to understand why (usually a mix of more than a single why) the occurrence happened. This part of the investigation process is crucial in providing the explanation of factors (operational, technical, organisational etc) and issues.

It is important to take into account the difference existing between the time of the occurrence and when the investigator performs this analysis, as it is very usual that the investigator has much more information available and plenty of time to analyse it compared to that available for the involved personnel during the incident.

Additionally, the investigator (or investigation team) could face the following obstacles during the occurrence analysis:

- Hindsight bias: As said before, investigators have more information and less “pressure” with respect to professionals involved in the incident. This may lead investigators to have an easier perception of the incident as a consequence of the gap between the analysis scenario (which includes also knowing exactly the outcome of events) and the “real time” occurrence scenario as perceived by witnesses.
- Counter-factual bias: Investigators have to analyse how and why the occurrence happened, avoiding a parallel interpretation of what could have happened if the circumstances or the actions taken had been different. There should be a clear distinction between the analysis of the “real” occurrence and the assessment of the “worst scenario”.
- Confirmation bias: the investigator who has already given himself answers will tend to find confirmation of those answers; avoid jumping to conclusions.
- Personnel judgement: Investigators shall focus on the actual facts, without judging the personnel performance during the incident.
- Micro-matching: The fact of combining various person’s behaviours with procedures or rules does not provide an added value to the investigation if these factors have not contributed to the safety occurrence.
- Proximal bias: The person or thing closest in time and place to the event
- Halo effect
- Judgmental language: Investigators should use a positive or neutral language avoiding expressions like:
 - They should have...
 - He failed to...
 - This is a violation of the procedure...
 - He became complacent
 - He demonstrated a lack of vigilance...
 - There was a lack of risk awareness

As stated above, the aim of the analysis is to describe why the incident occurred; therefore, the investigator should look beyond the obvious causes and aim to identify all the contributory factors, some of which may be related to weaknesses in the system’s defences or other organisational issues.

This should be done arguing the chain of events, as resulted from the occurrence reconstruction, in chronologic order and in an objective manner, taking the available information (about the entire system involved) as basis. The analysis should be based on objective facts and not on investigator’s opinions. Plausible facts (not supported by factual data or investigation evidence) can be presented provided that this must be clearly highlighted in the investigation report.

A good analysis activity should be understood by any reader without leaving doubts about how that incident happened, including all the available relevant information (radar images, communications either literally or summarised, except of applicable regulation and operational procedures, key information about the involved aircraft, etc).

As the reconstruction phase, also, the analysis could reveal unexplored aspects, hence the investigator could come back to information gathering to fill the gaps.

2.6.1. Investigation analysis: Applicable regulation

No applicable specific regulation for this section.

2.6.2. Investigation analysis: Best practices

- Investigations must be independent, confidential and developed in a protected environment of just culture.
- Investigations should be oriented to prevention of future occurrences and understood as an opportunity to learn and show the management how the system behaves in front of unexpected and undesired situations.
- Methodology for occurrence analysis
 - Systemic perspective
 - Focus on context and interactions in the normal operation of the system
 - Use of barrier models
 - Use of causal trees containing all environmental, technical & human related areas (useful to support interviews, for RAT evaluation, to present results to the management and to reuse in future occurrences)
 - HFFF
 - Use of HERA methodology for ATCO error analysis
 - Consider human error as a symptom, not as a cause
 - Focus mainly on detection and resolution phases as a way to avoid judgement based on outcome (recovery phase).
- Analysis of ATM specific occurrences (Technical)
 - Given the number of technical failures, it is not feasible to investigate all of them from a safety perspective, but organisations should investigate AA, A and B events.
 - Safety should focus on:
 - Interactions with systems and services in unexpected events
 - Known latent conditions:
 - Look for workarounds in place, which might point out to bad procedures.
 - Behind an active failure, might there be a latent condition.
 - Systemic issues (maybe local to certain facilities). Look for the “why” as a lead
 - Technical issues, usually, triggered by ATCOs, who are the ones affected by the fall down of services
 - Look for technical implications or failures underlying to operational occurrences
 - In usual technical failures, a technical analysis should be done
 - A risk based approach is recommended instead of compliance applied in three levels:
 - Detected events
 - Validated events (RAT applied)
 - High risk events (investigation performed)

- A loss of service with no users (e.g. ILS loss with no aircraft) is investigated based on the event reproduced in another environment and not in a pure consequential analysis. Otherwise, we could miss the lessons learned.
- Use of machine learning technologies to identify risk areas
- Convey useful info to management through event summaries adapted to their expertise (maybe not technical or operational, and written in plain language).

2.6.3. Investigation analysis: Used tools

- EUROCONTROL HERA (Human error in ATM)
- Barrier Model
- System Thinking

2.7. Conclusions: Introduction

Through this step, the investigator explains the *why* of the facts broken down in the previous stage of the investigation process, the occurrence analysis.

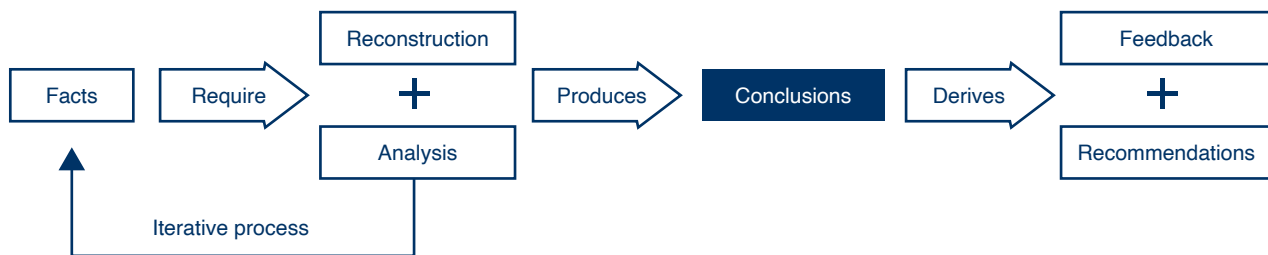


Figure 6: Phases in Occurrence investigation - Conclusions

Conclusions provides rationale to the actions taken by actors involved in the incident, through the evidences raised in the analysis, including those procedures or systems failing as well. Investigators do not focus only on issues and negative aspects found during the investigation, but they also highlight and strengthen positive actions taken by the involved personnel.

There will be a few cases where the absence of enough information substantiating some events, makes it impossible to establish conclusions in a categorical manner. In these cases, it is advisable the use of adverbs pointing out that there is no certainty about some conclusions, according to the information available, and making it clear that, with additional information, these could be confirmed or even changed.

This process of making up conclusions, allows the investigator identifying the contributing factors of the incident, understood as those elements that, if not happened in such a sequence, that specific safety occurrence would have not occurred. The identification of contributing factors highlights the problems and underlying conditions that triggered the incident, as well as allows the identification of the ATM ground contribution, being this contribution direct, indirect – contributing or aggravating – or with no contribution at all.

Last but not least, severity and repeatability scoring through RAT methodology (Risk Assessment Tool), if applicable, allows the investigator to calculate the risk factor of the incident.

2.7.1. Conclusions: Applicable regulation

No applicable specific regulation for this section⁴.

⁴ Commission Implementing Regulation about common European Risk Classification Scheme is expected to be in force by 2020 4Q. Reference to be updated.

2.7.2. Conclusions: Best practices

Conclusions should encompass the following set of information:

- A summary of the sequence of events – using non-technical language – focusing in the key facts of the occurrence.
- Description of the elements triggering the incident, with an identification of the main contributing factors, as well as the way they relate to each other
- The rationale for considering, or not, an ATM ground contribution (ANSP involvement)
- Main elements identified that substantiates the severity scoring, such as:
 - Was the conflict detected by ATCOs, not detected, or detected late?
 - Was the ATCO’s plan to solve that conflict correct, inadequate or there was no plan at all?
 - Was the execution of the plan correct, inadequate or there was no execution at all?
 - Was the conflict detected by a safety net?
 - After the event occurred, was the recovery correct, inadequate or there was no recovery at all?
 - Was there a TCAS warning, or did the crew/driver detected the conflict (see and avoid action)? Additionally, did the crew followed the TCAS warning?
- The main elements substantiating the systemic aspects of the reputability as follows:
 - If there existed design, procedures or equipment failures, and their nature
 - If a non-existing procedure or equipment would have prevented the safety occurrence
 - If there were other aspects involved, related to HHRR management, training, shifts, etc
- Non-systemic elements related to human involvement and the contextual conditions that existed at the time of the occurrence
- A short description of the context (regulatory, operational, ...)

2.7.3. Conclusions: Used tools

No specific tools for this stage of the investigation

2.8. Feedback: Introduction

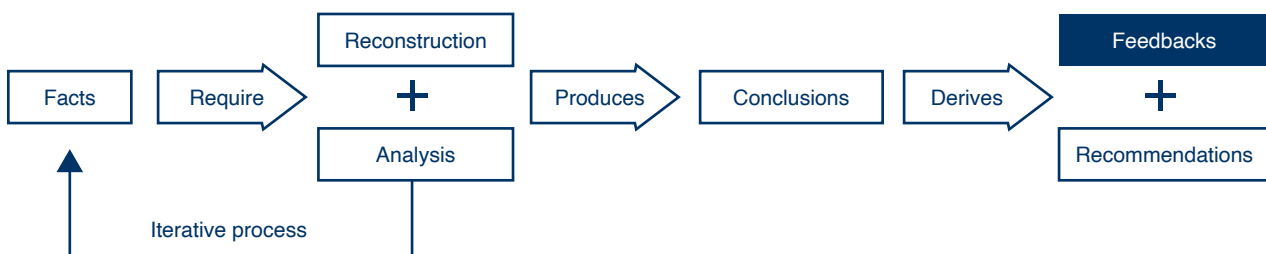


Figure 7: Phases in Occurrence investigation - Feedbacks

Effective feedback from incident reporting systems is essential if professionals and others are to learn from the past and pave the way for the future. Staff are entitled to receive feedback in relation to any report they make, including information about any action taken or reasons for not acting.

How many times do we hear professionals complaining that following a report no feedback is received?

How many times do we hear management complaining that ATCOs are not supportive?

If a reporter does not receive feedback it's easy to conclude the management aren't interested, so why they should?

More than the words it contains feedback is a message itself: "we want facilitate learning and expand awareness". Without feedback, learning and reporting culture simply die.

Whenever possible a feedback should be provided to reporters and, as far as practicable, to actors directly involved in an occurrence. Feedback is cathartic for people explaining how the personal behaviour was influenced by the system. It proves the professionals an investigation does not focus on blame or individual but on systemic issues and is a sort of advertisement for others. Feedback makes reporters part of the analysis, a process they do not just undergo but they participate to improve their world.

A transparent process with clear feedback mechanisms and overt demonstration of improvements made should be part of any revised incident reporting process.

2.8.1. Feedback: Applicable Regulation

Feedback is mentioned in many recitals of Regulations 376/2014, for example:

- (27) Information contained in occurrence reports should be analysed, and safety risks identified. Any appropriate consequent action for improving aviation safety should be identified and implemented in a timely manner. Information on the analysis and follow-up of occurrences should be disseminated within organisations, competent authorities of the Member States and the Agency, since providing feedback on occurrences that have been reported incentivises individuals to report occurrences. Where applicable and when possible, information on the analysis and follow-up of occurrences should also be provided to individuals who have directly reported occurrences to the competent authorities of the Member States or to the Agency. Such feedback should comply with the rules on confidentiality and protection of the reporter and the persons mentioned in occurrence reports pursuant to this Regulation.
- (33) The civil aviation safety system is established based on feedback and lessons learned from accidents and incidents.

Art. 13.3 of the same Regulation states that: "Each organization established in a Member State shall regularly provide its employees and contracted personnel with information concerning the analysis of, and follow-up on, occurrences for which preventive or corrective action is taken".

2.8.2. Feedback: Best Practices

To encourage reporting an organisation should acknowledge the efforts made by reporters. Whenever possible, feedback on the investigations and actions taken in response should be provided to the reporting persons.

A feedback can be defined:

1. Direct or "Hot feedback". When there is the need to directly communicate sensitive aspects to an actor involved. Usually the "face to face" technique is used. It respects the individuals, protects them against external judgmental biases (hindsight – attributional error, etc.), allows two-way communication and allows "feedback to feedback". It can be used for "significant" ATM related event.
2. Indirect or "cold feedback". When the occurrence does not present sensitive aspects, such as general technical failures, unaccustomed situations, minor events or non "significant" ATM related events. Usually are published on safety bulletins, flyers, boards, newsletters, etc.

There are also different moments and objectives for feedback:

1. To acknowledge a report received. This is the moment to explain what the course of actions in case is expected to start an investigation or to explain reasons for halting or dismissing;
2. During the reconstruction and analysis, by letting actors accessing recordings and participating the investigation as observers.
 - a. Pros:
 - i. provides feedback on what happened VS what was perceived
 - ii. increases investigations and actors point of views
 - iii. cathartic for professionals
 - iv. "good time" in case of people relieved from positions
 - v. meta message on a crystal-clear process the actors just not undergo
 - b. Cons:
 - i. Time consuming
 - ii. Costly if done during actors' working hours
3. Before producing the final report, by explaining what happened, why it happened and what is recommended for future prevention. It can be directed to actors directly involved and to line management. Asking professionals if they find themselves in the report and if the investigation highlighted facts or aspect the actor did not perceive at that moment. The same is for line management. During this phase, actors can be requested to sign and provide comments on investigations and their perspective for system improvement.
 - a. Pros:
 - i. Helpful for recipients
 - ii. Helps investigation consistency
 - iii. Test bench for the investigations
 - iv. Comments raised during feedback can be useful to refine or correct the final report
 - v. Helps lesson learning
 - vi. Provide elements for actors to be ambassador of the event (if he/she wants)
 - b. Cons:
 - i. Time consuming

2.8.3. Feedback: Used tools

- TOKAI
- E-mails
- Newsletters
- Intranet
- Unit Boards
- Meetings (e.g. during continuous training, etc.)
- Written messages
- Verbal messages

Whatever the tool used it should be clear, accessible, and meaningful.

2.9. Recommendations: Introduction

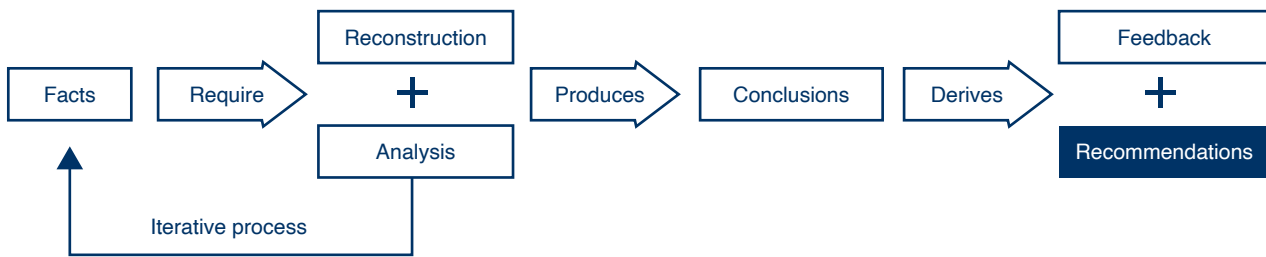


Figure 8: Phases in Occurrence investigation - Recommendations

Once the safety occurrence is investigated and the contributing factors are identified, the investigator/ investigation team should consider different possibilities/strategies to propose a removal, or at least a mitigation, of actual or potential deficiencies identified during the investigation, with the aim of making the system safer, through the establishment of safety recommendations.

These recommendations could address either human contribution, contextual or organisational factors associated to the occurrence, or a combination of them. The recommendations drawing-up will take into account, but not limited, the actual repetition and the potential future repeatability, as well as the associated risk level of the safety occurrence. Additionally, the recommendations issued can be classified as low-level recommendations (those dealing with active failures, mainly due to the human contribution) or as high-level recommendations (dealing with latent failures, more related to the organisation contribution). The latter are usually more effective in the objective of mitigating or eliminating the deficiencies identified, although more complex to carry out than the low-level ones.

Recommendations must address the barriers and be directly linked to the results of the investigation, aiming at the mitigation of the contributing factors. Not always it will be necessary issuing safety recommendations, this fact must be assessed by the investigator (or the investigation team) taking into account, Regulation 376/2014, the risk level of the occurrence, remedial actions already implemented, etc.

Recipients could be consulted before, on recommendations consistency asking them if the objective can be better reached in other way.

When the recommendations are determined, the necessary corrective measures, due dates, and associated responsible units will be defined as a subsequent step. Therefore this step in the investigation process not only involves the investigator (or group of investigators) and the organisation safety management units, but also the organisation units in charge of establishing and implementing the appropriate corrective measures derived from the safety recommendations, in the area of Human resources, systems, operations, etc. These units will take the responsibility of deploying the measures and to provide evidences of implementation.

The process of establishing corrective actions, as well as the subsequent monitoring of its implementation, applies, not only for the organisation investigation derived recommendation, but additionally to the recommendations stemming from the investigations carried out by the national designated safety investigation authority (according to Regulation (EU) No 996/2010).

2.9.1. Recommendations: Applicable Regulation

REGULATION (EU) No 376/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on the reporting, analysis and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007.

COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common

requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.

According to Regulation (EU) No 376/2014: in its 8th whereas, "...Organisations should analyse those occurrences that could have an impact on safety, in order to identify safety hazards and take any appropriate corrective or preventive action..."

Additionally, in its 28th whereas, it reads "...organisations should collect and analyse information on occurrences in order to identify and mitigate hazards associated with their activities. They should also assess associated safety risks and allocate resources to take prompt and appropriate safety risk mitigation measures..."

Article 13th of this Regulation states, in its first and second paragraph:

1. "Each organisation established in a Member State shall develop a process to analyse occurrences collected in accordance with Articles 4(2) and 5(1) in order to identify the safety hazards associated with identified occurrences or groups of occurrences.

Based on that analysis, each organisation shall determine any appropriate corrective or preventive action, required to improve aviation safety.

2. When, following the analysis referred to in paragraph 1, an organisation established in a Member State identifies any appropriate corrective or preventive action required to address actual or potential aviation safety deficiencies, it shall:
 - a. Implement that action in a timely manner; and
 - a. Establish a process to monitor the implementation and effectiveness of the action."

2.9.2. Recommendations: Best practices

- Recommendations are linked to the result of the analysis. Their description/wording should focus on needs or requirements (the what), whereas the derived corrective actions would set the specific operational or technical solutions answering those needs (the how). Recommendations are wide in description to facilitate the choice of the most appropriate corrective actions to achieve the goal
- Recommendations specify what we need to do in order to reinforce or establish barriers, remove the hazard, or reduce the likelihood of it to occur, or to mitigate the impact, once it has occurred, rather than focusing on active failures
- Recommendations are related to contributing factors
- Recommendations are for improving safety, and should aim higher at processes, further away from the actual occurrence:
 - High-level recommendations often are implemented after re-investigations or after compelling debate or doubts are expressed about the effectiveness of low-level recommendations
 - Low-level recommendations target the behaviour of erratic and unreliable human beings and suggest the tightening up of procedures
- Recommendations are realistic (concrete and viable)
- Special attention is paid for recommendations addressing systemic issues
- Recommendations priority is assessed and decided at management level
- Recommendations are issued by the investigation team, but these could coordinate with the units responsible for the implementation of the associated corrective actions before they are issued:
 - Pros: guarantee feasibility and acceptance

- Cons: If the process is “weak” independence could be compromised
- Recommendations are written using positive words
- Recommendations are free from local rationality (the purpose is that given a specific issue, the recommendation should address it in a way that is independent from local rationality)
- In order to set appropriate corrective actions, investigation reports (including their recommendations) are shared with the units responsible for its implementation. This allows them to understand the safety occurrence, and the contributing factors deriving in a given recommendation
- Whenever an impacted unit rejects a safety recommendation, this unit shall provide a solid rationale and an alternative measure if possible. The safety unit in charge of managing the recommendations and performing the follow-up of the implementation of associated corrective actions would assess this rationale and come back to the impacted unit for further details if required
- At the same time, the safety unit assess if a proposed corrective action (together with the rest of corrective actions) addresses the necessities/requirements set in the recommendation adequately
- Creating awareness on hazards can be a useful recommendation
- A way to bring safety recommendations forward is to seek benefits in other areas at the same time, e.g. capacity, cost efficiency, etc
- Local actions are more common as they are easier to apply; actions at wider levels are costly and have to be supported by a solid safety case
- It can be useful to differentiate between safety recommendations and proposals for improvement, depending on the risk and the ATM contribution. If the risk is low and/or there is no ATM contribution, proposals for improvement may be preferable than safety recommendations
- Establishment of a committee composed by the Board of Directors or a subset of it, informed about the most important safety occurrences (either due to its severity or repeatability) and the progress of the wider level corrective actions. This committee addresses issues regarding the proposed corrective measures, proposed timeframe, implementation delays, recommendation coverage, etc.
- There are three roles in the recommendation process:
 - i. Entry (sender)
 - i. Owner (recipient)
 - i. Implementation Agent (facilitator of the process – manages due dates)
- The recommendation proposal is usually⁵ included in the final report within a period time of 3 months from the date of notification of the occurrence. This should also be the time limit to agree remedial actions with the concerned units.

2.9.3. Recommendations: Used tools

- Database containing safety occurrence investigation information
- Tools for managing recommendations follow-up, that could vary from an excel sheet to more complicated database. It is useful to be able to have warnings according with the timing of implementation.
- Business intelligence tools to present recommendations information (per dependency, status, risk)

2.10. Monitoring: Introduction

The process of safety performance monitoring encompasses the development of appropriate indicators and its periodic measurement in order to guarantee that air navigation services are provided in compliance with safety margins, as well as detecting any possible deviations or trends that could compromise these margins. The aim of monitoring is to identify latent risks and areas of action for the maintenance and improvement of safety, as well as

⁵ There may be the case of agreements between the ANSP and its CAA to establish a posterior deadline, after the period of 3 months, for the establishment of safety recommendations –and associated remedial actions – derived from the safety investigation.

validating the effectiveness of the safety recommendations and associated corrective actions deployed.

In addition, safety performance monitoring process guarantees the consistency and coherency of safety indicators monitored within the Organisation with the indicators established at different levels (e.g. national, FAB or ECAC wide levels) so that they can also be used in safety analysis and assurance at all levels. It also establishes the provision of relevant data to the stakeholders in order to facilitate global safety evaluation.

The monitoring process encompasses three steps:

- **Definition of indicators**
Definition of safety indicators is based on the historic data of previous years, studies and reports performed, applicable legislation, etc. These indicators will be monitored along the year in comparison with the corresponding targets.
- **Follow-up**
In order to ease the follow-up and keep the organisation top management aware of the situation in the safety area, there will be a set of periodic reports comparing current actual data against the reference values, showing their evolution along the time.
- **Assessment**
If the monitoring process detects an actual or potential future deviation in the safety area, these deviations shall be represented to the Board, in order to trigger the corresponding corrective actions. If required, specific safety studies could be developed in order to get deeper within the possible causes of deviations. The consequence of a deviation should be an action plan, which establishes a set of mitigation measures, and subsequent monitoring of their effectiveness in an iterative process.

Finally, the monitoring cycle is closed with the review of the safety indicators and its targets, checking their adequacy to perform a continuous monitoring of the safety performance of the organisation.

2.10.1. Monitoring: Applicable Regulation

COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.

REGULATION (EU) No 376/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on the reporting, analysis and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007.⁶

COMMISSION IMPLEMENTING REGULATION (EU) 2019/317 of 11 February 2019 laying down a performance and charging scheme in the single European sky and repealing Implementing Regulations (EU) No 390/2013 and (EU) No 391/2013

REGULATION (EC) No 549/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 10 March 2004 laying down the framework for the creation of the single European sky (the framework Regulation).

According to Regulation (EU) No 2017/373, ATS.OR.200 3. i), "air traffic services providers shall have in place a safety management system (SMS), which includes, among its components, safety performance monitoring and measurement means to verify the safety performance of the organisation and validate the effectiveness of the safety risk controls."

Additionally, Regulation (EU) No 376/2014 states, in its Article 13 Paragraph 2, that, "when following the analysis

⁶ Regulation (EU) No 376/2014 amends Regulation (EU) N° 996/2010, but shall not interfere with it. Regulation (EU) No 376/2014 and (EC) No 2018/1139 should not give rise to two parallel reporting systems in any given State, and they should be seen as complementary.

referred to in paragraph 1, an organisation established in a Member State identifies any appropriate corrective or preventive action required to address actual or potential aviation safety deficiencies, it shall:

- a. implement that action in a timely manner
- b. establish a process to monitor the implementation and effectiveness of the action.”

Regulation (EC) No 549/2004 states in its 19th whereas that “the performance of the air navigation services system as a whole at European level should be assessed on a regular basis, with due regard to the maintenance of a high level of safety, to check the effectiveness of the measures adopted and to propose further measures.”

Furthermore, this Regulation establishes that, through its Article 11th 1st Paragraph, in order “to improve the performance of air navigation services and network functions in the single European sky, a performance scheme for air navigation services and network functions shall be set up. It shall include:

- a. Community-wide performance targets on the key performance areas of safety, the environment, capacity and cost-efficiency
- b. National plans or plans for functional airspace blocks, including performance targets, ensuring consistency with the Community wide performance targets; and
- c. Periodic review, monitoring and benchmarking of the performance of air navigation services and network functions.”

Additionally, Paragraph 4th of the Article 11th states a set of procedures applying to the performance scheme, among which “collection, validation, examination, evaluation and dissemination of relevant data related to the performance of air navigation services and network functions from all relevant parties, including air navigation service providers, airspace users, airport operators, national supervisory authorities, Member States and EUROCONTROL” is mentioned.

Commission Implementation Regulation (EU) 2019/317 states in its 11th whereas that “Key performance indicators should be defined in the key performance areas of safety, environment, capacity and cost-efficiency. These key performance indicators should be used for the purpose of setting achievable, sustainable, realistic and time-bound performance targets at Union level, national level or functional airspace block level. The key performance indicators should cover both en-route and terminal air navigation services, as well as network functions, in order to improve the overall performance of the network.”

Article 36th 1st Paragraph establishes that “For the purpose of monitoring in accordance with Article 37, national supervisory authorities, air navigation service providers, airport operators, airport coordinators, airspace users and the Network Manager shall provide to the Commission the data referred to in Annex VI in accordance with the specific requirements applicable to each party set out in that Annex”, while Annex VI part 2 details the data to be provided by the Air Navigation Service Providers.

2.10.2. Monitoring: Best practices

Nowadays the result of investigation reports is moving towards the use of big data and safety intelligence, in order to facilitate the process to follow recommendations, action plans and feedback.

The use of big data allows correlating safety indicators with other operational values such as traffic load, shifts, operational room configuration, etc... in order to detect potential precursor factors.

- Safety Occurrence Monitoring
 - Safety occurrence monitoring through a safety I approach implies extrapolation from few or quite particular cases, therefore this approach should be complemented with safety II techniques
 - Monitoring of normal operations
 - Use of NOSS methodologies

- Systematic analysis of over deliveries
- Systematic analysis of restriction compliance (speed or altitude)
- Systematic analysis of airborne and ground SNETs alerts
- Data gathering techniques & big data approaches
- Safety II can help make the safety case to support the safety measures proposed after occurrence investigation (safety benefits expected justify the investments)
- Recommendations effectiveness monitoring. The effectiveness of a corrective actions deployed could be done by assessing some indicators associated to a given measure (individually) or through the monitoring of the evolution of safety occurrences in a given unit (globally).
 - Generic effectiveness monitoring:
 - Top five challenges risks vs their corrective actions are tracked and monitored against effectiveness targets previously set
 - Effectiveness is “proved” through positive evolution of generic safety occurrence indicators
 - Specific effectiveness monitoring:
 - Not always feasible as it is difficult to trace the improvements to the safety measures as other changes may have been implemented simultaneously in the system
 - Effectiveness of safety measures to prevent non frequent events is difficult to prove
- Potential risk induced by mitigation measures have to be taken into account compared to their expected safety benefit
- Check of safety recommendations effectiveness is open for a given period and/or up to assessing that type of event decreases
- Surveys can be a powerful means to assess the effectiveness of recommendations

This way, as a result of the safety monitoring activity, organisation’s SMS will be able to provide key information to several internal and external actors so that the level of safety performance is enhanced continuously:

Examples of this information are as follows:

- Statistics elaborated from safety occurrence data (dashboard or other elaborated data)
- Periodic occurrence follow up with Q&S managers
- Interactive maps (google earth based) to identify hotspots and create awareness among pilots, flight schools, clubs and ATCOs

Public report containing occurrence statistics elaborated through BI tools.

2.10.1. Monitoring: Used tools

- Database containing safety occurrence data (position, time, sector, classification, severity, contributors, recommendations, correctives actions, causal factors, etc.)
- Database containing traffic data
- Tools allowing automatic update of real-time safety data (follow-up graphs and reports) – Business Intelligence Tools
- Automatic Safety Management Tools (ASMT) dashboards and heat-maps
 - TCAS RA, ATC system alerts
 - Separation Management Infringements, Airspace Infringements, Runway Incursions
- Observational surveys

- Tools allowing monitoring of
 - effectiveness of corrective actions
 - new changes deployed and associated risks

2.11. Personnel involved: Introduction

It is a requirement of a mature SMS in place in any organisation that every single member of the staff, including the top management, has a knowledge of how the organisation deals with safety issues.

Along with this requirement, the operational knowledge is necessary in order to get a more precise insight of what happened in a certain incident.

European regulations establish that any ANSP shall guarantee that the personnel are trained and competent to perform their SMS duties. This applies to any personnel acting as safety investigator. There shall be a specific training program for safety investigators, regardless they have an ATCO licence or not.

Depending on the ANSP internal procedures, it would be more or less complicated to have dedicated controllers assigned to safety departments. Problems could vary from the lack of available staff, to the lack of motivation or difficulties to adapt office work to local agreements in strongly unionised environments.

The safety team is in charge of the whole process, from the reception of safety reports to the issuing of safety recommendations and lessons dissemination.

As S. Dekker stated in his work “The Field Guide to Human Error Investigations”, it is the people who build up safety in organisations by tying together multiple technologies, adapting themselves to pressure and uncertainty, while dealing with multiple conflicting goals. For these reasons, people’s assessments and actions made sense at the time, given the circumstances that surrounded them.

Safety staff should have a specific training before working on safety tasks. Without being exhaustive, this training may include the following:

- Soft skills such as interview techniques, personal attitudes, communications and facilitation skills
- Technical skills such as safety procedures, tools and methodologies including HHFF specific training
- Regulatory framework

There are several problems identified in assigning operational ATCO’s to safety departments, among them:

- Personal knowledge of controllers involved in occurrences by safety staff may introduce some kind of bias in the investigation
- Having local operational staff could lead to an over-simplification of the facts in the investigation, given the local knowledge of this staff, and could also lead to overlooking certain facts
- Office working hours not attractive for shift workers
- Difficulty for OPS managers to take ATCOs out the OPS Room or TWR
- Economic drawbacks for ATCOs who leave OPS room for office collaboration

2.11.1. Personnel involved: Applicable regulation

COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.

According to Regulation (EU) 2017/373, Annex IV Specific Requirements for Providers Services, Subpart A, section 2 – Safety of services ATS.OR.200 Safety management system,

“An air traffic services provider shall have in place a safety management system (SMS), which may be an integral part of the management system required in point ATM/ANS.OR.B.005, that includes the following components:

4. Safety Promotion:

- i. Training programme that ensures that the personnel are trained and competent to perform their SMS duties
- ii. Safety communication that ensures that the personnel are aware of the SMS implementation

2.11.2. Personnel involved: Best practices

- Investigation team should be independent from the rest of the ATS/CNS units. It is useful to have investigators with a local background in the team (ATCO of the Unit involved or from a similar one). In the event of disagreement, the final decision is up to the Safety Manager.
- Assign operational ATCO's to the safety department, to increase insight on the operation (e.g. local operational procedures, local common practices, etc.) when investigating occurrences.
- Where participation of operational staff is difficult, encourage this participation by using some kind of rewards (e.g. time off).
- ATCOs involved in the incident contributes to the investigation in:
 - Interviews/questionnaire
 - Feedbacks
 - Dissemination of findings
 - Validating event reconstruction
- Allow ATCO's involved in the event to participate in the investigation (no conduction) and make proposals for improvement during the investigation.
- Disseminate lessons learned, so that reporters find that they are an important part of the safety system. If people report, but they do not see any action taken, they will eventually lose interest.

2.11.3. Personnel involved: Used tools

- Rewards. Could be economic, days off, change of professional status, etc
- Promotion channels within the ATC Unit to increase safety buy-in by operational staff (ATS/CNS)
- Dissemination of lessons learnt. Posters, mail, training, etc
- On boarding sessions to new hires

2.12. Human Factors: Introduction

The ATM system is a complex socio-technical system operating in a continually changing environment. It is recognised by CANSO for ANSPs to remain competitive and offer safe, efficient and value-added service to its customers, flexibility, anticipation and adjustment to the various operational demands and changes in technology, can only be done by humans, strongly supported by technology.

Effective human performance is required to deliver good air traffic management. To keep the system safe, efficient and effective, adaptation and flexibility is necessary. The study of human factors in ATM is essential to better understand how the impact of technology design, personnel selection, training, procedures, roles, tasks and responsibilities, as well as organisational management itself, is ensuring system performance adapted to the human and efficient risk management. It is the people in the system that provide this resilience. For obtaining

optimal human performance of front-line staff, the human factors discipline is an important enabler by providing the underlying expertise, knowledge, methods and techniques to address and solve specific human performance challenges in current and future work situations and the ATM system.

Traditionally, unsafe situations have been attributed to 'unreliable or erratic' human performance of individuals, instead of focusing how system fail. Rasmussen (1985, 1986) characterised human error as the result of imbalances between job demands and available resources to conclude that the roots of failure and success are essentially the same. In order to understand failure, it is essential to understand how practitioners usually achieve success in the face of demands, difficulties, pressures and dilemmas. Consequently, practitioners must face frequent trade-offs in their daily work, when dealing with competing goals like safety versus efficiency. In this respect, EUROCONTROL (2014) reflects the importance of the 'Local Rationality', or the local perspectives of the people who actually do the job.

According to a new view in safety management, defined as Safety-II, it is precisely the ability of people to adjust their performance to contextual conditions that explains why systems actually work. Thus, recognising how practitioners face everyday adaptations is a way to understand how expertise is developed. Then, the foundation of Safety-II is that practitioners are a resource necessary for system flexibility and resilience, who are continuously creating safety. Therefore, systemic (design) thinking is essential in tackling human performance challenges and human performance management, aligned with the 10 principles of systemic safety thinking of EUROCONTROL (2014).

The UE 373/2017 placed renewed attention on Human Factors focusing on new aspects that influence human performances such as training, stress, fatigue and abuse of psychoactive substances. Despite the regulation, lack of acceptable means of compliance and other difficulties make it hard to implement in most of the States and limited the possibility to identify best practices during the workshops. Nevertheless, participants raised the need to have some indications, like specific training on this topic for safety investigators; a transparent objective and a no discriminatory procedure related to stress, fatigue and psychoactive substances or how to manage privacy of individuals.

2.12.1. Human Factors: Applicable Regulation

COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.

IR 2017/373 establishes the specific requirements for air traffic control organisations to prevent and limit the negative effects of occupational fatigue and stress on ATCOs, the impact of rostering system, and the exclusion of psychoactive substances abuse to ensure air traffic safety. Specifically, reference is made to the need to prevent and mitigate these negative effects from a wider perspective, considering both the individual and the organisation for safety purposes. According to IR 2017/373 (ATS.OR.310 and 315) the ATC service provider shall:

- Develop and maintain a policy for the management of air traffic controllers' stress, including the implementation of a critical incident stress management program
- Provide air traffic controllers with education and information programs on the prevention of stress, including critical incident stress
- Develop and maintain a policy for the management of air traffic controllers' fatigue
- Provide air traffic controllers with information programs on the prevention of fatigue

IR 2017/373 also establishes in ATS.OR.320 that ATC providers shall develop, implement and monitor a rostering system in order to manage the risks of occupational fatigue of ATCOs, through a safe alternation of duty and rest periods considering eight specific categories, and that ATCOs or their representatives shall be consulted on the development and application of the rostering system.

The need to report states of fatigue is also laid down in **IR 2015/1018**, in its Annex III, as an occurrence in civil aviation to be mandatorily reported according to Regulation (EU) No 376/2014. Specifically, it refers to the need to report fatigue affecting, or potentially affecting, the ability to perform air navigation of air traffic duties safely.

Previously to IR 2017/373 and IR 2015/1018, **Regulation (EC) 1108/2009** already addressed stress and fatigue in ATC. In terms of fatigue, it established the need to prevent fatigue of personnel providing ATC service through a rostering system, addressing duty periods, duty time and adapted rest periods. Actually, it is stated in the regulation that limitations within the rostering system shall take into account relevant factors contributing to fatigue such as, in particular, sleep deprivation, disruption of circadian cycles, night hours, cumulative duty time for given periods of time and also the sharing of allocated tasks between personnel. In terms of stress, it is stated that the prevention of stress of personnel providing an ATC service shall be managed through education and prevention programs. Additionally, Regulation (EC) 1108/2009 also refers to ensure medical fitness, as well as to take into account operational and technical constraints as well as human factors principles in its planning and operations.

2.12.1. Human Factors: Best Practices

The main aim of setting best practice is to develop a framework to consider human factor aspects into an investigation, promoting identification, collection and assessment of human factors data.

But, how to overcome the unavailability of AMC or existing best practices that prevent the full achievement of these objectives? To do this hard job we must stick to the investigation steps, considering the main aspect and start sketching the future vision.

To consistently feed the investigation process, especially, data gathering and analysis, an investigator needs a deep sensibility on human factor. Human factor data is everywhere. In the artefacts, the technology, the procedure the culture and in the humans themselves. Being aware of this can induce to ask for support of an human factors expert whenever is perceived a strong influence of the matter.

The human factors data gathering is the hardest point since the vast majority of information related to humans are not under the form of data but as "soft" information.

To help the information collection, for a consistent and fruitful investigation, we should refer to:

- available data
- observational information

Available data can be found into many records or data bases such as Human Resources, training, rostering or any similar system, looking for elements that in isolation or connected to others can elicit new meanings.

For instance, if an ATCO:

1. Misinterpreted the color coding of a radar position indication and is 57 years old, the investigator could think, in first instance, that his/her ability to discriminate colors (e.g. blue and violet or green with light green) could be influenced by the age;
2. Was slow in reacting to a medium traffic and is the fifth consecutive morning and evening shift, again the investigator could think that the fatigue could be a contributing factor.

If confirmed after the application of the appropriate HHFF methodologies, this information would feed the analysis and the conclusions (recommendations as well).

Observational information or data can be found in many different situations, places or conditions. One of this is to fiscally observe the environment in which the professional was operating. Information are all around and can be elicited from observation. How an Ops room is organised, where it is placed, how is the lighting, how the chairs are projected, and maintained, if the back of the chairs are all up or down, how is the CWP ergonomic and thousands of others clues can orient the data gathering.

Here below there are some other examples of situations that could derive in further data gathering and analysis in the investigation:

An ATCO

1. Didn't manage to correct a wrong hear back, inducing a RWY incursion, and the TWR is positioned well above the engine test stand. The background noise might have limited his/her ability to hear
2. Didn't update the FDP with relevant information, and there are three identical computer mice for different purposes. He could have been confused operating the incorrect one
3. Didn't manage to identify a conflict between two opposite traffic at 10 NM. This fact could have been the result of a blind spot related issue

Interviews, if properly conducted in an absolutely confidential and protected environment, offer an additional opportunity to gather Observational data; a multitude of information, personal or not, that influence human performances or increase the expositions to risk or "human error" could, in fact, be revealed by interviewees.

All of the above can help to reveal phenomena that can be evaluated in the subsequent investigation steps. What is important is not to just detect the presence of human factor related issues but to directly link them with the results.

Once selected all the human factors data they can be considered in reconstruction, analysis and, therefore, in the conclusion to explain how they influenced or induced the occurrence. It is important to capture human elements, and their interaction with other system elements.

So, if stressors are found this doesn't mean the ATCO was stressed. The same is for fatigue. If, at the end of the shift or before the break, ATCO was tired it doesn't mean he/she was fatigued. For example, if an ATCO responsible for the arrival sector of an important TMA is tired because had to manage a heavy sequence this should not directly correspond to fatigue. Investigator should instead prove that accumulations of this specific factor lead to stress or fatigue, and additionally if this stress or fatigue, in case of being present, played a role in the development of the incident.

Recommendations, in particular, should address human factors aspects and remedial actions should be issued and oriented on the systemic barriers (e.g. system design) able to reduce risks for safety critical situations.

To support an efficient and consistent human factors data gathering, the safety manager or the responsible for Occurrence management process should:

- Create and enhance awareness of the relevance of human performance management in ATM and provide incident investigators with guidance on human performance
- Ask for or assign human factors experts support to Investigators
- Ask for Investigators training on human factors principles, in order to support them in the identification of connections between fatigue/stress and systemic (e.g., rostering) or individual issues during the investigation
- Design of a questionnaire to be used during interviews of any professional involved in ATM occurrence, with general questions about contributing (human) factors (e.g., used to identify any fatigue or stress issue)
- Promotion, design and implementation of fatigue and stress investigation procedures in operational safety
- Production of guidance material for stress and fatigue hazard identification (for instance during the interviews)
- Gather, during the investigation process, reliable information regarding fatigue and stress.

- Refer to the:
 - Human Factor Policy, or
 - Fatigue and Stress Risk Management System with the aim to maintain and improve the well-being of professionals, stating the Fatigue and Stress policy if implemented.
- Promote, within the boundary of the reporting system, Fatigue and Stress reporting for operational ATCOs
- Promote the adoption of a fatigue and stress taxonomy based on scientific sources, in order to rigorously and professionally investigate the risks associated with fatigue and stress
- In respect to GDPR, adopt an internal safety de-identified compilation of data related to gender, age, sleep chronotype, rostering, etc., and analysis from a systemic perspective, considering the operational context, organisational factors, personal factors as well as scientific principles (sleep debt, circadian cycle, workload, etc.)
- Take into account the best practices and trends in Human Performance in ATM (e.g. Automation related) as potential recommendations to be issued at the end of the investigation process

2.12.2.Human Factors: Used Tools

- TOKAI
- HERA Janus (only for error and contextual conditions identification. It needs to be followed by Safety II approach)
- Human Factor Case (EUROCONTROL)
- Stress and Fatigue reporting templates
- Guidance material for safety team related to fatigue and stress identification during the investigation process

Annex 1 – Data gathering, occurrence reconstruction and investigation analysis used tools per ANSP

Albania		Albcontrol
Combined Audio and Video	YES	Audio and video are synchronised
Easily accessible via PC or they need to be physically taken	NO	Need to be physically taken
On the wall and/or the glass	Both	
A tool that supports automatic/semi-automatic audio transcription	Transcription have to be done by hand	
A what if analysis on the video	Not available	
Any other stuff that ease data gathering and analysis	Playback, ASMT for SMI, E-TOKAI for recording of the occurrence, data gathering and also analysis (HERA, RAT).	

Austria		Austro Control
Combined Audio and Video	NO	in progress of getting a tool to synchronise them
Easily accessible via PC or they need to be physically taken	Part	Audio is accessible via PC, but the replay is available only c/o ACC
On the wall and/or the glass	/	
A tool that supports automatic/semi-automatic audio transcription	Transcription have to be done by hand	
A what if analysis on the video	Not available	
Any other stuff that ease data gathering and analysis	Access to the MET data and CHMI direct from the investigator's office.	

Bulgaria		BULATSA
Combined Audio and Video	NO	Separated. They use a tool for synchronising the audio and the video recording
Easily accessible via PC or they need to be physically taken	NO	Need to be physically taken
On the wall and/or the glass	On the glass	
A tool that supports automatic/semi-automatic audio transcription	Transcription have to be done by hand	
A what if analysis on the video	Not available	
Any other stuff that ease data gathering and analysis	MET Information, FPLs, Radar Track data (via SASSC tool), FDP information retrieved the FPL/FDP (e.g. trajectory, sectors, COP, etc.) the data from these sources is collected manually.	

Czech Republic		ANS CR
Combined Audio and Video	YES	Yes, they can use an automatic synchronisation including Safety Nets and weather condition data at the moment (radar)
Easily accessible via PC or they need to be physically taken	YES	Via PC (The investigators can even replay the situation from home, on weekend for instance)
On the wall and/or the glass		On the glass
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		Gathering facts is a manual process. The designed people/ investigators are allowed to put the relevant attachments for the investigation into special database (TIS).

Slovenia		Slovenia Control
Combined Audio and Video	YES	Recording and reproduction system RICOCHET provides for investigators combined audio and video. Recording directly from CWP caters for reproduction of ATCO interaction with his radar display. CNS utilises in parallel radar picture recording system RMCD for monitoring surveillance data quality and integrity.
Easily accessible via PC or they need to be physically taken	YES	They are accessible from technical monitoring room or on request transferred to secured server, accessible by investigators PC from any place.
On the wall and/or the glass		Both options on the wall and/or on the glass. On the glass includes mouse and keyboard ATCO actions visible.
A tool that supports automatic/semi-automatic audio transcription	NO	Transcription have to be done by hand
A what if analysis on the video	NO	
Any other stuff that ease data gathering and analysis		Data generated from Rostering, AIP, Operational Instructions, NOTAMs, Flight lists, Learning objective cases from the past are available on-line.

Germany		DFS
Combined Audio and Video	NO	Not combined at ACC or TWR Units. Combined at UAC Unit.
Easily accessible via PC or they need to be physically taken	NO	Playback of video via PC, screenshots are being taken of the relevant time for investigation. Audio has to be physically taken.
On the wall and/or the glass		On the wall. On the glass at one unit only.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		No. Data like MET data, technical logs, etc. have to be obtained manually

Hungary		HungaroControl
Combined Audio and Video	YES	We have synchronised playback of video and audio records
Easily accessible via PC or they need to be physically taken	YES	The records are accessible via 5 dedicated PC, 3 of them are in the investigators' offices and a video type export file can be made easily – that file can be played on any PC.
On the wall and/or the glass		On the glass.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		Access to Rostering system (which records the actual roster, licenses details such as validity, expiry, origin), access to the system FPL database (we can check the changes to FPL). We have an active playback mode of the ATS system records, when we can activate the measurement tools and measure anything we would like during playback.

Ireland		IAA
Combined Audio and Video	YES	They have two different systems. One system requires the investigator to synchronise the comms and radar data. The other system is synchronised and allows for an almost immediate playback of an occurrence.
Easily accessible via PC or they need to be physically taken	Part	System one requires recordings to be physically taken. System two allow for playback from a secure PC.
On the wall and/or the glass		Both
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		No. Data gathering is generally a time consuming exercise.

Italy		ENAV
Combined Audio and Video	NO	Audio and video, are separated. They need to be manually synchronised.
Easily accessible via PC or they need to be physically taken	Part	Only on a few major sites, audio can be downloaded through a server. In any case transcription is by hand on Word.
On the wall and/or the glass		On the wall. Video recordings are based on LAN signals. Only some inputs, executed by ATCOs, are displayed on recordings.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		No. Video and audio can be exported in commercial formats (not certified) useful for continuous training and lesson dissemination. If legal document is needed (AIR or Judiciary) the only possibility is to produce the physical recording or a plot on paper.

Malta		MATS
Combined Audio and Video	YES	Recording system that can synchronise both audio and video.
Easily accessible via PC or they need to be physically taken	Part	It is encrypted, however we can transfer to standard media because the tool has a special function for that.
On the wall and/or the glass		On the glass, including mouse and keyboard action.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available.
Any other stuff that ease data gathering and analysis		Our recording system can replicate practically all action by ATCO, from the glass means all actions are recorded.

Norway		AVINOR
Combined Audio and Video	NO	No automatic synchronisation, it has to be done manually.
Easily accessible via PC or they need to be physically taken	NO	Depending on coordination in advance with the relevant unit/management and CNS-department, the files can be made available and accessible for the investigator via PC, however this is not considered as "easily accessible". The type of recorders varies from one unit to another which adds on to the challenge of making data easily accessible.
On the wall and/or the glass		The recording will not show exactly what the controller was observing on the screen at the time, but no major differences. Observing the controllers inputs/clicks on the screen (PTL, conflict detection, range, handover, etc.) is possible on the system, but has to be done via replay on site.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available.
Any other stuff that ease data gathering and analysis		Gathering facts is considered being a manual process. The reporting system allows designated people to comment the report, incident, facts and to upload relevant attachments for the investigation. This could be Met-reports, pilot reports, action taken, procedures, flight plans, technical files, snapshots/pictures etc – which is of great value for investigation.

Poland		PANSA
Combined Audio and Video	YES	Recording system that separately records audio and video streams. Recording tool can automatically synchronise both of them
Easily accessible via PC or they need to be physically taken	YES	The recordings are available via PC and can be easily exported to standard media formats.
On the wall and/or the glass	Both	
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		We collect manually data from: MET system, FPLs, Radar track data, operational system logs – sectorisation, roster, traffic flow

Portugal		NAV Portugal
Combined Audio and Video	YES	Digital Synchronised replay (Passive video streaming)
Easily accessible via PC or they need to be physically taken	YES	Via PC.
On the wall and/or the glass		On the glass.
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available.
Any other stuff that ease data gathering and analysis		Automated system to backup all operational recorded data. Online fetching of recorded data for immediate replay. Security requirements assured by closed access system and built in encryption.

Spain		ENAIRE
Combined Audio and Video	Part	We have got a tool where we can synchronise them, but video used is not the real radar image ATC had on their screen, but a similar reproduction.
Easily accessible via PC or they need to be physically taken	Part	Depending on the Unit. In larger units we have online access to audios and video (pre-treated radar screen image). Not for small TWRs.
On the wall and/or the glass		
A tool that supports automatic/semi-automatic audio transcription		Transcription have to be done by hand
A what if analysis on the video		Not available
Any other stuff that ease data gathering and analysis		We've got an application accessible from our PCs where you can have information about ROC, ROD, true heading, IAS, Flight Plan, Action introduced by ATC (click on radar labels and data introduced) in our system (CFL, TFL, speed control, etc.)

U.S.A	FAA
Combined Audio and Video	YES Falcon does provide combined audio and video for replays.
Easily accessible via PC or they need to be physically taken	YES Falcon is only available via PC. A version is being considered that is compatible with mobile devices.
On the wall and/or the glass	
A tool that supports automatic/semi-automatic audio transcription	Transcription have to be done by hand
A what if analysis on the video	Falcon support a limited "what-if" capability with a simulation function that allows controllers to alter airplane tracks.
Any other stuff that ease data gathering and analysis	Falcon provides an aircraft search feature. CEDAR is the primary tool for data gathering and analysis.



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