

Acceptable Means of Compliance (AMC)

and

Guidance Material (GM)

to Part-ATS

Specific requirements for providers of air traffic services (ATS)

Initial Issue

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SUBPART A — ADDITIONAL ORGANISATION REQUIREMENTS FOR PROVIDERS OF AIR TRAFFIC SERVICES (ATS.OR)

Section 2 — Safety of services

AMC1 ATS.OR.200(1); (2); (3) Safety management system

GENERAL — NON-COMPLEX ATS PROVIDERS

- (a) The safety policy should include a commitment to improve towards the highest safety standards, comply with all the applicable legal requirements, meet all the applicable standards, consider the best practices and provide the appropriate resources.
- (b) In cooperation with other stakeholders, the air traffic services provider should develop, coordinate and maintain an emergency response plan (ERP) that ensures orderly and safe transition from normal to emergency operations and return to normal operations. The ERP should determine the actions to be taken by the air traffic services provider or specified individuals in an emergency and reflect the size, nature and complexity of the activities performed by the air traffic services provider.
- (c) Safety risk management may be performed using hazard checklists or similar risk management tools or processes, which are integrated into the activities of the air traffic services provider.
- (d) An air traffic services provider should manage safety risks related to changes. Management of changes should be a documented process to identify external and internal changes that may have an adverse effect on safety. It should make use of the air traffic services provider's existing hazard identification, risk assessment and mitigation processes.
- (e) An air traffic services provider should identify persons who fulfil the role of safety managers and who are responsible for coordinating the safety management system (SMS). These persons may be accountable managers or individuals with an operational role in the air traffic services provider.
- (f) Within the air traffic services provider, responsibilities should be identified for hazard identification, risk assessment and mitigation.

AMC1 ATS.OR.200(1)(i) Safety management system

SAFETY POLICY — COMPLEX ATS PROVIDERS

- (a) The safety policy should:
 - (1) be signed by the accountable manager;
 - (2) reflect organisational commitments regarding safety and its proactive and systematic management;
 - (3) be communicated, with visible endorsement, throughout the air traffic services provider;
 - (4) include safety reporting principles;
 - (5) include a commitment to:
 - (i) improve towards the highest safety standards;
 - (ii) comply with all the applicable legal requirements, meet all the applicable standards and consider the best practices;
 - (iii) provide appropriate resources; and

- (iv) enforce safety as one primary responsibility of all managers and staff;
 - (6) include the safety reporting procedures;
 - (7) clearly indicate which types of operational behaviours are unacceptable, and include the conditions under which disciplinary action would not apply; and
 - (8) be periodically reviewed to ensure it remains relevant and appropriate.
- (b) Senior management should:
- (1) continually promote the safety policy to all personnel and demonstrate their commitment to it;
 - (2) provide necessary human and financial resources for its implementation; and
 - (3) establish safety objectives and performance standards.

GM1 ATS.OR.200(1)(i) Safety management system

SAFETY POLICY — COMPLEX ATS PROVIDERS

Operational behaviour, when disciplinary action would not apply, could be where someone is not blamed for reporting something which would not have been otherwise detected.

GM2 ATS.OR.200(1)(i) Safety management system.

SAFETY POLICY — COMPLEX ATS PROVIDERS

- (a) The safety policy should state that the purpose of safety reporting and internal investigations is to improve safety, not to apportion blame to individuals.
- (b) An air traffic services provider may combine the safety policy with the policy required by ATM/ANS.OR.B.005(a)(2).

GM3 ATS.OR.200(1)(i) Safety management system

SAFETY POLICY — NON-COMPLEX ATS PROVIDERS

- (a) The safety policy should state that the purpose of safety reporting is to improve safety, not to apportion blame to individuals.
- (b) An air traffic services provider may combine the safety policy with the policy required by ATM/ANS.OR.B.005(a)(2).

AMC1 ATS.OR.200(1)(ii) Safety management system

ACCOUNTABILITIES — COMPLEX ATS PROVIDERS

The SMS of the air traffic services provider should ensure that:

- (a) everyone involved in the safety aspects of the provision of air traffic services has an individual safety responsibility for their own actions;
- (b) managers should be responsible for the safety performance of their respective departments or divisions; and
- (c) the top management of the provider carries an overall safety responsibility.

GM1 ATS.OR.200(1)(ii) Safety management system

SAFETY ACTION GROUP — COMPLEX ATS PROVIDERS

- (a) A safety action group may be established as a standing group or as an ad hoc group to assist or act on behalf of the safety review board as defined in point (b) of AMC2 ATS.OR.200(1)(ii);(iii).
- (b) More than one safety action group may be established depending on the scope of the task and the specific expertise required.
- (c) The safety action group should report to and take strategic direction from the safety review board and should comprise managers, supervisors and personnel from operational areas.
- (d) The safety action group should:
 - (1) monitor operational safety;
 - (2) resolve identified risks;
 - (3) assess the impact on safety of operational changes; and
 - (4) ensure that safety actions are implemented within agreed timescales.
- (e) The safety action group should review the effectiveness of previous safety recommendations and safety promotion.
- (f) Members of the safety action group should participate in the local runway safety team as per GM2 ADR.OR.D.027 'Safety programmes'.

AMC1 ATS.OR.200(1)(ii);(iii) Safety management system

ORGANISATION AND ACCOUNTABILITIES

An air traffic service provider should:

- (a) identify the safety manager who, irrespective of other functions, has ultimate responsibility and accountability, on behalf of the organisation, for the implementation and maintenance of the SMS;
- (b) clearly define lines of safety accountability throughout the organisation, including a direct accountability for safety on the part of senior management;
- (c) identify the accountabilities of all members of management, irrespective of other functions, as well as of employees, with respect to the safety performance of the SMS;
- (d) document and communicate safety responsibilities, accountabilities and authorities throughout the organisation; and
- (e) define the levels of management with authority to make decisions regarding safety risk tolerability.

AMC2 ATS.OR.200(1)(ii);(iii) Safety management system

ORGANISATION AND ACCOUNTABILITIES — COMPLEX ATS PROVIDERS

The SMS of the air traffic services provider should encompass safety by including a safety manager and a safety review board in the organisational structure.

- (a) Safety manager
 - (1) The safety manager should act as the focal point and be responsible for the development, administration and maintenance of an effective SMS. He or she should be independent of line management, and accountable directly to the highest organisational level.

- (2) The role of the safety manager should, as a minimum, be to:
 - (i) ensure that hazard identification, risk analysis and management are undertaken in accordance with the SMS processes;
 - (ii) monitor the implementation of actions taken to mitigate risks;
 - (iii) provide periodic reports on safety performance;
 - (iv) ensure maintenance of safety management documentation;
 - (v) ensure that there is safety management training available and that it meets acceptable standards;
 - (vi) provide advice on safety matters; and
 - (vii) monitor initiation and follow-up of internal occurrence/accident investigations.
- (3) The safety manager should have:
 - (i) adequate practical experience and expertise in air traffic services or a similar area;
 - (ii) adequate knowledge of safety and quality management;
 - (iii) adequate knowledge of the working methods and operating procedures; and
 - (iv) comprehensive knowledge of the applicable requirements in the area of air traffic services.

(b) Safety review board

- (1) The safety review board should be a high-level committee that considers matters of strategic safety in support of the accountable manager's safety accountability.
- (2) The board should be chaired by the accountable manager and composed of heads of functional areas.
- (3) The safety review board should, as a minimum:
 - (i) monitor safety performance against safety policy and objectives;
 - (ii) ensure that any safety action is taken in a timely manner; and
 - (iii) monitor the effectiveness of the air traffic services provider's SMS processes.
- (4) The safety review board should ensure that appropriate resources are allocated to achieve the planned safety performance.
- (5) The safety manager or any other relevant person may attend, as appropriate, safety review board meetings. He or she may communicate to the accountable manager all information, as necessary, to allow decision-making based on safety data.

GM1 ATS.OR.200(1)(iii) Safety management system

SAFETY MANAGER — COMPLEX ATS PROVIDERS

- (a) Depending on the size of the air traffic services provider and the nature and complexity of their activities, the safety manager may be assisted by additional safety personnel in the performance of all the safety-management-related tasks.
- (b) Regardless of the organisational set-up, it is important that the safety manager remains the unique focal point as regards the development, administration and maintenance of the air traffic services provider's SMS.

GM2 ATS.OR.200(1)(iii) Safety management system

SAFETY MANAGER — NON-COMPLEX AIR TRAFFIC SERVICES PROVIDERS

In the case of a non-complex air traffic services provider, the function of the safety manager could be combined with another function within the organisation provided that sufficient independence is guaranteed.

AMC1 ATS.OR.200(1)(iv) Safety management system

COORDINATION OF EMERGENCY RESPONSE PLANNING FOR ATS PROVIDERS — COMPLEX ATS PROVIDERS

- (a) An air traffic services provider should develop, coordinate and maintain a plan for its response to an emergency. It should:
 - (1) reflect the nature and complexity of the activities performed by the air traffic services provider;
 - (2) ensure an orderly and safe transition from normal to emergency operations;
 - (3) ensure safe continuation of operations or return to normal operations as soon as practicable; and
 - (4) ensure coordination with the ERPs of other organisations, where appropriate.
- (b) For emergencies occurring at the aerodrome or in its surroundings, the plan should be aligned with the aerodrome ERP and be coordinated with the aerodrome operator.

GM1 ATS.OR.200(1)(iv) Safety management system

TYPES OF EMERGENCIES

At least the following types of emergencies may be considered:

- (a) aircraft emergencies;
- (b) natural phenomena (e.g. extreme weather conditions);
- (c) acts of terrorism;
- (d) loss of the ability to communicate with the aircraft; and
- (e) loss of the air traffic services unit.

GM2 ATS.OR.200(1)(iv) Safety management system

COORDINATION OF THE EMERGENCY RESPONSE PLANNING FOR ATS PROVIDERS — COMPLEX ATS PROVIDERS

For aerodrome-related emergencies, please refer to GM4 ADR.OPS.B.005(a) 'Aerodrome Emergency Planning'.

AMC1 ATS.OR.200(1)(v) Safety management system

SAFETY MANAGEMENT MANUAL (SMM) — COMPLEX ATS PROVIDERS

The safety management manual should be the key instrument for communicating the approach to safety for the air traffic services provider. The SMM should document all aspects of safety management, including but not limited to the:

- (a) scope of the SMS;
- (b) safety policy and objectives;
- (c) safety accountability of the accountable manager;
- (d) safety responsibilities, accountabilities and authorities of key safety personnel throughout the air traffic services provider;
- (e) documentation control procedures;
- (f) hazard identification and safety risk management schemes;
- (g) safety performance monitoring;
- (h) incident investigation and reporting;
- (i) emergency response planning;
- (j) management of change (including organisational changes with regard to safety responsibilities and changes to functional systems); and
- (k) safety promotion.

AMC2 ATS.OR.200(1)(v) Safety management system

SAFETY RECORDS — COMPLEX ATS PROVIDERS

Safety records that should be maintained and retained include but are not limited to:

- (a) certificates;
- (b) limited certificates;
- (c) declarations;
- (d) safety policy;
- (e) safety accountabilities/responsibilities;
- (f) safety occurrences;
- (g) emergency response plan;
- (h) SMS documentation;
- (i) training and competence;
- (j) occurrence reports;
- (k) safety risk assessments including safety assessment of changes to the functional system;
- (l) determination of either complex or non-complex organisation; and
- (m) approved alternative means of compliance.

GM1 ATS.OR.200(1)(v) Safety management system

SAFETY MANAGEMENT MANUAL (SMM) — COMPLEX ATS PROVIDERS

The SMM may be contained in (one of) the manual(s) of the air traffic services provider.

GM1 ATS.OR.200(3)(i) Safety management system

SAFETY ASSURANCE — COMPLEX ATS PROVIDERS

(a) Leading indicators

- (1) Metrics that measure inputs to the safety system (either within an organisation, a sector or across the total aviation system) to manage and improve safety performance.
- (2) Leading indicators measure the specific features of the aviation safety system designed to support continuous improvement and to give an indication of likely future safety performance. They are designed to help identify whether the providers and regulators are taking actions and/or have processes in place that are effective in lowering the risk.

(b) Lagging indicators

Metrics that measure the outcome of the service delivery by measuring events that have already occurred and that impact safety performance. There are two subsets of lagging indicators:

- (1) Outcome indicators: These include only the occurrences that one aims to prevent, for example fatal or catastrophic accidents. Depending on the system, the severity of the occurrences that are included as outcome indicators can be adjusted to include all accidents and serious incidents.
- (2) Precursor indicators: These indicators do not manifest themselves in accidents or serious incidents. They indicate less severe system failures or 'near misses', and are used to assess how frequently the system comes close to severe failure. Because they are typically more numerous than outcome indicators, they can be used for trend monitoring.

(c) Safety management system

In the case of a complex air traffic services provider, the SMS should include all of these measures. Risk management efforts, however, should be targeted at leading indicators and precursor events. The reason for doing this is to reduce the number of accidents and serious incidents.

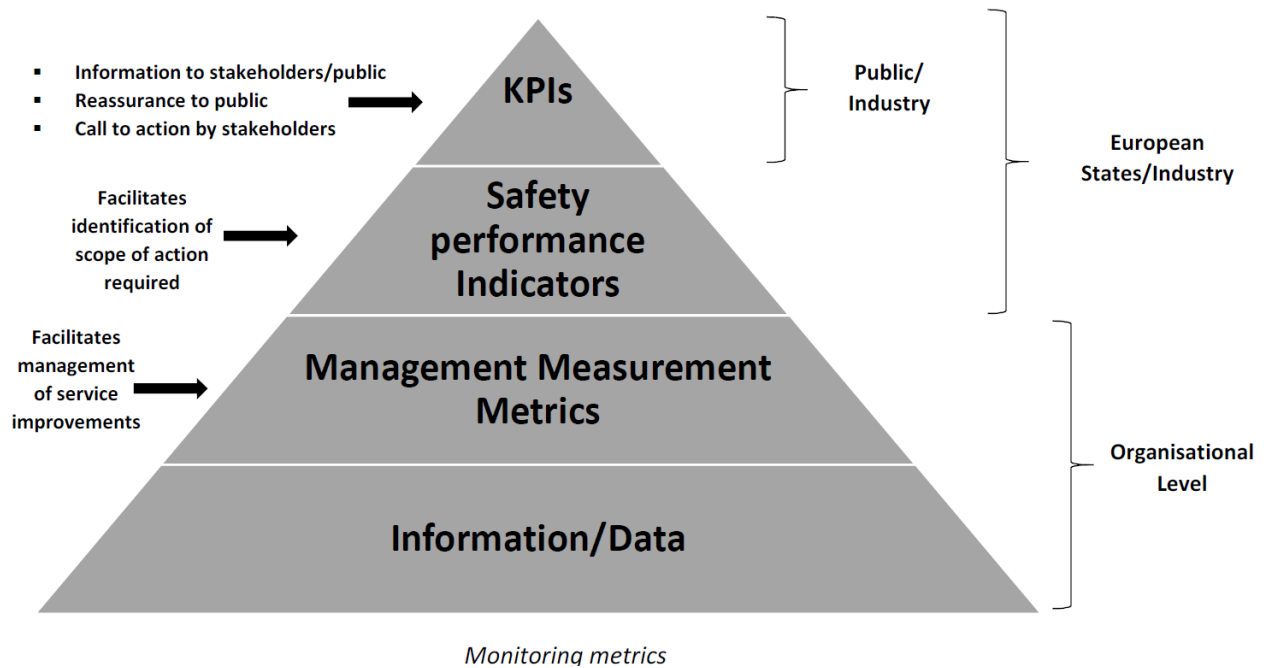
(d) Differing levels of safety performance monitoring

- (1) Measurements of safety in terms of undesirable events, such as accidents and incidents, are examples of 'lagging indicators', which can capture safety performance a posteriori. Such indicators give valuable signals to all involved in air traffic services — providers, regulators, and recipients — of the levels of safety being experienced and of the ability of the organisations concerned to take appropriate mitigation action.

However, other types of measurement — 'leading indicators' — can give a wider perspective of the safety 'health' of the functional system, and focus on systemic issues, such as safety maturity and SMS performance.

- (2) A holistic approach to performance monitoring is an essential input to decision-making with regard to safety. It is important to ensure that good safety performance is attributable to good performance of the SMS, not simply to lack of incidents or accidents. It is also essential that the metrics chosen match the requirements of the stakeholders and decision-makers involved in safety improvement.

- (3) As shown in the diagram, stakeholders in the wider aviation industry and the general public require relatively small numbers of safety indicators (safety performance indicators or key performance indicators) which can give an instant ‘feel’ for the overall position regarding safety performance. Conversely, those involved in the management of services concerned need a more detailed set of metrics on which to base decisions regarding the management of the services and facilities being reviewed.



AMC1 ATS.OR.200(3)(iii) Safety management system

CONTINUOUS IMPROVEMENT OF THE SMS — COMPLEX ATS PROVIDERS

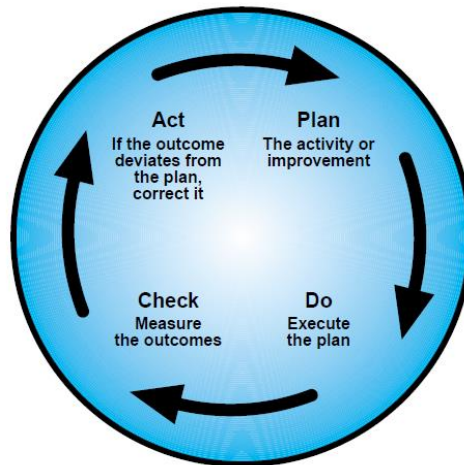
An air traffic services provider should continuously improve the effectiveness of its SMS by:

- (a) developing and maintaining a formal process to identify the causes of substandard performance of the SMS;
- (b) establishing one or more mechanisms to determine the implications of substandard performance of the SMS;
- (c) establishing one or more mechanisms to eliminate or mitigate the causes of substandard performance of the SMS; and
- (d) developing and maintaining a process for the proactive evaluation of facilities, equipment, documentation, processes and procedures (through internal audits, surveys, etc.).

GM1 ATS.OR.200(3)(iii) Safety management system

CONTINUOUS IMPROVEMENT OF THE SMS — COMPLEX ATS PROVIDERS

- (a) Substandard performance of the SMS can manifest itself in two ways. Firstly, where the SMS processes themselves do not fit their purpose (e.g. not adequately enabling the air traffic services provider to identify, manage and mitigate hazards and their associated risks) resulting in the safety performance of the service being impacted in a negative way. Secondly, where the SMS processes fit their purpose, but are not applied correctly or adequately by the personnel whose safety accountabilities and responsibilities are discharged through the application of the SMS. Personnel who have safety accountabilities and responsibilities are considered an essential part of the effectiveness of the SMS and viewed as part of the SMS.
- (b) Therefore, by detecting substandard performance of the SMS, the air traffic services provider can take action to improve the SMS processes themselves or to improve the application of the SMS processes by those with safety accountabilities and responsibilities resulting in an improvement to the safety performance.
- (c) Continuous improvement of the effectiveness of the safety management processes can be achieved through:
- (1) proactive and reactive evaluations of facilities, equipment, documentation, processes and procedures through safety audits and surveys; and
 - (2) reactive evaluations in order to verify the effectiveness of the system for control and mitigation of risks.
- (d) In the same way that continuous improvement is sought through safety performance monitoring and measurement (see GM1 ATM/ANS.OR.B.005(a)(3) and GM1 ATS.OR.200(a)(3)(i)) by the use of leading and lagging indicators, continuous improvement of the SMS provides the air traffic services provider with safety assurance for the service.
- (e) As with safety performance monitoring, the continuous improvement of the SMS lends itself to a process that can be summarised as:
- (1) Identify where there are potential weaknesses or opportunities for improvement;
 - (2) Identify what goes right and disseminate as best practice;
 - (3) Identify what can be done to tackle weaknesses or lead to improvement;
 - (4) Set performance standards for the actions identified;
 - (5) Monitor performance against the standards;
 - (6) Take corrective actions to improve performance; and
 - (7) Repeat the process by using the continuous improvement model below:



- (f) Taking into account that the SMS is being required to manage safety, it can be assumed that by continuously improving the effectiveness of the SMS, ATS providers should be able to better manage and mitigate, and ultimately control the safety risks associated with the provisions of their services.

AMC1 ATS.OR.200(4)(i) Safety management system

TRAINING AND COMMUNICATION — COMPLEX ATS PROVIDERS

(a) Training

- (1) All personnel should receive safety training as appropriate for their safety responsibilities.
- (2) Adequate records of all safety training provided should be kept.

(b) Communication

- (1) The ATS provider should establish communication about safety matters that:
 - (a) ensures that all personnel are aware of the safety management activities as appropriate for their safety responsibilities;
 - (b) conveys critical information, especially relating to assessed risks and analysed hazards;
 - (c) explains why particular actions are taken; and
 - (d) explains why safety procedures are introduced or changed.
- (2) Regular meetings with personnel where information, actions and procedures are discussed, may be used to communicate safety matters.

GM1 ATS.OR.200(4)(i) Safety management system

TRAINING — COMPLEX ATS PROVIDERS

The safety training programme may consist of self-instruction (e.g. newsletters, flight safety magazines), classroom training, e-learning or similar training provided by training organisations.

GM1 ATS.OR.205(a)(1) Safety assessment and assurance of changes to the functional system

GENERAL

- (a) The safety assessment should be conducted by the air traffic services provider itself. It may also be carried out by another organisation, on its behalf, provided that the responsibility for the safety assessment remains with the air traffic services provider.
- (b) A safety assessment needs to be performed when a change affects a part of the functional system managed by the provider of air traffic services and that is being used in the provision of its (air traffic) services. The safety assessment or the way it is conducted does not depend on whether the change is a result of a business decision or a decision to improve safety.

GM2 ATS.OR.205(a)(1) Safety assessment and assurance of changes to the functional system

SCOPE OF THE CHANGE

- (a) The description of the elements being changed includes the nature, functionality, location, performance, maintenance tasks, training and responsibilities of these elements, where applicable. The description of interfaces and interactions, between machines and between humans and machines, should include communication means, e.g. language, phraseology, protocol, format, order and timing and transmission means, where applicable. In addition, it includes the description of the context in which they operate.
- (b) There are two main aspects to consider in evaluating the scope of a change:
 - (1) The interactions within the changed functional system;
 - (2) The interactions within the changing functional system, i.e. those that occur during transitions from the current functional system to the changed functional system. During such transitions, components are replaced/installed in the functional system. These installation activities are interactions within the changing functional system and are to be included within the scope of the change.

As each transition can be treated as a change to the functional system, the identification of both the above has a common approach described below.

- (c) The scope of the change is defined as the set of the changed components and affected components. In order to identify the affected components and the changed components, it is necessary to:
 - (1) know which components will be changed;
 - (2) know which component's (components') behaviour might be directly affected by the changed components, although it is (they are) not changed itself (themselves);
 - (3) detect indirectly affected components by identifying:
 - (i) new interactions introduced by the changed or directly affected components; and/or
 - (ii) interactions with changed or directly affected components via the environment.
 - (4) Furthermore, directly and indirectly affected components will be identified as a result of applying the above iteratively to any directly and indirectly affected components that have been identified previously.

The scope of the change is the set of changed, directly impacted and indirectly impacted components identified when the iteration identifies no new components.

- (d) The context in which the changed service is intended to operate (see ATS.OR.205(a)(1)(iii)) includes the interface through which the service will be delivered to its users.

GM3 ATS.OR.205(a)(1) Safety assessment and assurance of changes to the functional system

TRAINING

If the change modifies the way people interact with the rest of the functional system, then a training might be required before the change becomes operational. Care should be taken when training operational staff before the change is operational, as the training may change the behaviour of the operational staff when they interact with the existing functional system before any other part of the change is made, and so may have to be treated as a transitional stage of the change.

For example, as a result of training, air traffic controllers (ATCOs) may come to expect information or alerts to be presented differently. People may also need refreshment training periodically in order to ensure that their performance does not degrade over time. The training needed before operation forms part of the design of the change, while the refreshment training is part of the maintenance of the functional system after the change is in operation.

GM4 ATS.OR.205(a)(1) Safety assessment and assurance of changes to the functional system

DESCRIPTION OF THE SCOPE — ‘MULTI-ACTOR CHANGE’

In reference to ‘multi-actor change’, please refer to GM1 ATM/ANS.OR.C.005(b)(1) Safety support assessment and assurance of changes to the functional system.

GM1 ATS.OR.205(a)(1)(iii) Safety assessment and assurance of changes to the functional system

INTERACTIONS

The identification of changed interactions is necessary in order to identify the scope of the change because any changed behaviour in the system comes about via a changed interaction. Changed interaction happens via an interaction at an interface of the functional system and the context in which it operates. Consequently, identification of both interfaces and interactions is needed to be sure that all interactions have identified interfaces and all interfaces have identified interactions. From this, all interactions and interfaces that will be changed can be identified.

AMC1 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system

FORM OF ASSURANCE

The air traffic services provider should ensure that the assurance required by ATS.OR.205(a)(2) is documented in a safety case.

AMC2 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system

COMPLETENESS OF THE ARGUMENT

The argument should be considered complete when it shows, as applicable, that:

- (a) the safety assessment in ATS.OR.205(b) has produced a sufficient set of non-contradictory valid safety criteria;
- (b) safety requirements have been placed on the elements changed and on those elements affected by the change;
- (c) the safety requirements as implemented meet the safety criteria;

- (d) all safety requirements have been traced from the safety criteria to the level of the architecture at which they have been satisfied;
- (e) each component satisfies its safety requirements;
- (f) each component operates as intended, without adversely affecting the safety; and
- (g) the evidence is derived from known versions of the components and the architecture and known sets of products, data and descriptions that have been used in the production or verification of those versions.

GM1 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system

SAFETY CRITERIA

'Safety criteria will remain satisfied' means that the safety criteria continue to be satisfied after the change is implemented and put into operation. The safety case needs to provide assurance that the monitoring requirements of ATS.OR.205(b)(6) are suitable for demonstrating, during operation, that the safety criteria remain satisfied and, therefore, the argument remains valid.

GM2 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system

ASSURANCE LEVELS

The use of assurance level concepts, e.g. design assurance levels (DAL), software assurance levels (SWAL), hardware assurance levels (HWAL), can be helpful in generating an appropriate and sufficient body of evidence to help establish the required confidence in the argument.

GM3 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system

SAFETY REQUIREMENTS

The following non-exhaustive list contains examples of safety requirements that specify:

- (a) for equipment, the complete behaviour, in terms of functions, accuracy, timing, order, format, capacity, resource usage, robustness to abnormal conditions, overload tolerance, availability, reliability, confidence and integrity;

The complete behaviour is limited to the scope of the change. Safety requirements should only apply to the parts of a system affected by the change. In other words, if parts of a system can be isolated from each other and only some parts are affected by the change, then these are the only parts that are of concern;
- (b) for people, their performance in terms of tasks (e.g. accuracy, response times, acceptable workload, reliability, confidence, skills, and knowledge in relation to their tasks);
- (c) for procedures, the circumstances for their enactment, the resources needed to perform the procedure (i.e. people and equipment), the sequence of actions to be performed and the timing and accuracy of the actions; and
- (d) interactions between all parts of the system.

GM1 to AMC2 ATS.OR.205(a)(2) Safety assessment and assurance of changes to the functional system
COMPLETENESS OF THE ARGUMENT

(a) Sufficiency of safety criteria

- (1) A sufficient set of safety criteria is one where the safety goal of the change is validly represented by the set of individual safety criteria, each criterion of which must be valid in its own right and not contradict another criterion or any other subset of criteria. A valid criterion is a correct, complete and unambiguous statement of the desired property. An individual valid criterion does not necessarily represent a complete safety criterion. An example of an invalid criterion is that the maximum take-off weight must not exceed 225 Tonnes because weight is measured in Newtons and not in Tonnes. An example of an incomplete criterion is that the accuracy must be 5 m because no reliability attribute is present. This implies it must always be within 5 m, which is impossible in practice.
- (2) Optimally, a sufficient set of criteria would consist of the minimum set of non-overlapping valid criteria and it is preferable to a set containing overlapping criteria.
- (3) Criteria that are not relevant, i.e. ones that do not address the safety goal of the change at all, should be removed from the set as they contribute nothing, may contradict other valid criteria and may serve to confuse.
- (4) There are two forms of overlap: complete overlap and partial overlap.
 - (i) In the first case, one or more criteria can be removed and the set would remain sufficient, i.e. there are unnecessary criteria.
 - (ii) In the second case, (partially overlapping criteria) if any criterion were to be removed, the set would not be sufficient. Consequently, all criteria are necessary; however, validating the set would be much more difficult. Showing that a set of criteria with significant overlap do not contradict each other is extremely difficult and consequently prone to error.
- (5) It may, in fact, be simpler to develop an architecture that supports non-overlapping criteria than to attempt to validate a partially overlapping set of criteria.

(b) Safety requirements

- (1) The safety requirements are design characteristics/items of the functional system to ensure that the system operates as specified. Based on the verification/demonstration of these characteristics/items, it could be concluded that the safety criteria are met.
- (2) The highest layer of safety requirements represents the desired safety behaviour of the change at its interface with the operational context.
- (3) In almost all cases, verification that a system behaves as specified cannot be accomplished, to an acceptable level of confidence, at the level of its interface with its operational environment. To this end, the system verification should be decomposed into verifiable parts, taking into account the following principles:
 - (i) Verification relies on requirements placed on these parts via a hierarchical decomposition of the top level requirements, in accordance with the constraints imposed by the chosen architecture.

- (ii) At the lowest level, this decomposition places requirements on elements, where verification that the implementation satisfies its requirements can be achieved by testing.
 - (iii) At higher levels in the architecture, during integration, verified elements of different types are combined into subsystems/components, in order to verify more complete parts of the system.
 - (iv) While they cannot be fully tested, other verification techniques may be used to provide sufficient levels of confidence that these subsystems/components do what they are supposed to do.
 - (v) Consequently, since decomposing the system into verifiable parts relies on establishing requirements for those parts, then safety requirements are necessary.
- (4) The architecture may not have requirements. During development, the need to argue satisfaction of safety criteria, which cannot be performed at the system level for any practical system, drives the architecture because verifiability depends on the decomposition of the system into verifiable parts.
- (c) Satisfaction of safety criteria
- (1) The concept laid down in AMC2 ATS.OR.205(a)(2) is that, provided each element meets its safety requirements, the system will meet its safety criteria. This will be true provided (2) and (3) below are met.
 - (2) The activity needed to meet this objective consists of obtaining sufficient confidence that the set of safety requirements is complete and correct, i.e. that:
 - (i) the architectural decomposition of the elements leads to a complete and correct set of safety requirements being allocated to each sub-element;
 - (ii) each safety requirement is a correct, complete and unambiguous statement of the desired behaviour and does not contradict another requirement or any other subset of requirements; and
 - (iii) the safety requirements allocated to an element necessitate the complete required safety behaviour of the element in the target environment.
 - (3) This should take into account specific aspects such as:
 - (i) the possible presence of functions within the element that produce unnecessary behaviour. For instance, in the case where a previously developed element is used, activities should be undertaken to identify all the possible behaviours of the element. If any of these behaviours is not needed for the foreseen use, then additional requirements may be needed to make sure that these functions will not be solicited or inadvertently activated in operation or that the effects of any resulting behaviour are mitigated;
- (d) other requirements that are not directly related to the desired behaviour of the functional system. These requirements often relate to technical aspects of the system or its components. Activities should ensure that each of these requirements does not compromise the safety of the system, i.e. does not contradict the safety requirements or criteria.

(e) Traceability of requirements

The traceability requirement can be met by tracing to the highest-level element in the architectural hierarchy that has been shown to satisfy its requirements, by verifying it in isolation.

(f) Satisfaction of safety requirements

- (1) The component view taken must be able to support verification, i.e. the component must be verifiable.
- (2) Care should be taken in selecting subsystems that are to be treated as components for verification to ensure that they are small and simple enough to be verifiable.

(g) Adverse effects on safety

- (1) Interactions of all changed components or components affected by the change, operating in their defined context, have to be identified and assessed for safety in order to be able to show that they do not adversely affect safety. This assessment must include the failure conditions for all components and the behaviour of the services delivered to the component including failures in those services.
- (2) Interactions between changing components, as they are installed during transitions into operation, and the context in which they operate have to be identified and assessed for safety in order to be able to show that they do not adversely affect safety. This assessment must include the failure conditions for all installation activities.

In some cases, installing components during transition into operation may cause disruption to services other than the one being changed. These services fall within the scope of the change (see GM1 ATM/ANS.OR.A.045(c); (d)), and consequently the safety effects failures of these services, due to failures of the installation activities, have to be assessed as well and, if necessary, their impacts mitigated.

- (3) Interactions in complex systems are dealt with in ATM/ANS.OR.A.045(e)(1).

(h) Configuration identification

- (1) AMC2 ATS.OR.205(a)(2), point (f) is only about configuration of the evidence and should not be interpreted as configuration management of the changed functional system. However, since the safety case is based on a set of elements and the way they are joined together, the safety case will only be valid if the configuration remains as described in the safety case.
- (2) Evidence for the use of a component should rely on testing activities considering the actual usage domains and contexts. When the same component is used in different parts of the system or in different systems, it may not be possible to rely on testing in a single context since it is unlikely that the contexts for each use will be the same or can be covered by a single set of test conditions. This applies equally to the reuse of evidence gathered from testing subsystems.

GM1 ATS.OR.205(b) Safety assessment and assurance of changes to the functional system

SAFETY ASSESSMENT METHODS

- (a) The air traffic services provider can use a standard safety assessment method or it can use its own safety assessment method to assist with structuring the process. However, the application of a method is not a guarantee of the quality of the results. It is therefore not sufficient for a safety case to claim that the assurance provided is adequate due to compliance with a standard or method.
- (b) There are databases available that describe different safety assessment methods, tools and techniques² that can be used by the air traffic services provider. The provider must ensure that the safety assessment method is adequate for the change being assessed and that the assumptions inherent in the use of the method are recognised and accommodated appropriately.

AMC1 ATS.OR.205(b)(1) Safety assessment and assurance of changes to the functional system

COMPLETENESS OF HAZARD IDENTIFICATION

The air traffic services provider should ensure that hazard identification:

- (a) targets complete coverage of any condition, event, or circumstance related to the change, which could, individually or in combination, induce a harmful effect;
- (b) has been performed by personnel trained and competent for this task; and
- (c) need only include hazards that are generally considered as credible.

AMC2 ATS.OR.205(b)(1) Safety assessment and assurance of changes to the functional system

HAZARDS TO BE IDENTIFIED

The following hazards should be identified:

- (a) New hazards, i.e. those introduced by the change relating to the:
 - (1) failure of the functional system; and
 - (2) normal operation of the functional system; and
- (b) Already existing hazards that are affected by the change and are related to:
 - (1) the existing parts of the functional systems; and
 - (2) hazards outside the functional system, for example, those inherent to aviation.

² For example, <http://www.nlr.nl/downloads/safety-methods-database.pdf> or <http://www.scsc.org.uk/>

GM1 ATS.OR.205(b)(1) Safety assessment and assurance of changes to the functional system**HAZARD IDENTIFICATION****(a) Completeness of hazard identification**

In order to achieve completeness in the identification of hazards, it might be beneficial to aggregate hazards and to formulate them in a more abstract way, e.g. at the service level. This might in turn have drawbacks when analysing and evaluating the risk of the hazards. The appropriate level of detail in the set of hazards and their formulation, therefore, depends on the change and the way the safety assessment is executed.

Only credible hazards need to be identified. A credible hazard is one that has a material effect on the risk assessment. A hazard will not be considered credible when it is either highly improbable that the hazard will occur or that the accident trajectories it initiates will materialise. In other words, a hazard need not be considered if it can be shown that it induces an insignificant risk.

(b) Sources of hazards

(1) Hazards introduced by failures or nominal operations of the ATM/ANS functional systems may include the following factors and processes:

- (i) design factors, including equipment, procedural and task design;
- (ii) operating practices, including the application of procedures under actual operating conditions and the unwritten ways of operating;
- (iii) communications, including means, terminology, order, timing and language and including human–human, human–machine and machine–machine communications;
- (iv) installation issues;
- (v) equipment and infrastructure, including failures, outages, error tolerances, nuisance alerts, defect defence systems and delays; and
- (vi) human performance, including restrictions due to fatigue and medical conditions, and physical limitations, when considered relevant to the change assessment.

(2) Hazards introduced in the context in which the ATM/ANS functional system operates may include the following factors and processes:

- (i) wrong, insufficient or delayed information and inadequate services delivered by third parties;
- (ii) personnel factors, including working conditions, company policies for and actual practice of recruitment, training and allocation of resources, when considered relevant to the change;
- (iii) organisational factors, including the incompatibility of production and safety goals, the allocation of resources, operating pressures and the safety culture;
- (iv) work environment factors such as ambient noise, temperature, lighting, annoyance, ergonomics and the quality of man–machine interfaces; and
- (v) external threats such as fire, electromagnetic interference and sources of distraction, when considered relevant to the change.

(3) The hazards introduced in the context in which the ATM/ANS services are delivered may include the following factors and processes:

- (i) errors, failures, non-compliance and misunderstandings between the airborne and ground domains;
 - (ii) traffic complexity, including traffic growth, fleet mix and different types of traffic, when considered relevant to the change;
 - (iii) wrong, insufficient or delayed information delivered by third parties;
 - (iv) inadequate service provisioning by third parties; and
 - (v) external physical factors, including terrain, weather phenomena, volcanoes and animal behaviour, when considered relevant to the change.
- (c) Methods to identify hazards
- (1) The air traffic services provider may use a combination of tools and techniques, including functional analysis, what if techniques, brainstorming sessions, expert judgement, literature search (including accident and incident reports), queries of accident and incident databases in order to identify hazards.
 - (2) The air traffic services provider needs to make sure that the method is appropriate for the change and produces (either individually or in combination) a valid (necessary and sufficient) set of hazards. This may be aided by drawing up a list of the functions associated with part of the functional system being changed. The air traffic services provider needs to make sure their personnel that use these techniques are appropriately trained to apply these methods and techniques.

AMC1 ATS.OR.205(b)(2) Safety assessment and assurance of changes to the functional system
 DETERMINATION OF THE SAFETY CRITERIA FOR THE CHANGE

When determining the safety criteria for the change being assessed, the air traffic services provider should, in accordance with ATS.OR.210, ensure that:

- (a) the safety criteria support a risk analysis that is:
 - (1) relative or absolute, i.e. refers to:
 - (i) the difference in safety risk of the system due to the change (relative); or
 - (ii) the difference in safety risk of the system and a similar system (can be absolute or relative); and
 - (iii) the safety risk of the system after the change (absolute); and
 - (2) objective, whether risk is expressed numerically or not;
- (b) the safety criteria are measurable to an adequate degree of certainty;
- (c) the set of safety criteria can be represented totally by safety risks, by other measures that relate to safety risk or a mixture of safety risks and these other measures;
- (d) the set of safety criteria should cover the change; the safety criteria selected are consistent with the overall safety objectives established by the air traffic services provider through its SMS and represented by its annual and business plan and safety key performance indicators; and
- (e) where a safety risk or a proxy cannot be compared against its related safety criteria with acceptable certainty, the safety risk should be constrained and actions should be taken, in the long term, so as to manage safety and ensure that the air traffic services provider's overall safety objectives are met.

AMC1 ATS.OR.205(b)(3) Safety assessment and assurance of changes to the functional system**COMPLETENESS OF RISK ANALYSIS**

The air traffic services provider should ensure that the risk analysis is carried out by personnel trained and competent to perform this task and should also ensure that:

- (a) a complete list of harmful effects in relation to the identified:
 - (1) hazards, when the safety criteria are expressed in terms of safety risk, or proxies, when the safety criteria are expressed in relation to proxies; and
 - (2) hazards introduced due to implementation is produced; and
- (b) the risk contributions of all hazards and proxies are evaluated; and
- (c) risk analysis is conducted in terms of risk or in terms of proxies or a combination of them, using specific measurable properties that are related to operational safety risk; and
- (d) results can be compared against the safety criteria.

AMC2 ATS.OR.205(b)(3) Safety assessment and assurance of changes to the functional system**SEVERITY CLASSIFICATION OF ACCIDENTS LEADING TO HARMFUL EFFECTS**

When performing a risk analysis in terms of risk, the air traffic services provider should ensure that the harmful effects of all hazards are allocated a safety severity category and that, where there is more than one safety severity category of harm, any severity classification scheme satisfies the following criteria:

- (a) The scheme is independent of the causes of the accidents that it classifies, i.e. the severity of the worst accident does not depend upon whether it was caused by an equipment malfunction or human error;
- (b) The scheme permits unique assignment of every harmful effect to a severity category;
- (c) The severity categories are expressed in terms of a single scalar quantity and in terms relevant to the field of their application;
- (d) The level of granularity (i.e. the span of the categories) is appropriate to the field of their application;
- (e) The scheme is supported by rules for assigning a harmful effect unambiguously to a severity category; and
- (f) The scheme is consistent with the air traffic services providers views of the severity of the harmful effects covered and can be shown to incorporate societal views of their severity.

AMC1 ATS.OR.205(b)(4) Safety assessment and assurance of changes to the functional system**RISK EVALUATION**

The air traffic services provider should ensure that the risk evaluation includes:

- (a) an assessment of the identified hazards for a notified change, including possible mitigation means, in terms of risk or in terms of proxies or a combination of them;
- (b) a comparison of the risk analysis results against the safety criteria taking the uncertainty of the risk assessment into account; and
- (c) the identification of the need for risk mitigation or reduction in uncertainty or both.

AMC2 ATS.OR.205(b)(4) Safety assessment and assurance of changes to the functional system**RISK MITIGATION**

When the risk evaluation results show that the safety criteria cannot be satisfied, then the air traffic services provider should either abandon the change or propose additional means of mitigating the risk. If risk mitigation is proposed, then the air traffic services provider should ensure that it identifies:

- (a) all of the elements of the functional system, e.g. training, procedures that need to be reconsidered; and
- (b) for each part of the amended change, those parts of the safety assessment (requirements from (a) to (f)) that need to be repeated in order to demonstrate that the safety criteria will be satisfied.

GM1 ATS.OR.205(b)(4) Safety assessment and assurance of changes to the functional system**RISK ANALYSIS IN TERMS OF SAFETY RISK**

(a) Risk analysis

When a risk assessment of a set of hazards is executed, in terms of risk:

- (1) the frequency or probability of the occurrence of the hazard should be determined;
- (2) the possible sequences of events from the occurrence of a hazardous event to the occurrence of an accident, which may be referred to as accident trajectories, should be identified. The contributing factors and circumstances that distinguish the different trajectories from one another should also be identified, as should any mitigations between a hazardous event and the associated accident;
- (3) the potential harmful effects of the accident, including those resulting from a simultaneous occurrence of a combination of hazards, should be identified;
- (4) the severity of these harmful effects should be assessed, using a defined severity scheme according to point (f) of AMC2 ATS.OR.205(b)(3); and
- (5) the risk of the potential harmful effects of all the accidents, given the occurrence of the hazard, should be determined, taking into account the probabilities that the mitigations may fail as well as succeed, and that particular accident trajectories will be followed when particular contributing factors and circumstances occur.

(b) Severity schemes

The severity determination should take place according to a severity classification scheme.

The purpose of a severity classification scheme is to facilitate the management and control of risk. A severity class is, in effect, a container within which accidents can be placed if their severities are considered similar. Each container can be given a value which represents the consequences, i.e. small for accidents causing little harm and big for accidents causing a lot of harm. The sum of the probabilities of all the accidents assigned to a severity class multiplied by the value that is related to the severity class, is the risk associated with that class. If the value that represents severity for all classes is scalar, then the total risk is the sum of the risks in each severity class.

(1) Single-risk value severity schemes

Such schemes use a single severity category to represent harm to humans. Other categories representing other kinds of harm e.g. damage to aircraft and loss of separation, may be present but do not represent harm to humans. In these circumstances, risk analysis would actually be reduced to frequency/probability analysis.

(2) Multiple-risk value severity schemes

Multiple-risk value severity schemes, which use a number of severity categories to classify different levels of harm, facilitate the management and control of risk in a number of ways. At the simplest level, the distribution of accidents across the severity classes gives a picture of whether the risk profile of a system is well balanced. For example, many accidents in the top and bottom severity classes with few in between suggests an imbalance in risk, perhaps due to an undue amount of attention having been paid to some types of accident at the expense of others. More detailed management and control of risk includes:

- (i) Severity classes may be used as the basis for reporting accident statistics.
 - (ii) Severity classes combined with frequency (or probability) classes can be used to define criteria for decision-making regarding risk acceptance.
 - (iii) The total risk associated with one or more severity classes can be managed and controlled. For example, the sum of the risk from all severity classes represents the total risk and may be used as a basis for making decisions about changes.
 - (iv) Similarly, the risk associated with accident types of different levels of severity can be compared. For example, comparing runway infringement accidents with low speed taxiway accidents would allow an organisation to focus their efforts on mitigating the accident type with greatest risk.
- (c) The air traffic services provider should coordinate its severity scheme(s) when performing multi-actor changes to ensure adequate assessment. This includes coordination with air traffic services providers outside of the EU.

GM1 to AMC1 ATS.OR.205(b)(4) Safety assessment and assurance of changes to the functional system
RISK ANALYSIS IN TERMS OF PROXIES — EXAMPLES

Point (c) of AMC1 ATS.OR.205(b)(2) allows safety assessment to be performed in terms of risk, proxies or a combination of risk and proxies. This GM provides two examples to illustrate the use of proxies in safety analysis.

(a) Use of proxies when assessing the safety of a wind farm installation

- (1) A wind farm is to be introduced on or near an aerodrome. It is assumed that before the introduction of the wind farm, the safety risk of the air traffic services being provided at the aerodrome was acceptable. To return to this level after the introduction of the farm, the change would also be acceptable.

A diagram showing the effects this has on the risk at the aerodrome is shown below:

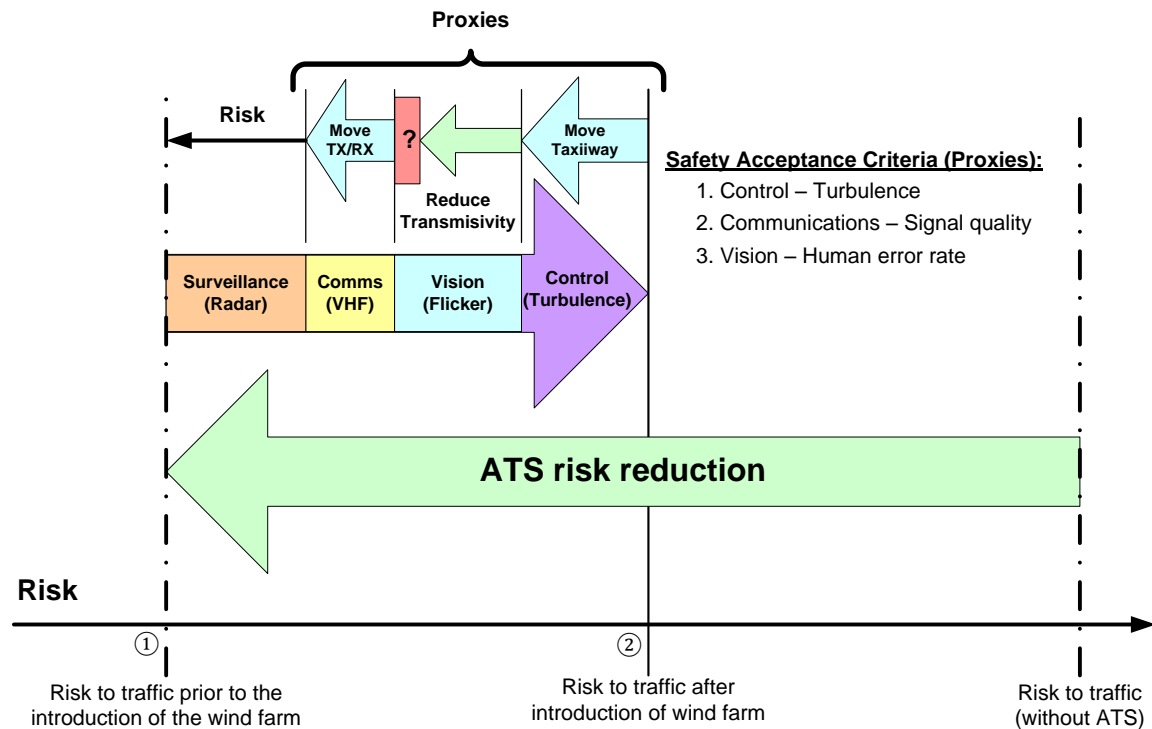


Figure 1: Evaluation of risks after the introduction of wind farm

- (2) The risk due to the introduction of the wind farm will rise from ① to ②, if not mitigated, because:
- (i) turbulence will increase and so may destabilise manoeuvring of aircraft;
 - (ii) the movement of the blades will cause radio interference (communications radio and surveillance radar) and so communications may be lost or aircraft may be hidden from view on the radar screen; and
 - (iii) the flicker in the peripheral vision of ATCOs, caused by the rotation of the blades, may capture attention and increase their perception error rate.
- (3) The problem of analysing the safety impact can be split into these areas of concern since they do not interact or overlap and so satisfy the independence criterion (b) of AMC2 ATS.OR.210(a). However, whilst it can be argued that each is a circumstantial hazard and that in each case a justifiable qualitative relationship can be established linking the hazard with the resulting accident (so satisfying the causality criterion (a) of AMC2 ATS.OR.210(a)), the actual or quantitative logical relationship is, in each case, extremely difficult to determine. Conditions for seeking proxies have, therefore, been established:
- Performing a risk evaluation using actual risk may not be worthwhile due to the considerable cost and effort involved; and
 - The first two criteria for proxies have been satisfied.
- Consequently, it may be possible to find proxies that can be used more simply and effectively than performing an analysis based on risk.
- (4) The solutions proposed below are for illustrative purposes only. There are many other solutions and, for each change, several should be investigated. In this example, the following proxies, which satisfy the measurability criterion (c) of AMC2 ATS.OR.210(a), are used to set safety criteria:

- (i) Turbulence can be measured and predicted by models so the level of turbulence can be a proxy.

In this example, let's assume the only significant effect of turbulence is to light aircraft using a particular taxiway. It is possible to predict the level of turbulence at different sites on the aerodrome and an alternative taxiway is found where the level of turbulence after the introduction of the wind farm will be less than that currently encountered on the present taxiway. This can be confirmed during operation after the change by monitoring.

- (ii) Signal quality can be also be predicted by models and measured so it can be used as a proxy.

In this example, it is possible to move the communications transmitter and receiver aerials so that communications are not affected by interference. Sites can be found using modelling and the signal quality confirmed prior to moving the aerials by trial installations during periods when the aerodrome is not operating.

- (iii) Human error rate in detecting events on the manoeuvring area can be measured in simulations and can be used as a proxy.

It is suggested that increasing the opaqueness of the glass in the control tower will reduce the effects of flicker on the ATCOs, but there is no direct relationship between the transmissivity and the effects of flicker. It is, therefore, decided to make a simulation of the control tower and measure the effects of flicker on human error rate using glass of different levels of transmissivity.

However, there is a conflict between increasing the opaqueness of the glass to reduce the effects of flicker and decreasing it to improve direct vision, which is needed so that manoeuvring aircraft can be seen clearly. In other words, the simulation predicts a minimum for the human error rate that relates to a decrease, as the effects of flicker decrease, followed by an increase, as the effects of a lack of direct vision increase. This minimum is greater than the human error rate achieved by the current system and so the risk of the wind farm, in respect of flicker, cannot be completely mitigated. This is shown by the red box with a question mark in it on the diagram.

- (5) Finally, the argument for the performance of surveillance radars is commonly performed using risk. This can be repeated in this case since the idea is to filter the effects of the interference without increasing the risk. Moreover, if necessary, a system may be added (or a current one improved) to reduce the risk simply and economically and the effects of the additional system may be argued using risk.
- (6) Since risks can be combined, the safety impacts of the changes to the surveillance radar by filtering the effects of the interference together with the addition of another system or the improvement of the current system can be established by summing the risks associated with these two kinds of change.
- (7) In these circumstances, it is not possible to argue objectively that the risk of introducing the wind farm has been mitigated, as risks cannot be summed with proxies. This demonstrates the difficulties of using proxies. However, it may be possible to argue convincingly, albeit subjectively, that installing another system or improving the current system improves the current level of risk by a margin large enough to provide adequate compensation for the unmitigated effects of flicker.

(8) In summary, this example shows how proxies and risks can be combined in a single assurance case to argue that a change to a functional system can be introduced safely. It also demonstrates that the strategies available to demonstrate safety are not generic, but are dependent on identifying analysable qualities or quantities related to specific properties of the system or service that are impacted by the change.

(b) Use of proxies when changing to electronic flight strips

(1) An air traffic services provider considers the introduction of a digital strip system in one of its air traffic control towers to replace the paper flight progress strips currently in use. This change is expected to have an impact on several aspects of the air traffic control service that is provided such as the controller's recollection of the progress of the flight, the mental modelling of the traffic situation and the communication and task allocation between controllers. A change of the medium, from paper to digital, might, therefore, have implications on the tower operations, and, hence, on the safety of the air traffic. The actual relation between the change of the strip medium and the risk for the traffic is, however, difficult to establish.

(2) The influence of the quantity on the risk is globally known, but cannot easily be quantified. One difficulty is that strip management is at the heart of the air traffic control operations: the set of potential sequences of events from a strip management error to an accident or incident is enormous. This set includes, for example, the loss of the call sign at the moment a ground controller needs to intervene in a taxiway conflict, and whether this results in an incident depends, for example, on the visibility. This set also includes the allocation of a wrong standard instrument departure (SID) to an aircraft, and whether this results in an accident depends, for example, on the runway configuration.

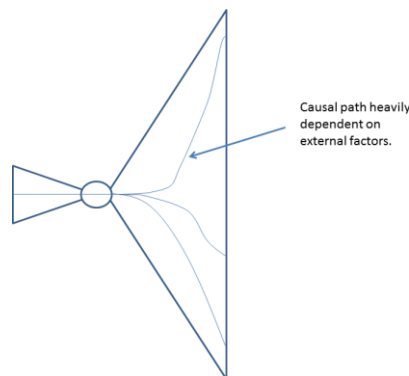


Figure 2: Notional Bow Tie Model of a strip management error

(3) The Bow Tie Model of a strip management error has, figuratively speaking, a vertically stretched right part. This expresses that a hazard — such as the loss of a single strip — may have many different outcomes which heavily depend on factors that have nothing to do with the cause of the hazard — factors such as the status of the aircraft corresponding to the absent strip, that aircraft's position on the aerodrome, the traffic situation and the visibility.

(4) Another difficulty with the relationship between the change of the medium and the risk to the air traffic is that several human and cultural aspects are involved. The difficulty lies in the largely unknown causal relationship between these human and cultural aspects and the occurrences of accidents and incidents. As an example of this, it is noted that strip manipulation — like moving a strip into another bay, or making a mark to indicate that a landing clearance is given — assists a controller in distinguishing the potential from the actual developments. The way of working with paper strips generates impressions in a wider variety than digital strips by their physical nature:

handling paper strips has tactile, auditory and social aspects. This difference in these aspects may lead to a difference in the quality of the controller’s situation awareness which may lead to a difference in the efficacy of the controller’s instructions and advisories, which may lead to a difference in the occurrence of accidents and incidents. However, the relation between the change of the medium and the risk for the air traffic is difficult to assess and would require a great deal of effort, time and experimentation to quantify.

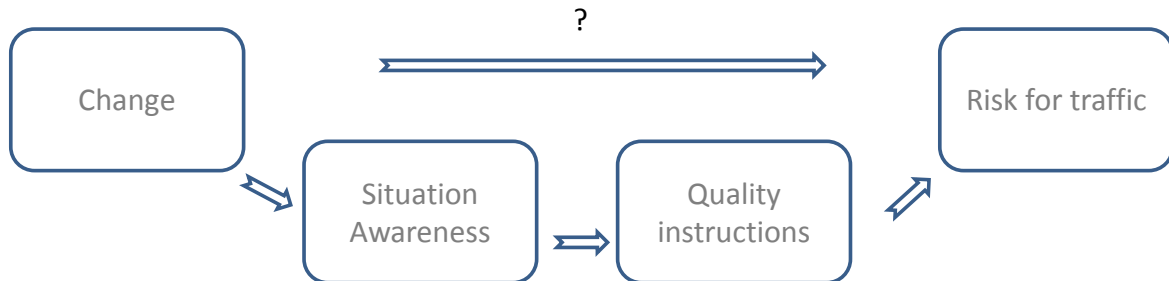


Figure 3: Relation between the change of flight strip and the risk

- (5) There is probably a relation between the change of the flight progress strip medium and the risk for air traffic: a new human–machine interface may have an effect on the situation awareness of some individual controllers in some circumstances, which might have an effect on whether, when and what instructions are given, and this in turn influences the aircraft movements, and, hence, the risks. The question by what amount risks increase or decrease is very hard to answer.
- (6) Performing a risk evaluation using actual risk may not be worthwhile due to the difficulties and considerable cost and effort involved in assessing the risk of the change directly. Therefore, the use of proxies might be preferred. A quantity is only considered an appropriate proxy if it satisfies the criteria in point AMC2 ATS.OR.210(a):
 - (i) Causality: The quantity used as proxy can be expected to be influenced by the change, and the risk can be expected to be influenced by the quantity. In addition to this causal relationship, a criterion can be formulated and agreed upon that expresses by which amount the value of the quantity may shift due to the change. Note that the influence of the proxy on the risk cannot easily be quantified, otherwise it might be more beneficial to use risk as a measure and the quantity as an auxiliary function.
 - (ii) Measurability: The influence of the change on the quantity can be assessed before as well as after the change.
 - (iii) Independence: When the proxy selected does not cover all hazards, a set of proxies should be used. Any proxy of that set should be sufficiently isolated from other proxies to be treated independently.

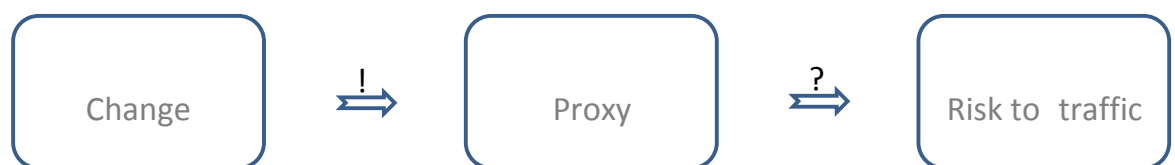


Figure 4: Relation between proxy and risk

- (7) There is a relationship between the change and the proxy, and there is a relationship between the proxy and the risk to traffic. The first relationship can be assessed (indicated by the '!'), while the

second cannot (indicated by the '?'). An acceptance criterion is typically formulated for the amount the proxy value might increase or decrease.

- (8) Proxy 1: Head-down time. The head-down time is a good proxy as it satisfies the conditions of:
- (i) Causality: It is known that more head-down time leads to a higher risk but there is no well-established or generally accepted statement in literature in terms of: 'x % more head-down time implies y% more accidents', not to mention for the specific circumstances of the specific air traffic control tower. The causal relationship indicated in Figure 4 can be established because:
 - (A) the head-down time can be expected to change as the manipulation, writing and reading of digital strips might cost more, or perhaps less, attention and effort than the handling of paper strips;
 - (B) the loss of head-up time of ground and runway controllers implies less surveillance, at least less time for the out-of-the-window-view in good visibility, and this implies a later or less probable detection of conflicts; and
 - (C) an example of an acceptance criterion reads: 'The introduction of the digital strip system does not lead to a significant increase in the head down time'.
 - (ii) Measurability: The influence of the change on the head-down time can be assessed before the change by means of real-time human-in-the-loop experiments in which controllers are tasked to handle equal amounts of traffic in equal circumstances, one time using paper strips and another time using digital strips. The percentage of head-down time can then be determined by observing the controllers by cameras and eye-trackers.
- (9) Proxy 2: Fraction of erroneous SID allocations. The fraction of erroneous SID allocations is a good proxy as it satisfies the conditions of:
- (i) Causality: It can be imagined that an erroneous SID selected in the flight management system (FMS) might lead to accidents, but the precise conditional probability is small and difficult to estimate as it depends on several external factors such as the flight paths of the correct and incorrect SIDs, the presence of other traffic, the timing and geometry of the trajectories, the cloud base or the vigilance of the controller. The causal relationship indicated in Figure 4 can be established because:
 - (A) the number of incorrect SIDs indicated on electronic strips can be expected to be less than on paper strips, because of the possibilities of systematic checks with respect to runway allocation, runway configuration, SID allocation of the predecessor and destination in the flight plan;
 - (B) the allocation of an incorrect SID to an aircrew might lead to a situation in which the aircraft manoeuvres in an unanticipated way, possibly leading to a conflict with another aircraft, for example departing from a parallel runway; and
 - (C) an example of an acceptance criterion reads: 'The introduction of the digital strip system should lead to a decrease of the fraction of erroneous SID allocations of more than 20 %'.
 - (ii) Measurability: The influence of the change on the fraction of erroneous SID allocations can be assessed before the change by means of an analysis of the causes and occurrences of

such errors and the estimated efficacy of the systematic checks. The fractions can be assessed after the change by the statistics of the event reports.

- (10) Finally, the last condition of independence of proxies is also satisfied. For the purpose of this example, the proxies in (5) and (6) form a set of independent proxies that are complete, i.e. they cover all identified hazards introduced by the replacement of paper strips by a digital strip system.

AMC1 ATS.OR.205(b)(5) Safety assessment and assurance of changes to the functional system

VERIFICATION

The air traffic services provider should ensure that verification activities of the safety assessment process include verification that:

- (a) the full scope of the change is addressed throughout the whole assessment process, i.e. all the elements of the functional system or environment of operation that are changed and those unchanged elements that depend upon them and on which they depend are identified;
- (b) the way the service behaves complies with and does not contradict any applicable requirements placed on the changed service or the conditions attached to the providers certificate;
- (c) the specification of the way the service behaves is complete and correct;
- (d) the specification of the operational context is complete and correct;
- (e) the risk analysis is complete as per AMC1 ATS.OR.205(b)(3);
- (f) the safety requirements are correct and commensurate with the risk analysis;
- (g) the design is complete and correct with reference to the specification and correctly addresses the safety requirements;
- (h) the design was the one analysed; and
- (i) the implementation, to the intended degree of confidence, corresponds to that design and behaves only as specified in the given operational context.

GM1 ATS.OR.205(b)(5) Safety assessment and assurance of changes to the functional system

OUTCOME OF RISK EVALUATION

The purpose of risk evaluation is to evaluate the risk of the change and to compare that against the safety criteria with the following outcomes in mind:

- (a) A possible (desired) outcome is that the assessed risk satisfies the safety criteria. This implies that the change is assessed as sufficiently safe to implement.
- (b) Another possible outcome is that the assessed risk does not satisfy the safety criteria. This might lead to the decision to refine the risk analysis, to the decision to add mitigating means, or to the decision to abandon the change.

GM2 ATS.OR.205(b)(5) Safety assessment and assurance of changes to the functional system

RISK EVALUATION — UNCERTAINTY

- (a) The outcome of a risk analysis is uncertain due to modelling, estimates, exclusion of rare circumstances or contributing factors, incident and safety event underreporting, false or unclear evidence, different

expert opinions, etc. The uncertainty may be indicated explicitly, e.g. by means of an uncertainty interval, or implicitly, e.g. by means of a reference to the sources the estimates are based upon.

- (b) Where possible sequences of events, contributing factors and circumstances are excluded in order to simplify the risk estimate, which may be necessary to make the estimate of risks feasible, arguments and evidence justifying this should be provided in the safety case. This may result in increasing the uncertainty of the risk estimations.

GM3 ATS.OR.205(b)(5) Safety assessment and assurance of changes to the functional system

RISK EVALUATION — FORMS OF RISK EVALUATION

The risk evaluation can take several forms, even within the safety assessment of a single change, depending on the nature of the risk analysis and the safety criteria:

- (a) If a set of safety requirements has been created and can be unambiguously and directly related to the safety criteria, then the risk evaluation takes the form of justifying that these requirements satisfy the safety criteria;
- (b) If the safety criteria have been established in terms of the likelihood of the hazards and the severity of their effects, then the risk evaluation takes the form of verifying that the assessed risks satisfy the safety criteria in terms of risks; and
- (c) If the values of all relevant proxies have been determined, then the risk evaluation takes the form of verifying that these values satisfy the safety criteria in terms of proxies.

GM4 ATS.OR.205(b)(5) Safety assessment and assurance of changes to the functional system

TYPE OF RISK MITIGATION

Risk mitigation may be achieved in the following ways:

- (a) an improvement of the performance of a functional subsystem;
- (b) an additional change of the ATM/ANS functional system;
- (c) an improvement of the services delivered by third parties;
- (d) a change in the physical environment; or
- (e) any combination of the above-mentioned methods.

GM1 ATS.OR.205(b)(5)(ii) Safety assessment and assurance of changes to the functional system

VERIFICATION OF SAFETY CRITERIA

As the complete behaviour of the change is reflected in satisfying the safety criteria for the change, no safety requirements are set at system or change level. Nevertheless, safety requirements can be placed on the architecture and the components affected by the change.

AMC1 ATS.OR.205(b)(6) Safety assessment and assurance of changes to the functional system

MONITORING OF INTRODUCED CHANGE

The air traffic services provider should ensure that within the safety assessment process for a change, the monitoring criteria, that are to be used to demonstrate that the safety case remains valid during the operation of the changed functional system, are identified and documented. These criteria are specific to the change and should be such that they indicate that:

- (a) the assumptions made in the argument remain valid;
- (b) critical proxies remain as predicted in the safety case and are no more uncertain; and
- (c) other properties that may be affected by the change remain within the bounds predicted by the safety case.

GM1 ATS.OR.205(b)(6) Safety assessment and assurance of changes to the functional system

MONITORING OF INTRODUCED CHANGE

- (a) Monitoring is intended to maintain confidence in the safety case during operation of the changed functional system. At entry into service, the safety criteria become performance criteria rather than design criteria. Monitoring is, therefore, only applicable following entry into service of the change.
- (b) Monitoring is likely to be of internal parameters of the functional system that provide a good indication of the performance of the service. These parameters may not be directly observable at the service level, i.e. at the interface of the service with the operational context. For example, where a function is provided by multiple redundant resources, the availability of the function will be so high that monitoring it may not be useful. However, monitoring the availability of individual resources, which fail much more often, may be a useful indicator of the performance of the overall function.

AMC1 ATS.OR.210(a) Safety criteria

OTHER MEASURES RELATED TO SAFETY RISKS

When the air traffic services provider specifies the safety criteria with reference to another measure that relates to safety risk, it should use one or more of the following:

- (a) proxies;
- (b) recognised standards and/or codes of practice; and
- (c) the safety performance of the existing functional system or a similar system elsewhere.

AMC2 ATS.OR.210(a) Safety criteria

OTHER MEASURES RELATED TO SAFETY RISKS — PROXIES

Proxies for safety risk, used as safety criteria for those parts of the functional system affected by the change, can only be employed when:

- (a) a justifiable causal relationship exists between the proxy and the harmful effect, e.g. proxy increase/decrease causes risk increase/decrease;
- (b) a proxy is sufficiently isolated from other proxies to be treated independently; and
- (c) the proxy is measurable, quantitatively or qualitatively, to an adequate degree of certainty.

GM1 ATS.OR.210(a) Safety criteria

SAFETY CRITERIA IN TERMS OF PROXIES FOR SAFETY RISKS

- (a) In the safety assessment of functional systems, it may not always be possible or desirable to specify safety criteria in terms of quantitative values of risk. Instead, safety criteria may be defined in terms of other measures that are related to risk. These measures are called proxies and they need to meet the requirements for a proxy as stated in AMC2 ATS.OR.210(a). For examples of their use, see GM1 to AMC1 ATS.OR.205(b)(4).

- (b) A proxy is some measurable property that can be used to represent the value of something else. In the safety assessment of functional systems, the value of a proxy may be used as a substitute for a value of risk, providing it meets the requirements for a proxy as stated in AMC2 ATS.OR.210(a). Examples of proxies are the frequency of airspace infringements, runway incursions, false alert rate, head-down time, limited sight, level of situation awareness, fraction of read back errors, reduced vigilance, amount of turbulence, distraction of controller's attention, inappropriate pilot behaviour, system availability, information integrity and service continuity.

An example of the concept of using a different but specific quantity to assess an actually relevant quantity is the transposition/measure of an aircraft's altitude which is in terms of barometric pressure or the transposition/measure of an aircraft's airspeed which is in terms of dynamic pressure.

- (c) A proxy is a measure of a certain property along the causal trajectory between the hazard/event and the harmful effects of the hazard/event in question (see Figure 5). The causal relationship between the proxy and the accident must be justified in the safety case, i.e. it must satisfy AMC2 ATS.OR.210(a). This means that the accident trajectory must be modelled and analysed such that the causal relationship can be assured but without the need to evaluate the quantitative nature of this relationship. It is assumed that since the proxy lies between the hazard/event and the accident, then there is a quantitative causal relationship between the rate of the hazard/event's occurrence and the rate of the proxy's occurrence. As a consequence, the variation of values of the proxy correlates with values of the hazards/events rate of occurrence and the value of the rate at which the harmful effects occur, i.e. the accident rate, and this relationship is a monotonically increasing one. This means that when the proxy value, e.g. Proxy₁, increases/decreases, the associated risk value of the related accident, e.g. Accident₁, increases/decreases accordingly.

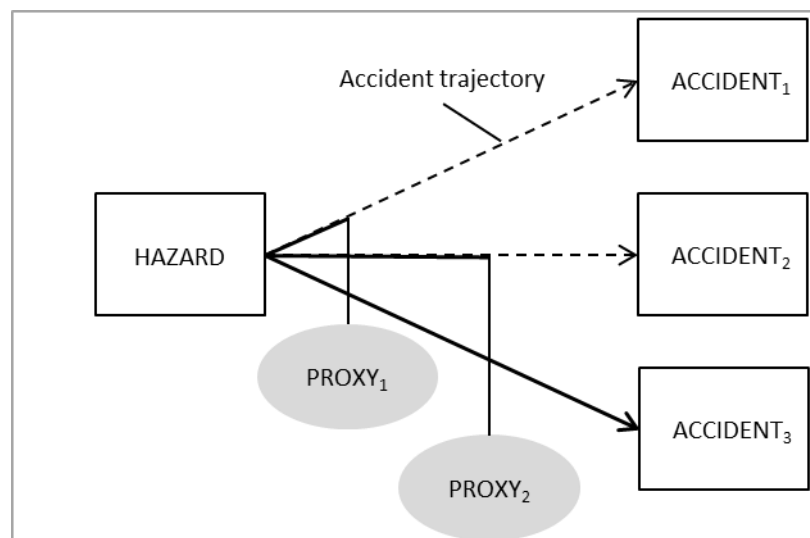


Figure 5: Use of proxies along accident trajectories

- (d) Proxies might be preferred where the extra effort needed to identify, describe and analyse a complete set of sequences of events from the occurrence of a hazard to the occurrence of an accident or incident has no added value in the safety assessment. The intrinsic reasons for the amount of the extra effort are the number of significantly different event sequences, the complexity of some accident scenarios, the existence of many barriers preventing the occurrence of a hazard developing into an accident and the lack of evidence on the probability of some events or the frequency of occurrence of some external circumstances and factors. The usage of proxies might then make the safety assessment more tractable and comprehensible and increase the quality of the risk analysis.

- (e) The main advantages of proxies are the easy recognition of safety issues by operational staff involved in the safety assessment, and the direct focus on the analysis and mitigation of the identified hazards and safety issues introduced or affected by the change.
- (f) The main disadvantage of using proxies is that it is not possible to express risk by a uniform measure. However, the value of the proxy should be measurable.
- (g) For further details on the use of proxies, please refer to GM1 to AMC1 ATS.OR.205(b)(4), which contains two examples to assist in the selection and use of proxies in safety analysis.

Section 3 — Specific human factors requirements for air traffic control service providers

AMC1 ATS.OR.305(a) Responsibilities of air traffic control service providers with regard to the problematic use of psychoactive substances by air traffic controllers

POLICY AND PROCEDURES

Within the context of the policy, the air traffic control service provider should:

- (a) provide training or educational material to air traffic controllers relating to:
 - (1) the effects of psychoactive substances on individuals and subsequently on air traffic control service provision;
 - (2) established procedures within its organisation regarding this issue; and
 - (3) their individual responsibilities with regard to legislation and policies on psychoactive substances.
- (b) make available appropriate support for air traffic controllers who are dependent on psychoactive substances;
- (c) encourage air traffic controllers who think that they may have such a problem to seek and accept help made available by their air traffic control service provider;
- (d) ensure that air traffic controllers are treated in a consistent, just and equitable manner as regards the problematic use of psychoactive substances; and
- (e) establish and implement principles and procedures for occurrence investigation and analysis to consider the problematic use of psychoactive substances as a contributing factor.

GM1 ATS.OR.305(a) Responsibilities of air traffic control service providers with regard to the problematic use of psychoactive substances by air traffic controllers

POLICY

- (a) Guidance for the development and implementation of the policy is contained in ICAO Doc 9654 'Manual on Prevention of Problematic Use of Substances in the Aviation Workplace', First Edition - 1995, and in particular:
 - (1) Attachment A (pp. 27–34) as regards elements for the definition and the implementation of policy and programme;
 - (2) Chapter 3 (pp. 9–12) as regards the identification, treatment, and rehabilitation of staff, with related supporting material, available in Attachment C (pp. 61–68); and
 - (3) Attachment D (pp. 69–75) as regards the employment consequences of problematic use of substances.

TRAINING AND EDUCATION PROGRAMMES

- (b) Guidance for the development and implementation of training and education programmes is contained in ICAO Doc 9654 'Manual on Prevention of Problematic Use of Substances in the Aviation Workplace', First Edition - 1995, in particular:
- (1) Chapter 2 (pp. 6–7) as regards the education of the workforce and educational material, with related supporting material available in Attachment A (pp. 35–48); and
 - (2) Attachment B (pp. 49–59) and Attachment F (pp. 87–94), where extracts from the ICAO Manual of Civil Aviation Medicine are provided

GM2 ATS.OR.305(a) Responsibilities of air traffic control service providers with regard to the problematic use of psychoactive substances by air traffic controllers

THIRD PARTY ASSISTANCE TO AIR TRAFFIC CONTROLLERS

The air traffic control service provider may employ third-party assistance. Such assistance should be made freely available to air traffic controllers who are dependent on psychoactive substances.

AMC1 ATS.OR.305(b) Responsibilities of air traffic control service providers with regard to the problematic use of psychoactive substances by air traffic controllers

PROCEDURE FOR THE DETECTION OF CASES OF PROBLEMATIC USE OF PSYCHOACTIVE SUBSTANCES

The objective, transparent and non-discriminatory procedure should specify:

- (a) the mechanisms and responsibilities for its initiation;
- (b) its applicability in terms of timing and locations;
- (c) the person(s)/body responsible for testing the individual;
- (d) the testing process;
- (e) thresholds for psychoactive substances;
- (f) the process to be followed in case of detection of problematic use of psychoactive substances by an air traffic controller; and
- (g) the appeal process.

GM1 ATS.OR.305(b) Responsibilities of air traffic control service providers with regard to the problematic use of psychoactive substances by air traffic controllers

PROCEDURE FOR THE DETECTION OF CASES OF PROBLEMATIC USE OF PSYCHOACTIVE SUBSTANCES

Guidance for the development and implementation of the procedure for detection of cases of psychoactive substances is contained in ICAO Doc 9654 'Manual on Prevention of problematic use of Substances in the Aviation Workplace', First Edition - 1995, particularly in Chapter 5 (pp. 15–23) and Attachment E (pp. 77–85) as regards biochemical testing programmes, with related supporting material.

GM1 ATS.OR.310 Stress

EXPLANATION OF THE FUNDAMENTALS OF STRESS

(a) Introduction

- (1) The job of an air traffic controller is considered to be responsible and demanding, and at times can lead to the experience of high levels of stress. The combination of skills and knowledge

required to complete air traffic control tasks is wide. Visual spatial skills, perception, information processing, image and pattern recognition, prioritising, logical problem-solving, application of rules and procedures and decision-making form core skills to which we can add interpersonal communication, teamwork and technical vocabulary usage.

- (2) Air traffic control also requires to constantly adapt to an ever-changing traffic picture and work environment within restricted time constraints. This has the potential to lead to considerable work pressure. In contrast, there may be times when traffic flows are low and controllers experience relatively low levels of activity. For some controllers, this may bring its own kind of stress due to the increased efforts required to maintain vigilance under light traffic load.
- (3) Thus, the work of an air traffic controller has the potential to induce high levels of stress; however, the stress experienced by controllers is always unique to the individual and their interaction with their environment.
- (4) 'Stress' is a term that is in common use within everyday language and can mean different things to different people depending on the context in which it is used. In lay terms, stress is often used to describe an external pressure experienced by an individual whilst at the same time encompassing the subjective experience of this pressure. Usually the term is used in a negative way. In this sense, the lay use of the term 'stress' encompasses both the cause and the effect, and this can lead to confusion as to its meaning.

(b) Technical definitions of stress

- (1) Even in its technical use, the word 'stress' is sometimes used when the term 'stressor' (or pressure) would be more appropriate, referring to the cause of a stress experience. Stressors can be internal (cognitive or physical) or external (environmental) to the individual and may be defined as any activity, event or other stimulus that causes the individual to experience stress.
- (2) It is helpful to clarify the way the term 'stress' and other technical terms are used. For the purposes of this guidance material, stress is defined following the Transactional Model of Stress. This views stress as the outcomes experienced by an individual when faced with a potentially stressful event. The experience of the event as negatively stressful (distress), neutral or positive (eustress) is based on the individual's perception of their ability to manage the event. Under this definition, stress is a manifestation in the individual of usually negative effects, which can lead to a decrease in performance and negative health effects.
- (3) A stressor can also act to improve performance when it is a stimulus to increase arousal and improves the outputs of an individual in the short to medium term. Too much arousal paradoxically leads to an inverse effect and subsequent detriment in performance.
- (4) Acute stress is, as its name suggests, episodic and occurring for short periods of time. In most cases, the cause of the stress is eliminated by the air traffic controller taking action to manage the situation leading to stress. High levels of acute stress may lead to hyper-arousal and may leave an air traffic controller feeling exhausted. It is important to identify work situations that lead to this acute stress and manage this within the work schedule.
- (5) Chronic stress differs from acute stress only in that it is ongoing and even low levels of continuous chronic stress can lead to performance degradation and serious health implications, if it is not addressed. Chronic stress is insidious in its nature and a sufferer may become so accustomed to the sensations that they are unaware of the long-term negative effects. Chronic stress commonly leads to a sense of inability to cope.

- (6) Both acute and chronic stresses have the potential to lead individuals into hyper-aroused states which may result in panic where task and skill performance, planning, reasoning and judgement are significantly impaired. In such instances, a well-practised but incorrect action, for that particular circumstance, may be performed when an alternative and more appropriate response is required.
- (7) Chronic stress may result in a condition known as burnout. Burnout is generally identified by the following characteristics: disaffection with the job leading to a decrease in motivation with an associated decrease, perceived or otherwise, in performance.

(c) Sources of stress

Broadly speaking, the stress experienced by an air traffic controller at work is a function of their underlying background levels of stress, related to lifestyle, health and well-being, personality, organisational/work environment, levels of satisfaction with life generally, and the acute stress imposed by and operational conditions at any given time. There are three major sources of stress: environmental, work-related, and personal.

(1) Environmental/physical stressors

- (i) Physical stressors are underlying conditions that can either be internal to the body (e.g. pain, hunger, lack of sleep, exhaustion), or external environmental factors (e.g. noise pollution, overcrowding, excess heat). The common factor among all of these stressors is that they all create a physically uncomfortable environment that can cause stress. Stress is not solely dependent on the intensity of a stimulus, but also on the duration of exposure. For example, a low-pitched but persistent noise can cause as much stress as a sudden loud noise.
- (ii) In the air traffic control room, some common environmental/physical stressors could be:
 - (A) uncomfortable temperature;
 - (B) cramped workspace;
 - (C) air quality;
 - (D) lighting conditions; and
 - (E) intrusive noise or vibration.

(2) Work-related stressors

- (i) Stress in the workplace can come from a variety of sources besides physical stimuli. Some of these include:
 - (A) continuing high levels of workload near or above the maximum traffic handling capacity of an air traffic controller;
 - (B) a heterogeneous traffic mix where aircraft have varying levels of equipment and considerable variability in pilot skills;
 - (C) unsuitable or unreliable equipment;
 - (D) inappropriate, vague procedures;
 - (E) complex equipment which is insufficiently understood or mistrusted;
 - (F) supervision of trainees or less experienced colleagues;

- (G) workload and task breakdown not being matched to the level of technical skill of the controller, lack of support or too much support (interference);
 - (H) role ambiguity, where it is unclear where the responsibilities lie;
 - (I) interpersonal conflict with colleagues, other professionals;
 - (J) poor management relations (social dialogue), working conditions, e.g. rostering; and
 - (K) unusual or emergency situations.
- (ii) Incidents, including emergencies and accidents, that lead controllers to feel that they are not coping may lead to the experience of critical incident stress; this, in turn, may impair performance in varying degrees.

(3) Personal stressors

- (i) Personal stressors include the range of events that occur throughout people's lives but external to the workplace. The belief that such stressors can be left at home, however, is a myth, and these personal stressors accompany air traffic controllers to work every day.
- (ii) Personal issues such as health, personal life, living situation and major life events (deaths, births, marriages, and moving house) add to the background level of stress that individuals have to cope with. Where these are excessive, they can interfere with work due to the distraction they cause and the mental effort they require to resolve them.
- (iii) Stress is also considered to have a contagious quality, which happens when a stressed person or stressed persons create stressful situations for those around them.

(d) Signs of stress in the individual

Signs of stress are many and varied. Some of the most commonly observed are shown below:

(1) Physiological

- (i) Cardiovascular: increased pulse rate, elevated blood pressure, chest pains;
- (ii) Respiratory: shortness of breath, tightness of chest, hyperventilation, dizziness;
- (iii) Gastrointestinal: loss of appetite, gas pain, abdominal cramps, indigestion, diarrhoea, nausea;
- (iv) Sweaty palms;
- (v) Aching neck, jaw and back muscles;
- (vi) Trembling;
- (vii) Sleep disturbance, tiredness;
- (viii) Itching;
- (ix) Getting easily startled;
- (x) Susceptibility to minor illnesses; and
- (xi) Other: headaches, muscular tension, general weakness, psychosomatic symptoms.

(2) Psychological

- (i) Emotional: anger, guilt, mood swings, low self-esteem, depression and anxiety;

- (ii) Concentration problems, forgetfulness;
- (iii) Pessimism;
- (iv) Difficulty in making decisions;
- (v) Irritability;
- (vi) Loss of interest;
- (vii) Loss of self-control; and
- (viii) Loss of confidence.

(3) Behavioural

- (i) Self-medication, drugs or alcohol;
- (ii) Excess fatigue;
- (iii) Sleep disruption;
- (iv) Social withdrawal;
- (v) Absenteeism;
- (vi) Staff turnover rates; and
- (vii) Job performance decrements.

(e) Impact of stress on air traffic controllers' performance of air traffic control tasks

Any source of stress has the potential to create unique subjective experiences in different individuals, and these may be positive or negative experiences or something in between.

(f) Negative experiences of stress

There is a number of ways in which stress experienced by air traffic controllers can be manifested in the performance of air traffic control tasks. Some of these are listed in Table 1, but, in general terms, performance of tasks decreases due to the detrimental effects that high levels of stress can have on perception, awareness, decision-making and judgement. In the longer term, health and well-being may also be compromised, leading to decreased performance of air traffic controllers.

Table 1 below shows the effects on air traffic controller performance which can be linked to stress and which can potentially have very significant implications for the safety performance of an operation.

Difficulty in concentrating and reduced vigilance — easily distracted.
Errors, omissions, mistakes, incorrect actions, poor judgment and memory.
Tendency to cut corners, skip items and look for the easiest way out.
Either slowness (due to lack of interest) or hyperactivity (due to adrenaline).
Focusing on easily manageable details while ignoring serious threats.
Tendency to pass responsibility on to others.
Fixation on single issues or even a mental block.
Unwillingness to make decisions — decisions are postponed or take longer to be made.
Fewer plans and backup plans are made.

Increase in risk-taking, leading to an increase in the number of violations, especially when frustrated with failures.
Excessively hurried actions — due to adrenaline and alertness level, there is a tendency to act very quickly even when there is no time pressure. Hurried actions increase the chance of errors.
In cases of significantly high stress, a controller will often: <ol style="list-style-type: none"> (1) return to old procedures that may no longer be applicable, appropriate or safe; (2) use non-standard phraseology when communicating; (3) return to the use of one's native language; and/or (4) look for items in a place where they used to be, but are no longer located.

Table 1: Effects of stress on physical and mental performance of air traffic control tasks

(g) Mitigation of stress in the individual and the organisation

Air traffic control service providers have a duty to take care of their employees and the customers of their services. They should aim at mitigating the negative effects of stress. This is best achieved by ensuring that a range of preventative measures as well as countermeasures are in place. These include:

- (1) adoption of a stress policy and/or a critical incident stress management policy within the organisation;
- (2) completion of regular risk assessment of sources of occupational stress and its effects on individuals and operations;
- (3) employee stress level monitoring;
- (4) adoption of stress intervention/mitigation/prevention practices and, where the organisation identifies a source of stress, use of a stress team/committee;
- (5) stress management training for all levels of employees;
- (6) education and prevention programmes on stress; and
- (7) staff support mechanisms (e.g. peer counselling, professional support from health practitioners, critical incident stress management (CISM) programmes);
- (8) adequate rostering allowing time to evacuate stress; and
- (9) promotion of sports or relaxation activities.

AMC1 ATS.OR.310(a) Stress

STRESS MANAGEMENT POLICY

- (a) The air traffic controllers' stress management policy should:
- (1) declare the commitment to proactively and systematically monitor and manage stress, and describe the expected benefits for the safety of operations;
 - (2) be signed by the accountable manager;
 - (3) reflect organisational commitments regarding the implementation of a critical incident stress management programme;

- (4) be communicated, with visible endorsement, throughout the air traffic control service provider;
 - (5) include the commitment to:
 - (i) provide appropriate resources;
 - (ii) consider the best practices;
 - (iii) enforce stress management programme(s) as a responsibility of managers, staff involved in stress management and air traffic controllers;
 - (6) be periodically reviewed to ensure it remains relevant and appropriate.
- (b) In accordance with the policy in point (a), the air traffic control service provider should establish and implement:
- (1) procedures for critical incident stress management;
 - (2) principles and procedures to enable stress reporting;
 - (3) principles and procedures for occurrence investigation and analysis to consider stress as contributing factor; and
 - (4) method(s) for the identification and management of the effect of air traffic controllers' stress on the safety of operations.

GM1 ATS.OR.310(a) Stress

CRITICAL INCIDENT STRESS MANAGEMENT

The purpose of critical incident stress management (CISM) programmes is to prepare an organisation for the potential aftermath of an incident. These programmes come in a number of different forms, but have the added benefit of providing education on the effects of stress, how stress affects performance and stress management, even when the incident is relatively minor and perhaps personal to the individual.

Guidance for the implementation of a CISM programme may be found in the EUROCONTROL document: 'Human Factors — Critical Incident Stress Management: User Implementation Guidelines', edition 2.0 of 24 October 2008.

GM1 ATS.OR.310(b) Stress

INFORMATION AND EDUCATION PROGRAMMES

Scientific material proposed as guidance for information and education programmes on stress may be found in the EUROCONTROL document 'Human Factors Module — Stress', edition 1.0 of 15 March 1996.

GM1 ATS.OR.315 Fatigue

EFFECTS OF FATIGUE

Guidance material on fatigue and its effects on safety-relevant aviation professionals may be found in Chapter 2 'Scientific principles for fatigue management' of ICAO Doc 9966 'Manual for the Oversight of Fatigue Management Approaches', second edition 2016.

AMC1 ATS.OR.315(a) Fatigue

FATIGUE MANAGEMENT POLICY

- (a) The air traffic controllers' fatigue management policy should:
 - (1) declare the commitment to proactively and systematically monitor and manage fatigue and describe the expected benefits for the safety of operations;
 - (2) be signed by the accountable manager;
 - (3) address the mitigation of the operational impact of air traffic controllers' fatigue;
 - (4) be communicated, with visible endorsement, throughout the air traffic control service provider;
 - (5) include a commitment to:
 - (i) consider the best practices;
 - (ii) provide appropriate resources; and
 - (iii) enforce fatigue management as a responsibility of managers, staff involved in fatigue management procedures and air traffic controllers;
 - (6) be periodically reviewed to ensure it remains relevant and appropriate.
- (b) In accordance with the policy in point (a), the air traffic control service provider should establish and implement:
 - (1) principles and procedures to enable fatigue reporting;
 - (2) principles and procedures for occurrence investigation and analysis to consider fatigue as contributing factor;
 - (3) procedures for the identification and management of the effect of fatigue on the safety of operations.

GM1 to AMC1 ATS.OR.315(a) Fatigue

FATIGUE TAXONOMY

When establishing procedures to enable air traffic controllers to report when fatigued, an associated taxonomy for fatigue should be established.

GM2 to AMC1 ATS.OR.315(a) Fatigue

FATIGUE IN OCCURRENCE INVESTIGATION AND ANALYSIS

Fatigue may have a significant impact on the performance of air traffic controllers and consequently on the safety of air operations. Therefore, when investigating occurrences, the air traffic control service providers should analyse the occurrence for fatigue as a contributing factor.

The analysis of available occurrence reports where fatigue was identified as contributing factor, generated by the air traffic control service providers or by other sources, could support the implementation and the improvement of fatigue management.

GM3 to AMC1 ATS.OR.315(a) Fatigue

IDENTIFICATION AND MANAGEMENT OF THE EFFECT OF FATIGUE ON THE SAFETY OF OPERATIONS

- (a) The following non exhaustive list contains some of the initiatives that the air traffic control service provider may undertake in order to identify air traffic controllers' fatigue:
- (1) establishment of a procedure allowing air traffic controllers to report when fatigued, and promotion of its use. Templates for such reporting procedure could be established;
 - (2) utilisation of system support to manage rostering principles and thresholds established in accordance with ATS.OR.320, also highlighting criticalities in advance;
 - (3) undertaking fatigue surveys;
 - (4) application of scientific principles on fatigue and fatigue management and their effect on the operational and organisational context.
- (b) The knowledge and understanding of the underlying scientific principles of fatigue, as well of its potential impact on the safety of operations, may represent a considerable added value for the effectiveness of fatigue management arrangements established within the organisation. For this purpose, the air traffic control service provider might consider making available education and information programmes for staff involved in fatigue management, such as operational and safety managers, staff in charge of managing the rostering system, staff in charge of occurrence investigation.
- (c) Activities air traffic control service providers could undertake to monitor the effectiveness of the established fatigue management arrangements may be but are not limited to the following:
- (1) verification of the allocation and implementation of duty and rest periods in accordance with the rostering principles established in ATS.OR.320;
 - (2) collection and analysis of data related to planned versus achieved rosters, and in particular:
 - (i) exceedances of planned working hours and reasons generating exceedances;
 - (ii) variation of the nature of the duty (office work, operational air traffic control service provision, training, etc.);
 - (iii) operational circumstances which required a modification of established duty and rest periods; and
 - (iv) swapped shifts between air traffic controllers and impact on the established fatigue management principles;
 - (3) verification of the use and of the effectiveness of the procedure allowing air traffic controllers to self-declare fatigue, when such procedure is established; and
 - (4) analysis if specific roster patterns generate fatigue and, as a consequence, sickness or cases of provisional inability in accordance with Commission Regulation (EU) 2015/340.

GM1 ATS.OR.315(b) Fatigue

INFORMATION PROGRAMMES

Information programmes may consist of lectures, leaflets, posters, CDs, and any other informative material to raise the awareness of the effects of fatigue on the individuals and on air traffic control service provision, and to advise on the need and the means to manage it. When choosing the most appropriate information programme and the medium, the air traffic control service provider should evaluate the level of awareness of

its staff of fatigue management, the type of operations (e.g. single-person operations, nightshifts), and the periodicity of human factors training in the scope of refresher training.

GM2 ATS.OR.315(b) Fatigue
INFORMATION PROGRAMMES

Scientific material proposed as guidance for information programmes on fatigue may be found in the document 'Fatigue and Sleep Management: Personal strategies for decreasing the effects of fatigue in air traffic control' (Brussels: Human Factors Management Business Division (DAS/HUM), EUROCONTROL, 2005).

AMC1 ATS.OR.320(a)(6);(7) Air traffic controllers' rostering system(s)
NIGHT TIME

Night time should be considered as the time between midnight and 05.59.

GM1 ATS.OR.320(a) Air traffic controllers' rostering system(s)
STRUCTURE AND VALUES OF THE ROSTERING SYSTEM

The selection and the regular revision of an appropriate structure and of appropriate values of the rostering system, in accordance with ATS.OR.320(a) and which fit the intended operations, should be based upon:

- (1) scientific principles;
- (2) data gathered by the air traffic control service provider; and
- (3) best practices.

GM1 ATS.OR.320(b) Air traffic controllers' rostering system(s)
AIR TRAFFIC CONTROLLERS' INVOLVEMENT

Additional guidance concerning the involvement of air traffic controllers in the definition of rostering systems is available in EUROCONTROL Study on Shiftwork practices — ATM and related Industries, edition 1.0 of 14 April 2006.

SUBPART B — TECHNICAL REQUIREMENTS FOR THE PROVISION OF AIR TRAFFIC SERVICES (ATS.TR)

Section 1 — General requirements

GM1 ATS.TR.100(b) Working methods and operating procedures for providers of air traffic services
SPECIAL AND ALTERNATIVE CONDITIONS AND OPERATING PROCEDURES FOR ATS PROVIDERS PROVIDING SERVICES TO FLIGHT TESTS

- (a) While flight tests are regularly conducted in compliance with the standards and the provision specified in ATS.TR.100 (a), some of them need to follow specific additional or alternative conditions and procedures approved by the competent authority to meet the needs of flight tests carried out during the flight. This is also the case for flight tests involving more than one aircraft in the same flight test. These special provisions will not jeopardise the safety of the other airspace users and the population in the area overflown.

- (b) In order to ensure safe operations within the provision of air traffic service for flight tests control, the air traffic controllers providing these services may need to have specific knowledge of flight tests and/or be briefed, depending on the specificities of the flight profiles.
- (c) Air traffic controllers that provide air traffic services to flight tests (flight test ATCOs) may need to obtain their specific competence through a dedicated training as specified in Commission Regulation (EU) 2015/340.
- (d) Air traffic services for flight test should be provided through dedicated and specific procedures. These procedures should address:
 - (1) Compatibility with other airspace users
 - (i) In order to ensure the compatibility of the flight test with other airspace users and to ensure safe operations and an acceptable rate of success of flight test, the air traffic services provider should ensure proper coordination at all levels, including strategic, pre-tactical and real-time coordination.
 - (ii) An air traffic services unit providing services to flight test is responsible for ensuring compatibility of their activities with other airspace users.
 - (2) Flight plan

The air traffic services unit should obtain all the necessary details related to flight tests (e.g. from the design organisation or the entity wishing to carry out the flight test).
 - (3) Flight tests with limited manoeuvrability

During certain phases of the flight test, the capability to normally perform manoeuvres may only be possible after a necessary period of time (e.g. for the flight crew to get into a configuration that allows the execution of these manoeuvres).

The air traffic services provider should obtain the necessary information about the phases of flight and the duration if known.

For the conduct of these flights, the use of a temporarily reserved area is preferred. If unable, after prior coordination with the relevant air traffic services units neighbouring the flight tests, the use of a transponder should be mandated.

This real-time information does not relieve the air traffic services unit responsible for providing services to the flight tests from the obligation to ensure traffic separation and assure compatibility with all airspace users.
- (e) The above-mentioned procedures are not exhaustive and additional provisions may be necessary to meet the needs of flight tests. The paramount principle is anyhow to make provisions without contradicting the standards and the provision specified in ATS.TR.100(a).