Cooperative Network Design

Risk Analysis Tool

Guidance Material

EUROCONTROL

AUTHORISATION SHEET

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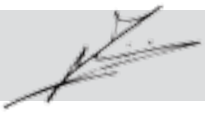
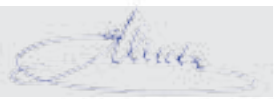
SRC Chairman & Co-Chair of the SAFREP Task Force	Jos WILBRINK 	14 September 2009
Safety Team Chairman & Co-chair of the SAFREP Task Force	Dr. Erik MERCKX 	14 September 2009
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SUMMARY

Risk is a factor that exists in every human endeavour, including operations involving aircraft – whether in the air or on the ground. Each movement of aircraft involves some level of risk because the system, being human-based, is fallible. Identifying and mitigating risk is critical to increasing the level of safety. The Risk Analysis Tool (RAT) provides a method for consistent and coherent identification of risk elements. It also allows users to effectively prioritise actions designed to reduce the effect of those elements.

The RAT tool has evolved over time to be a sophisticated yet simple program for quantifying the level of risk present in any air incident. Requiring only a brief series of program inputs to produce a valid result, the tool expresses the relationship between actions and consequences and provides a quantifiable value to these relationships.

The RAT is not a risk mitigation tool in and of itself. Instead, it allows the analysis of a single event in order to understand the factors involved and then place the event in context with other events.

The objective of this document is to give guidance on how to use the severity and risk marksheets developed by EUROCONTROL, the European Organisation for the Safety of Air Navigation.

The format of these guidelines has been kept simple and easy to read in order to facilitate a common understanding. Consequently, it contains components and information that should be appropriate to score severity and risk of recurrence for safety occurrences as required by ESARR2 – Reporting and Assessment of Safety Occurrences in ATM.

The present version has been developed by the SAFREP Task Force Ad-Hoc group on Safety KPIs during 2008 – 2009, on the basis of the initial ESARR guidance material (EAM2-GUI5 issued 31/05/2005).

This document is complemented with two Excel files containing the Qualitative and Quantitative marksheets.

We recommend that you read this document fully before using the marksheets, in conjunction with evaluating a few real incidents in each category of the marksheets.

This will allow investigators to understand the mechanism of the barrier model behind the marksheets and to apply them in a consistent manner.

Based on experience of the developers, to be fully conversant with using the marksheets will take investigators approximately 1 ½ days.

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1. KEY TERMS AND CONCEPTS

The following definitions apply when using this guide.

Term	Initiating
Risk of collision	ICAO Doc 4444: Airprox – risk of Collision: "The risk classification of an aircraft proximity in which serious risk of collision has existed."
Severity	Describes the level of effect/consequences of hazards on the safety of flight operations (i.e. combining level of loss of separation and degree of ability to recover from hazardous situations). The overall severity of one occurrence is built up from the risk of collision/proximity (separation and rate of closure) and the degree of controllability over the incident.
Risk	The combination of overall probability, or frequency/likelihood, or occurrence of a harmful effect induced by a hazard and the severity of that effect.
Reliability Factor	The level of confidence in the assessment (scoring) undertaken, based on the data available.

Table 1: Key Definitions for ATM Occurrence Assessment

The interrelationships of these concepts are expressed in Figure 1 below:

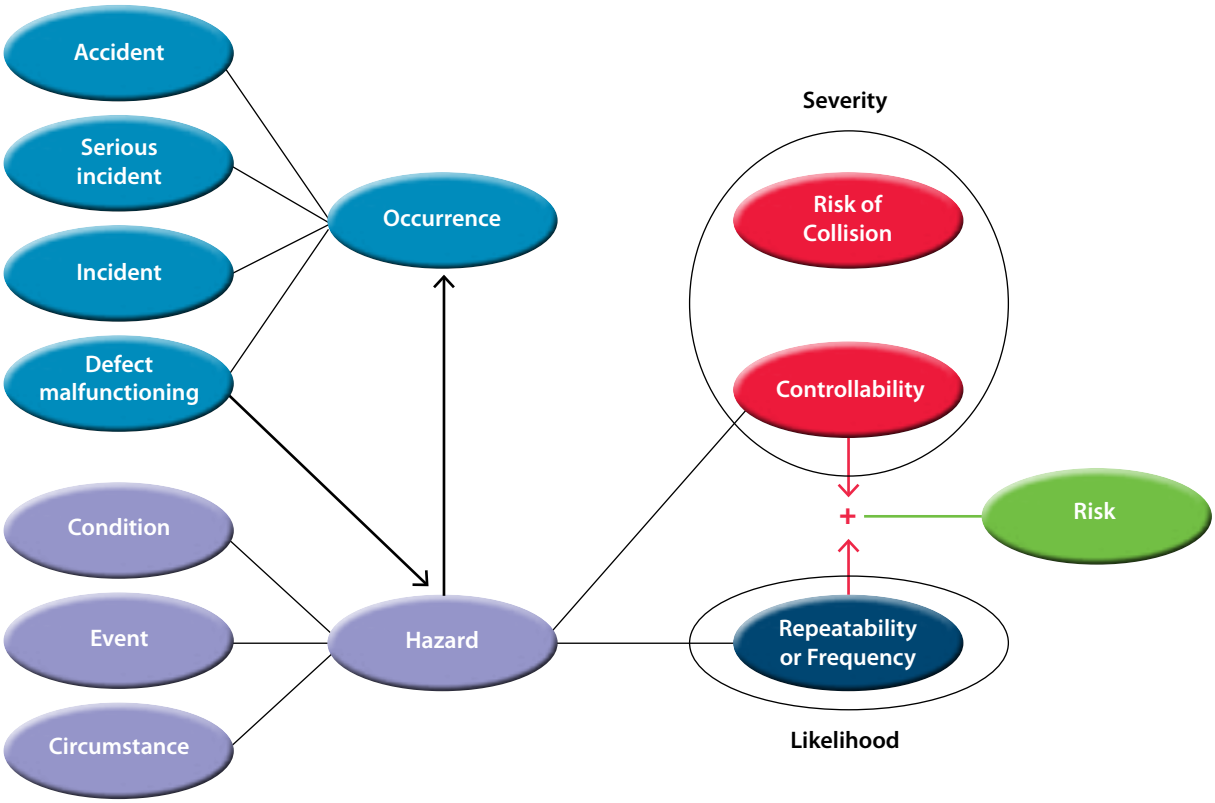


Figure 1: Schematic Representation of Definitions

2. SCORING SYSTEM

The objective of the safety occurrence classification exercise is to produce a severity and risk or recurrence assessment for safety occurrences (refer to ESARR 2 requirement 5.1.6 *"The severity of each occurrence is determined, the risk posed by each such occurrence classified, and the results recorded").*

The evaluation should therefore assess the likely consequence of such occurrence(s), including the question as to whether it is likely to re-occur and the likelihood of it doing so.

The marksheet system retains the principles of a question-based scoring system as it provides an objective basis for judgement which is easy to use.

The number of aircraft involved in the occurrence determines or confirms the type of safety occurrence, i.e. ATM specific, aircraft specific which may have some ATM ground involvement or simply ATM only, etc. Table 2 provides guidance in which marksheet to use.

NOTE: The scores for the criteria in assessing Severity and Risk are representative for each individual criterion. There is no intention to quantify the importance of each criterion in comparison to others. No hierarchy between criteria and no trade-off shall be done between them. The information to score the criteria shall come from the investigation process and not vice-versa. This is a tool to support the investigator in classifying the safety occurrence in an objective manner. Whenever there is not enough information available to score a criterion or there are disagreements between investigators, the disputed criterion should be left un-scored. The marksheet will automatically affect the Reliability Factor for the incident. A description of the Reliability Factor and how it is scored is given in Section 4.

2.1 ASSESSMENT PROCEDURE

Preliminary Note:

The severity marksheets are to be seen as a guide to severity and risk or recurrence assessment.

Scoring marksheets is NOT a system that, through calculations, will determine a definite severity and risk for any type of occurrence. There is a need for additional procedures, such as moderation panels to ensure adjustments and smoothing of results based on the operational experience of the investigators. By using the marksheets and its barrier model, the subjectivity of the final assessment will be reduced. Consistent, objective and harmonised assessments will be achieved by investigators from various stakeholders with different backgrounds and cultures (e.g. where appropriate: ANSPs, REGs, airlines, AAIBs).

Overview of Scoring Marksheet(s)

Not all marksheets in the Severity Marksheet Classification Scheme need to be used. Every incident will be assessed based on which scheme fits best. Table 2 provides some guidance on which marksheet to use depending on the type of occurrence.

Number of aircraft involved	Marksheet to use (Section Ref in this document)	Purpose
More than one aircraft	2.1.1	When 2 or more aircraft are involved in the occurrence - usually for incidents with airborne aircraft, e.g. usually involving separation minima infringements or inadequate separations.
Aircraft – aircraft tower	2.1.2	When the occurrence is an encounter between two aircraft under tower control. This includes situations where: a) both aircraft are airborne; b) both aircraft are on the ground; c) one aircraft is airborne and one aircraft is on the ground.
Aircraft with ground movement	2.1.3	When the occurrence is an encounter between aircraft and a vehicle. In this situation, the aircraft could be on the ground or it could be airborne.
One aircraft	2.1.4	When only one aircraft is involved in the occurrence (e.g. an airspace infringement, a level bust without a second aircraft involvement, a loss of separation with ground and/or obstacles). The near-CFIT occurrences should be assessed with this marksheet.
ATM specific occurrence	2.1.5	To be applied in the cases of technical occurrences influencing the capability to provide safe ATM services.

Table 2: Types of Scoring Marksheets

Within each section there are two types of marksheet, one for Quantitative analysis of an ATM occurrence and one for Qualitative analysis. In cases where more than one controller and/or more than one pilot crew were involved in the incident with different performances, there is generally a preference noted from the practice, to use the Quantitative marksheet. This is probably because more flexibility in granting marks is allowed when using the Quantitative version of the marksheet.

Each marksheet has two key sections:

A: Severity – the overall severity of one occurrence is built up from the **risk of collision/proximity** (separation and rate of closure) and the degree of **controllability** over the incident. There is also a specific spreadsheet to enable the scoring of ATM Specific Occurrences (i.e. technical incidents affecting the capability to provide safe services) where the severity is looked at differently i.e. it considers the failure criticality, the coverage of the failure and the required time to restore the ATM function affected or to fail-safe to a degraded mode by introducing contingency measures.

The ATM elements in the marksheet include three columns covering Ground, Airborne and ATM Overall segments (except for the marksheet dealing with ATM Specific Occurrences, which are ATM Ground only). In the Risk of collision section, only one should be used to record either the ATM Ground or the ATM Airborne part, **never both**. The ATM Airborne column should be used to score the ATM Airborne part only in cases where ATC is not responsible for providing separation (i.e. certain classes of airspaces - e.g. close encounter between IFR and VFR flights in Class E airspace).

In the Controllability section the ATM Airborne column is used to record the pilot execution and the effectiveness of the airborne safety nets.

The score in the ATM Overall column is automatically calculated and represents the overall score for both ATM Ground and ATM Airborne for each criteria being scored.

B: Repeatability – this section computes the probability that a similar occurrence will recur in the future.

Both these sections have a number of sub elements to be scored. For each specific situation the values are not fixed and can be adjusted by the investigator within the provided values.

At the top of each marksheet is an overall set of indicators that provide an ongoing dynamic view of how the Severity and Risk of Recurrence classification is progressing as users work through the marksheet. Figure 2 provides an overview of these indicators.

Note: The risk classification grid follows the ATM Overall and Ground values through colour coding, while the marksheets computes potentially values for all ATM segments (Ground, Airborne and total ATM Overall). The decision to show Ground and ATM Overall was retained to give ANSPs a quick return on the value (ATM Overall) to be eventually made available to the public through the Annual Summary Template (as required by ESARR2) and a value to assess their own performance (ATM Ground).

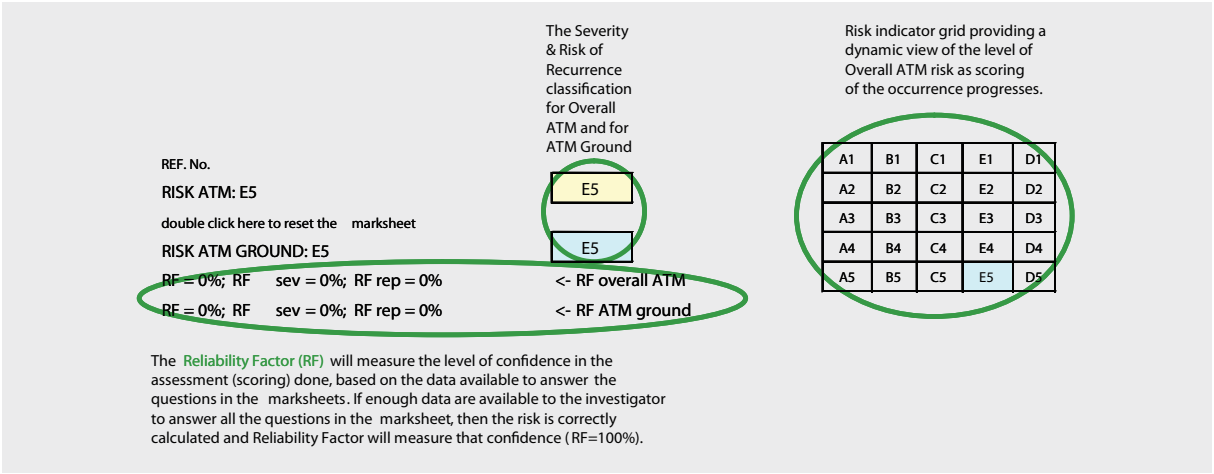


Figure 2: Dynamic Risk View

Figure 3 provides a high level overview of the various elements in the marksheets.

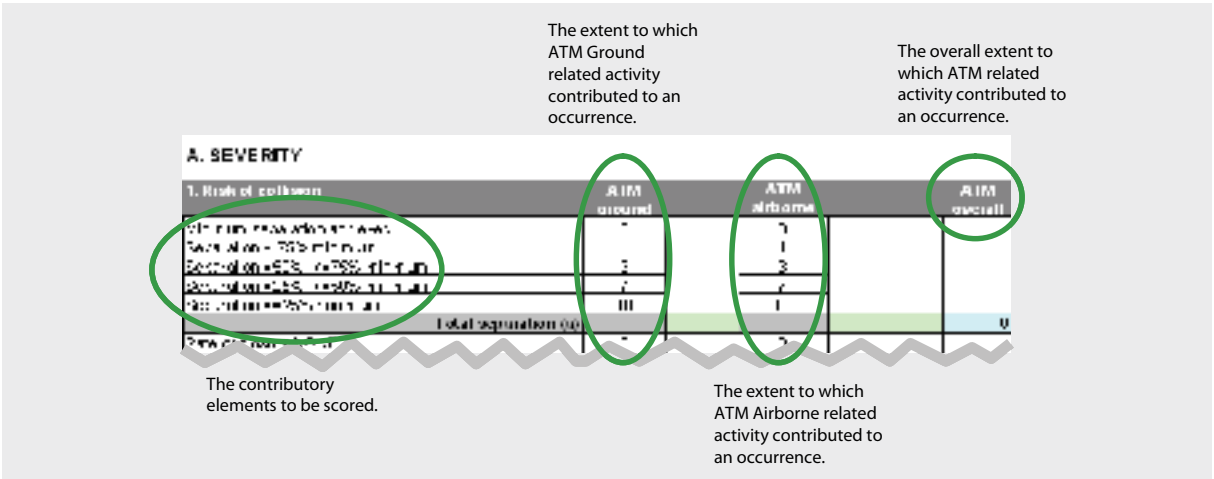


Figure 3: Marksheet Overview

The following sections provide guidance on how to complete each of the Severity and Risk Classification Marksheets.

Note: When completing the marksheet, it is recommended that you make use of the relevant cells (in yellow on the Excel spreadsheet) to record comments on why a specific score was given. This information will prove to be invaluable should you need to revisit, perhaps after a period of time, reasons why a particular score was given.

QUANTITATIVE VERSION – SEVERITY Marksheet

A. SEVERITY

1. Risk of collision	ATM ground		ATM airborne		ATM overall
Minimum separation achieved	0		0		
Separation + 75% minimum	1		1		
Separation >50%, <=75% minimum	3		3		
Separation >25%, <=50% minimum	7		7		
Separation <=25% minimum	10		10		
Total separation (a)					0
Rate of closure NONE	0		0		
Rate of closure LOW (<=85knots, <=1000ft/mn)	1		1		
Rate of closure MEDIUM (>85 and <=205 knots, >1000 and <=2000 ft/mn)	2		2		
Rate of closure HIGH (>205 and <=700 knots, >2000 and <=4000 ft/mn)	4		4		
Rate of closure VERY HIGH (>700knots, >4000ft/mn)	5		5		
Total rate of closure (b)					0

TOTAL (1-ATM) Risk of Collision (a)+(b)	**0**
TOTAL (1-ATM Ground) Risk of Collision (a)+(b)	**0**

2. Controllability	ATM ground		ATM airborne		ATM overall
Conflict detected	0		0		
Conflict detected late	3		0		
Conflict NOT detected	5		0		0
Plan CORRECT	0		0		
Plan INADEQUATE	3		0		
NO plan	5		0		0
Execution CORRECT	0		0		
Execution INADEQUATE	3		5		
NO execution	5		10		0
Loss of separation detected because of STCA	3		0		
No detection (including by STCA)	5		0		0
Recovery CORRECT	0		0		
Recovery INADEQUATE	5		6		
NO recovery or the ATM ground actions for recovery have worsened the situation or ATM airborne has worsened the situation	10		15		0
TCAS triggered (useful RAs only to be considered) or see and avoid pilot decision (in the absence of TCAS)	10		0		
NO TCAS RA	0		10		0
Pilot(s) followed RA (or, in absence of RA, took other effective action, as a result of see and avoid decision)	0		0		
Pilot(s) INSUFFICIENTLY followed RA	0		10		
Pilot(s) INCORRECTLY followed RA (or, in the absence of RA, took other inadequate action)	0		15		0
	TOTAL (2-ATM Ground)	0	TOTAL (2-ATM Airborne)	0	0

TOTAL SEVERITY :	
SEVERITY ATM =(1) + (2-ATM)	**0**
SEVERITY ATM Ground = (1) + (2-ATM Ground)	**0**

QUALITATIVE VERSION - SEVERITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

A. SEVERITY

	1. Risk of collision					
RF	Separation ATM Ground	achieved	> 75%	**75%** - 50%	**50%** - 25%	<= 25%
RF	Separation ATM Airborne	achieved	> 75%	**75%** - 50%	**50%** - 25%	<= 25%
RF	Rate of closure ATM Ground	NONE	LOW	MEDIUM	HIGH	VERY HIGH
RF	Rate of closure ATM Airborne	NONE	LOW	MEDIUM	HIGH	VERY HIGH

	2. Controllability			
RF	Conflict detected	YES	Late	NO
RF	Plan	Correct	Inadequate	None
RF	Execution ATM Ground	Correct	Inadequate	None
RF	Execution ATM Airborne	Correct	Inadequate	None
RF	Detection of loss of separation (including STCA)	by ATCO	by STCA	No detection
RF	Recovery ATM Ground	Correct	Inadequate	None
RF	Recovery ATM Airborne	Correct	Inadequate	None
RF	TCAS/Own initiative see and avoid	Triggered		None
RF	Pilot action	Follow RA (or, in absence of RA, took other effective action)	Insufficien-tly followed RA	Incorrectly followed RA (or took other inadequate action)

SEVERITY ATM	**E**
SEVERITY ATM Ground	**E**

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title e.g. Separation ATM Ground". The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY Marksheet Guidance

❶ Risk of Collision

Risk of collision criterion refers to the physical space/margins that we have left to a collision and according to its ICAO definition it is a PROXIMITY criterion.

Geometry of the encounter is very important and the overall risk of collision will be derived from the achieved separation combined with the rate of closure.

The score for risk of collision, either from the achieved separation or the rate of closure, could be lowered if there is positive visual identification of the pilot with the encounter.

Certain encounters are inherently more severe than others. E.g. head-on encounters are more severe than aircraft moving in the same direction.

- The separation sub-criterion refers to the separation, intended or not, as in fact this criterion looks at the physical horizontal and vertical distances achieved between aircraft.
- When scoring separation, the "best" value of the infringed horizontal and vertical separation shall be taken in the consideration.
- When no separation minimum is defined, then the moderation panel/investigators, based on expert judgement, will choose a score between 0 and 10.
- When there is no agreement on the distances between the aircraft, the criterion should not be scored at all and the field should be left blank. This will be reflected in the value of the Reliability Factor.
- The "worst" value between horizontal and vertical rate of closure will be taken into consideration when scoring the rate of closure sub-criterion.
- When no agreement on the values for rate of closure can be achieved between the aircraft, then the moderation panel/investigators, should not score the criterion at all and the field should be left blank. This will be reflected in the value in the Reliability Factor.

❷ Controllability

Controllability is the second major sub-criterion of Severity and describes the "level of control" that players had over the situation (ATCOs and pilots supported by Safety Nets). ATM, both total aviation and ATM ground, segments have to be considered from the perspective of control over the situation. The purpose of this step is to balance (positively or negatively) the result of the proximity evaluation in the light of the amount of control that the ATM exhibited.

This facilitates an evaluation of the amount of luck or providence intervention that "saved the day". The "logic" is that if there has been some control over the situation, even though the separation was tight, it was nevertheless achieved by the system. For this step it is proposed to follow the typical defence barriers as they apply chronologically (See Section 3).

Other factors that could influence the controllability are:

- Available reaction time. Encounters that allow the pilot little time to react to avoid a collision are more severe than encounters in which the pilot has ample time to respond.

- Environmental conditions, weather, visibility and surface conditions.

Conflict detection sub-criterion refers to ATM ground detection and therefore the column ATM Overall will inherit the same score as ATM Ground. The ATM Airborne score will always be zero for this sub-criterion.

- 'Conflict DETECTED' includes cases where conflict is detected but the decision of the ATCO is to accept the situation. It includes cases when detection was made with the support of a predictive STCA (Short Term Conflict Alert) warning that gives sufficient time to execute a plan. In cases of Tower related incidents, conditions that degrade the quality of the visual information available to the pilot and controllers, such as poor visibility, increase the variability of the pilot and controller detection, planning execution and response and, as such, may influence the scoring and hence the severity of the incident.

- 'Conflict detected LATE' should not be scored automatically whenever separation is infringed; consideration should be taken with regard to the circumstances involved before a decision to score is made. This criterion should be scored if the conflict was detected late, but there was still time to form a plan and execute it. In units with predictive STCA, the conflict is detected due to the predictive STCA.

- 'Conflict NOT detected' should NOT be scored in cases such as level busts or other incidents where ATM Ground cannot form a prior plan, conflict detection is not applicable and a zero should be scored to maintain the Reliability Factor tracked.

Planning sub-criterion refers to the ATM Ground plan and therefore the column ATM Overall will inherit the same score as ATM Ground. When assessing the planning "performance," the timing and efficiency of that planning should also be assessed. The plan refers to the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation. This plan will be referred to in the subsequent Execution steps but not necessarily in the Recovery step.

- When the planning is either late or does not lead to a timely and effective resolution of the conflict then 'Plan INADEQUATE' should be scored.

- When 'Conflict NOT detected' is scored, then 'NO plan' should also be scored.

- Whenever Conflict detection is not applicable (such as Level bust cases) then Planning sub criterion is not applicable and a zero should be marked.

The 'plan' adequacy to be assessed is the plan that the ATCO team is forming to solve the hazard situation detected, before any excursion of the safety envelope occurs (i.e. separation is infringed).

Execution sub-criterion refers in general to ATM Ground execution in accordance with the developed plan and therefore in case of no pilot deviation from the instructed plan, the column ATM Overall will inherit the same score as ATM Ground. Pilot execution will be scored in the ATM Airborne column. Execution refers to the execution of the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation.

- When assessing the execution, the time and efficiency of that execution should be assessed.

- ATM Ground execution is INADEQUATE when it is not timely or not effective. It refers to the same plan developed in the 'Planning' criterion, prior to the system excursion of the safety envelope. It includes the cases when it is contrary to any prior good planning. The pilot execution is scored separately in the ATM Airborne column.

- When no conflict is detected, 'Conflict NOT detected' should be selected. In addition, 'NO plan' and 'NO execution' should also be selected. No execution also comprises cases when there is a plan but it is not implemented at all.

- Whenever Conflict detection and Planning are not applicable such as deviation from ATC clearance (e.g. runway incursion due to pilot deviation from ATC clearance) then the Execution criterion for ATM Ground is also not applicable.

Loss of Separation detected because of STCA. The STCA (Short Term Conflict Alert) sub-criterion should be scored when the controller failed to detect the conflict without the safety net's support and consequently failed to plan and execute a correct resolution (the conflict has been observed due to safety nets - useful safety nets warning). In cases involving of false/nuisance alerts this criterion should be disregarded.

- When the conflict is detected by the ATCO then a zero should be scored.

- STCA usage in the unit needs careful consideration when scoring this criterion. It needs to make a difference between predictive and current STCA – parameterisation is important. A large time warning in advance will bring warnings that will potentially be nuisances.

- 'No STCA warning' should be scored when the conflict was not detected or detected late by the ATM Ground and STCA should have been triggered according to its implemented logic, but it failed to function. Hence the ground safety net barrier did not work.

Recovery from actual conflict is the phase requiring immediate actions to restore the "equilibrium" or at least to confine the hazard. ATM ground recovery would be scored in the ATM Ground column; pilot recovery will be scored in the column ATM Airborne. This sub-criterion refers to the ATM Ground recovery and the ATM Airborne recovery. Therefore, the column ATM Overall will inherit the sum of both the Ground and Airborne values.

- Scoring 'Recovery INADEQUATE' indicates that the ATM reaction, after the actual conflict is declared, had not improved the situation.

- When scoring 'NO recovery….', consideration should be made as to whether a TCAS/pilot see and avoid action was triggered or not, as this could be the reason why the ATC instruction was not followed. In this case, there should be no penalty on the ATM airborne part.

- When the aircraft are diverging, then the Recovery should be scored as 'Not Applicable' and a zero should be given.

- When assessing the recovery the time and efficiency of that recovery should be considered. The Recovery step starts from the moment when the safety margins have been breached (potentially due to the fact that the plan for solving the hazardous situation was inadequate or totally missing). From this step, the plan is a new one and is different from the first plan established in the detection/planning phase. It is seeking the performance of bringing the system back within its safety envelope (such as re-establishment of the separation minima). Recovery might include, depending on type of occurrence (e.g. airspace in which it occurred and services to be provided), cases where traffic information or avoiding actions were necessary to be issued by ATC.

Airborne Safety Nets – The TCAS sub-criterion should be scored only for useful[1] TCAS RAs (as per ICAO definitions).

- The 'No TCAS RA' option should be used in situations when the geometry of the encounter would require a TCAS RA (based on ICAO TCAS logic) and that did not occur.

- 'TCAS triggered....' should be scored as not applicable (i.e. a score of zero should be given) if adequate ATC instructions are issued before the pilot reaction due to TCAS RA.

- For cases where TCAS has saved the day, 'TCAS triggered....' will be scored. The score will be assigned in the ATM Ground column to reflect that the ground barrier has failed and because TCAS is considered to be an integrated component of ATM Airborne and ATM Overall.

- In cases of Runway events, lack of see and avoid should be scored in the case of low visibility and IMC conditions (or during night time), or if the ATM airborne barrier, see and avoid, is not functioning any more in low visibility.

1- RA classifications
Useful RA - The ACAS II system generated an advisory in accordance with its technical specifications in a situation where there was, or would have been, a risk of collision between the aircraft.
Unnecessary RA - The ACAS II system generated an advisory in accordance with its technical specifications in a situation where there was not, or would not have been, a risk of collision between the aircraft.
False RA - The ACAS II system generated an advisory which was based on a false track created by erroneous surveillance data or an onboard system malfunction.
Phantom RA - A form of a false RA in which the ACAS II system generated an advisory against a non existing threat aircraft.

Pilot execution of TCAS RA (or application of see and avoid where appropriate in cases where TCAS is not applicable) and recovery is a criterion to gather the complementary performance to ATM ground.

- For the criterion 'Pilot(s) followed RA (or, in absence of RA, took other effective action, as a result of an alerted see and avoid decision)' the NIL scoring is retained mainly to facilitate the qualitative scheme but also to recall that the system both ATM Ground has been penalised already in the 'TCAS triggered' sub-criterion above.

- 'Pilot(s) INSUFFICIENTLY followed RA' applies when pilot action is not reacting fully in accordance with the resolution advisory, but ATM ground has enough controllability over the situation.

- 'Pilot(s) INCORRECTLY followed RA (or, in the absence of RA, took other inadequate action)' is scored for ATM Overall whenever the pilot actions were either missing or contradictory (e.g. did not follow the RA). Another example here could be some of the level bust cases where ATM Ground has NO margin to recover and to instruct accordingly and it is only providence that saved the day. A contradictory reaction or non-reaction to a TCAS RA should be considered as being the worst case possible.

NOTE: The use of see and avoid refers to an 'alerted' see and avoid. The following is an extract from the Australian Civil Aviation Safety Authority of what an alerted see-and-avoid concept is. *"Pilots are alerted to the presence of another aircraft, usually by mutual contact (especially for GA pilots). They can then ensure that the aircraft is flown clear of conflicting traffic or can arrange mutual separation. Alerting devices must be guaranteed for the see and avoid to be a dependable line of defence. Also, there must be enough time for pilots to resolve situational awareness and establish alerted see-and-avoid."*

QUANTITATIVE VERSION - REPEATABILITY Marksheet

B. REPEATABILITY

3. Systemic issues	ATM ground		ATM airborne		ATM overall
Procedures DESIGN	12		12		
Procedures IMPLEMENTATION	8		8		
Procedures LACK OF	8		8		0
Equipment DESIGN	12		12		
Equipment IMPLEMENTATION	8		8		
Equipment LACK OF	8		8		0
Human resources management (staff planning, staff assignment, training) DESIGN	12		12		
Human resources management IMPLEMENTATION	8		8		
Human resources management LACK OF	8		8		0
Other contributing factors DESIGN	12		12		
Other contributing factors IMPLEMENTATION	8		8		
Other contributing factors LACK OF	8		8		0
	TOTAL 4a	0	TOTAL 4b	0	0
Total (4-ATM) = (4a)+(4b)	**0**				
Total (4-ATM Ground) = (4b)	**0**				

4. Window of Opportunity			
	Situation		
Methods	Daily routine	Workload peak	Emergency/ Unusual situations
normal	7	5	3
degraded mode	6	4	2
contingency	3	2	1
Total (5)			

TOTAL REPEATABILITY :	
ATM =(3-ATM)+(4)	**0**
ATM Ground = (3-ATM GROUND)+(4)	**0**

QUALITATIVE VERSION - REPEATABILITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

B. REPEATABILITY

	3. Systemic issues			
RF	Procedures - ATM Ground	Design	Implement	Lack of
RF	Procedures - ATM Airborne	Design	Implement	Lack of
RF	Equipment - ATM Ground	Design	Implement	Lack of
RF	Equipment - ATM Airborne	Design	Implement	Lack of
RF	Human resources management - ATM Ground	Design	Implement	Lack of
RF	Human resources management - ATM Airborne	Design	Implement	Lack of
RF	Other contributing factors - ATM Ground	Design	Implement	Lack of
RF	Other contributing factors - ATM Airborne	Design	Implement	Lack of

	4. Window of Opportunity			
RF	Situation	Daily routine	Workload peak	Emergency/ Unusual situations
RF	Methods	Normal	Degraded mode	Exceptional

REPEATABILITY ATM	5
REPEATABILITY ATM Ground	5

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY Marksheet Guidance

❸ Systemic Issues

Systemic Issues sub-criterion refers to absent or failed defences, including the systems, conditions, equipment, situations, procedures, countermeasures or behaviours which normally prevent this type of occurrence. Systemic issues refer also to the Organisational latent system-based factors which were present before the incident, and may have contributed to the occurrence of specific adverse task or environmental conditions or absent or failed defences. 'System' is understood in this marksheet to be the aggregation of people, equipment and procedures.

The sub-criteria have been retained consistent with issues in - Design, Implementation and Absence/Lack of:

- Procedures – DESIGN - The procedures are badly designed and are inducing safety issues. Cases involving overloads could be scored here (e.g. for design of the detection of overloads).

- Procedures – IMPLEMENTATION -This should reflect issues in the implementation of a procedure, such as implementation done differently from that required by the design. Cases involving overloads could be scored here (e.g. for implementation issues). All the human aspects that impact on the implementation (lack of training or violation of procedures) shall NOT be scored here but in the Human Resources Management issues.

- Procedures LACK OF - Procedures are needed and are missing. Absence of procedures was identified as a contributory cause to the assessed occurrence. Cases involving overloads could be scored here (e.g. lack of means to detect overloads).

- The same logic used for Procedures is to be followed for Equipment.

Human resources management refers to that part of the system which is concerned with "people". It covers therefore all related issues such as recruitment, training, competency checks as well as staff planning, operational room management etc.

- The Human resources management - DESIGN - causes can range from manpower planning up to shift roster and design of training etc. Those systemic causes should be retrievable amongst the occurrence causes.

Note: ATM Airborne and ATM Ground columns are differentiated as one relates to aircraft and the other to the ground system, with the global ATM picture being given by the total sum of the two.

Other issues include Human Involvement (Human Factors) and active failures that are not necessarily identified as system issues but are contributing factors that led to the occurrence.

- Issues such as hear-back, read-back errors, all the physiological and psychological errors can be included in this category. It is sometimes difficult to identify a contributing factor as a systemic issue, even when 'substitution' test techniques are applied. However, investigators will consider it worth retaining for subsequent trend analysis.

Systemic/Contributing Factors. An area is provided (in blue to the right of the Systemic Issues area of the marksheet) where a list of the list of systemic/contributing factors can be listed. Two options are available:

1. By selecting from a drop-down list provided to choose the relevant option. (Available only for Categories of causes).
2. Alternatively a list of causes defined within the HEIDI taxonomy, or a customised list, can be selected by selecting CTRL+L to open the selection window, selecting the preferred list and selecting the relevant cause.

Note: More than one cause can be selected by ticking the relevant boxes.

Note: Irrespective of whether they are systemic or not, all contributing factors are part of the Repeatability criteria and will drive the likelihood value and **NOT** the Severity part.

4 Window of Opportunity

"Window of Opportunity" refers to the possibility of such a situation (traffic, weather and other elements) to exist in the future in conjunction with the working methods that were required to be in use at the time of occurrence.

Note: Methods or techniques either normal, degraded mode or exceptional are roughly linked to the type of situation. However, what is aimed at being captured here are the circumstances in conjunction with the methods/techniques to be applied. This would concern more the medium categories of 'emergency/unusual' and 'workload peak' where there is not necessarily an obvious link with the techniques to be applied. Types of situations that fall under the 'Emergency/unusual' category are those that, at the time of the occurrence, there are already emergency or unusual situations being handled by the position involved, e.g. aircraft hijack, radio communication failure, bomb threat, engine failure etc.

- Normal: The ATM Unit operates under its normal conditions without any degraded modes or contingencies in place.

- Degraded Mode: The ATM unit is working at a reduced level of service invoked by equipment outage or malfunctions, staff shortage or procedures are becoming inadequate as a knock-on effect of one or several deficient system elements.

- Contingency: Contingency measures are in place and the ATM unit is operating under exceptional conditions e.g. industrial action, pandemics, closure of airspace for major military exercises or war operations etc.

QUANTITATIVE VERSION – SEVERITY Marksheet

A. SEVERITY

1. Risk of collision	ATM ground		ATM airborne		ATM overall
Safety margin achieved	0		0		
Safety margin infringed minor	1-3		1-3		
Safety margin infringed medium	4-6		4-6		
Safety margin infringed significant	7-9		7-9		
Safety margin infringed critical	10		10		
Total safety margin (a)					0
Rate of closure NONE	0		0		
Rate of closure LOW (<=20knots)	1		1		
Rate of closure MEDIUM (>20 and <=40knots)	2		2		
Rate of closure HIGH (>40 and <=80 knots)	4		4		
Rate of closure VERY HIGH (>80knots)	5		5		
Total rate of closure (b)					0

TOTAL (1-ATM) Risk of Collision (a)+(b)	**0**
TOTAL (1-ATM Ground) Risk of Collision (a)+(b)	**0**

2. Controllability	ATM ground		ATM airborne		ATM overall
Conflict detected	0		0		
Conflict detected late	3		0		
Conflict NOT detected	5		0		0
Plan CORRECT	0		0		
Plan INADEQUATE	3		0		
NO plan	5		0		0
Execution CORRECT	0		0		
Execution INADEQUATE	3		5		
NO execution	5		10		0
Loss of separation detected because of Ground safety net (e.g. A-SMGCS Level 2 safety net)	3		0		
No detection (including by Ground safety net)	5		0		0
Recovery CORRECT	0		0		
Recovery INADEQUATE	5		6		
NO recovery or the ATM ground actions for recovery have worsened the situation or ATM airborne has worsened the situation	10		15		0
See and avoid pilot or driver decision	10		0		
No see and avoid action possible	0		10		0
Pilot/ Driver took other effective action, as a result of see and avoid decision	0		0		
Pilot/ Driver took INSUFFICIENT action as a result of see and avoid	0		10		
Pilot/ Driver INCORRECTLY took other action or NO pilot action with no further ATM ground controlability margin	0		15		0
	TOTAL (2-ATM Ground)	0	TOTAL (2-ATM Airborne)	0	0

TOTAL SEVERITY :	
SEVERITY ATM =(1) + (2-ATM)	**0**
SEVERITY ATM Ground = (1) + (2-ATM Ground)	**0**

QUALITATIVE VERSION – SEVERITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

A. SEVERITY

	1. Risk of collision					
RF	Separation ATM Ground	achieved	minor	medium	significant	critical
RF	Separation ATM Airborne	achieved	minor	medium	significant	critical
RF	Rate of closure ATM Ground	NONE	LOW	MEDIUM	HIGH	VERY HIGH
RF	Rate of closure ATM Airborne	NONE	LOW	MEDIUM	HIGH	VERY HIGH

	2. Controllability			
RF	Conflict detected	YES	Late	NO
RF	Plan	Correct	Inadequate	None
RF	Execution ATM Ground	Correct	Inadequate	None
RF	Execution ATM Airborne	Correct	Inadequate	None
RF	Detection of loss of separation (including ground safety nets)	by ATCO	by ground safety net	No detection
RF	Recovery ATM Ground	Correct	Inadequate	None
RF	Recovery ATM Airborne	Correct	Inadequate	None
RF	See and avoid pilot decision	Yes		None possible
RF	Pilot action as a result of see and avoid decision	Effective	Insufficient	No pilot action with no further ATM ground controllability margin

SEVERITY ATM	E
SEVERITY ATM Ground	E

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY Marksheet Guidance

1 Risk of Collision

Risk of collision criterion refers to the physical space/margins that we have left to a collision and, according to its ICAO definition it is a PROXIMITY criterion.

Geometry of the encounter is very important and the overall risk of collision will be derived from the achieved separation combined with the rate of closure.

The score for risk of collision, either from the achieved separation or the rate of closure, could be lowered if there is positive visual identification of the pilot with the encounter.

Certain encounters are inherently more severe than others. E.g. encounters with two aircraft on the same runway are more severe than incidents with on aircraft on the runway and one aircraft approaching the runway. Similarly, head-on encounters are more severe than aircraft moving in the same direction.

- The separation sub-criterion refers to the separation, intended or not, as in fact this criterion looks to the physical horizontal and vertical distances achieved between aircraft.
- When scoring separation, the 'best' value of the infringed horizontal and vertical separation shall be taken into consideration.
- When determining whether the safety margin was achieved or not, and if not, then the severity of the separation infringement, the separation criteria from the 'More than One Aircraft' marksheet should be used (e.g. under low visibility or radar environment.
- When no separation minimum is defined then the moderation panel/investigators, based on expert judgment, will choose a score between 0 and 10, based on the perceived safety margin achieved. If there is no agreement on the safety margin between the aircraft and vehicle, then the moderation panel/investigators, will not score the criterion at all and the field should be left blank. This will be reflected in the value of the Reliability Factor.
- For each specific situation, the values are not fixed and can be adjusted by the investigator within the provided values.
- The rate of closure should be measured at the moment the separation is infringed (not at the closest point of approach). If separation is lost after the crossing point, the rate of closure should be scored as zero.
- The 'worst' value between the horizontal and vertical speed different will be taken into consideration when scoring the rate of closure sub-criterion.
- When no agreement on the values for rate of closure can be achieved between the aircraft and vehicle, then the moderation panel/investigators, should not score the criterion at all and the field should be left blank. This will be reflected in the value in the Reliability Factor.

- When exercising their professional judgement in establishing the rate of closure and the overall risk of collision, the investigators should pay attention to the approach speed of the aircraft and the distance to the runway at which, e.g. a go-around was initiated.

2 Controllability

Controllability is the second major sub-criterion of Severity and describes the 'level of control' that players had over the situation (ATCOs and pilots supported by Safety Nets). ATM, both total aviation and ATM Ground segments have to be considered from the perspective of control over the situation. The purpose of this step is to balance (positively or negatively) the result of the proximity evaluation in the light of the amount of control that the ATM exhibited.

This facilitates an evaluation of the amount of luck or providence intervention that 'saved the day'. The 'logic' is that if there has been some control over the situation, even though the separation was tight, it was nevertheless achieved by the ATM system. For this step it is proposed to follow the typical defence barriers as they apply chronologically. For each specific situation, the values are not fixed and can be adjusted by the investigator, but only within the provided values.

Other factors that could influence the controllability are:

- Available reaction time – encounters that allow the pilot little time to react to avoid a collision are more severe than encounters in which the pilot has ample time to respond.
- Environmental conditions – weather, visibility, surface conditions.

For guidance on the usage of the barrier model, see Section 3.

Conflict detection sub-criterion refers to ATM ground detection and therefore column ATM Overall will inherit the same score as ATM Ground.

- 'Conflict detected LATE' should also be scored when the conflict is only partially detected and not all the side effects are considered. This criterion should not be scored automatically whenever the separation is infringed or the safety margin is not achieved, but circumstances involved should be considered before a decision to score is taken. The conflict was detected late but there was still time to form a plan and execute it.

- 'Conflict NOT detected' should be NOT scored in cases such deviation from ATM clearance (e.g. runway incursion due to pilot deviation from clearance) or other incidents where ATM ground cannot form a prior detection and plan, conflict detection is not applicable and a 0 should be scored to maintain the Reliability Factor tracked.

Planning sub-criterion refers to ATM ground plan and therefore the column ATM Overall will inherit the same score as ATM ground. When assessing the planning "performance" the timing and efficiency of that planning should be assessed. The plan refers to the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation. This plan will be referred to in the next steps of the Execution but not necessarily in the Recovery step.

- When the planning is either late or does not lead to a timely and effective resolution of the conflict then INADEQUATE planning should be scored.

- When 'Conflict NOT detected' is scored, 'NO plan' should also be scored.

- Whenever Conflict detection is not applicable, such as deviation from ATC clearance, (e.g. runway incursion due to pilot deviation from ATC clearance), then Planning sub criterion is not applicable and a zero should be scored.

Execution sub-criterion refers in general to ATM ground execution in accordance with the developed plan and therefore in cases involving no pilot deviation from the instructed plan, the column ATM Overall will inherit the same score as ATM Ground. Pilot execution will be scored in the ATM Airborne column. Execution refers to the execution of the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation.

- When assessing the execution, the time and efficiency of that execution should be assessed.

- ATM ground execution is INADEQUATE when it is not timely or not effective. It refers to the same plan developed in the 'Planning' criterion, prior to the system excursion of the safety envelope. It includes cases when it is contrary to prior good planning. The pilot execution is scored separately in the ATM Airborne column.

- When no conflict is detected, 'Conflict NOT detected' should be selected. In addition, 'NO plan' and 'NO execution' should also be selected. No execution also comprises cases when there is a plan but it is not implemented at all.

- Whenever Conflict detection and Planning are not applicable such as deviation from ATC clearance (e.g. runway incursion due to pilot deviation from ATC clearance) then the Execution criterion for ATM ground is also not applicable.

Loss of Separation Detected Because of Ground Safety Net sub-criterion should be scored when a controller failed to detect the conflict without the safety net's support and consequently failed to plan and execute a correct resolution (the conflict has been observed due to safety nets - useful safety nets alert). In cases of false/nuisance alerts or units without Ground Based Safety Nets, this criterion should be scored as not applicable and a zero should be given.

- Ground safety net usage needs careful consideration when scoring this criterion. It needs to make a difference between predictive and current Ground safety net (e.g. A-SMGCS safety net) – parameterisation is important.

- 'NO Detection (Including by Ground Safety Net)' should be scored when the conflict was not detected or detected late by the ATM ground and the Ground Based Safety Net warning should have been triggered according to its implemented logic but it failed to function. Hence the ground based safety net barrier did not work as designed.

Recovery from actual conflict is the phase requiring immediate actions to restore the "equilibrium" or at least to confine the hazard. ATM ground recovery would be scored in the ATM Ground column. Pilot recovery will be scored in the ATM Airborne column. Recovery is assessing potentially a different plan from the initial one scored in the Planning and Execution criteria. In certain cases (depending on the airspace and type of services ensured) correct recovery can be just the action of passing traffic information.

- The recovery phase is very important in assessing the level of controllability over the occurrence. The INADEQUATE recovery refers to the fact that ATM reaction, after the actual conflict is declared, had not improved the situation. However an accident did not occur.

- When scoring Recovery, time and efficiency of that recovery should be assessed.

- When scoring 'NO recovery….', consideration should be made as to whether a pilot see and avoid action was triggered or not. It could be that the reason for not following the ATC instruction was a see and avoid action. In this case, there should be no penalty on the ATM airborne part.

- When the aircraft are diverging, then the Recovery should be scored as 'Not Applicable' and a zero should be given.

- The Recovery step starts from the moment when the safety margins have been breached (potentially due to the fact that the plan for solving the hazardous situation was inadequate or totally missing). From this step the plan is a new one ie different from the first plan established in the detection/planning phase and is seeking the performance of bringing the system back within its safety envelope (such as re-establishment of the separation minima). Recovery might include, depending on type of occurrence (e.g. airspace in which occurred and services to be provided), cases where traffic information or avoiding actions had to be issued by ATC.

Airborne Safety Nets – 'See and avoid pilot decision' sub-criterion should be scored only for alerted see and avoid (see note below). 'No see and avoid possible' should be used in situations when the Stop Bars were not functioning or they were not turned on, although they should have been.

- Pilot execution and recovery is a criterion to gather the complementary performance to ATM ground.

- For the criterion 'Pilot took other effective action', the score should be zero as both ground and overall ATM has been penalised already in the previous criterion. This sub criterion is retained to facilitate the qualitative scheme. This criterion also applies when the pilot is correctly following ATM ground adequate recovery actions. In cases where the airport and aircraft are equipped with a safety net system (e.g. via Mode S) this should be considered in addition to see and avoid.

- 'Pilot took INSUFFICIENT action as a result of 'see and avoid" applies when pilot action are not fully effective.

- 'Pilot INCORRECTLY took other action or NO pilot action with no further ATM ground controllability margin' should be scored for overall ATM whenever the pilot actions were either missing or contradictory to the last resort of see and avoid. Another example here could be some of the runway incursion cases where ATM ground has NO margin to recover and to instruct accordingly, and it is only providence that saved the day. A contradictory reaction or non-reaction to a last resort see and avoid should be considered the worst case possible.

QUANTITATIVE VERSION - REPEATABILITY Marksheet

B. REPEATABILITY

3. Systemic issues	ATM ground		ATM airborne		ATM overall
Procedures DESIGN	12		12		
Procedures IMPLEMENTATION	8		8		
Procedures LACK OF	8		8		0
Equipment DESIGN	12		12		
Equipment IMPLEMENTATION	8		8		
Equipment LACK OF	8		8		0
Human resources management (staff planning, staff assignment, training) DESIGN	12		12		
Human resources management IMPLEMENTATION	8		8		
Human resources management LACK OF	8		8		0
Other contributing factors DESIGN	12		12		
Other contributing factors IMPLEMENTATION	8		8		
Other contributing factors LACK OF	8		8		0
	TOTAL 4a	0	TOTAL 4b	0	0

Total (4-ATM) = (4a)+(4b)	**0**
Total (4-ATM Ground) = (4b)	**0**

4. Window of Opportunity			
	Situation		
Methods	Daily routine	Workload peak	Emergency/ Unusual situations
normal	7	5	3
degraded mode	6	4	2
contingency	3	2	1
Total (5)			

TOTAL REPEATABILITY :	
ATM =(3-ATM)+(4)	**0**
ATM Ground = (3-ATM GROUND)+(4)	**0**

QUALITATIVE VERSION - REPEATABILITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

B. REPEATABILITY

	3. Systemic issues			
RF	Procedures - ATM Ground	Design	Implement	Lack of
RF	Procedures - ATM Airborne	Design	Implement	Lack of
RF	Equipment - ATM Ground	Design	Implement	Lack of
RF	Equipment - ATM Airborne	Design	Implement	Lack of
RF	Human resources management - ATM Ground	Design	Implement	Lack of
RF	Human resources management - ATM Airborne	Design	Implement	Lack of
RF	Other contributing factors - ATM Ground	Design	Implement	Lack of
RF	Other contributing factors - ATM Airborne	Design	Implement	Lack of

	4. Window of Opportunity			
RF	Situation	Daily routine	Workload peak	Emergency/ Unusual situations
RF	Methods	Normal	Degraded mode	Exceptional

REPEATABILITY ATM	5
REPEATABILITY ATM Ground	5

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

REPEATABILITY Marksheet Guidance

3 Systemic Issues

Systemic Issues sub-criterion refers to absent or failed defences, including the systems, conditions, equipment, situations, procedures, countermeasures or behaviours which normally prevent this type of occurrence. Systemic issues refer also to the Organisational latent system-based factors which were present before the incident, and may have contributed to the occurrence of specific adverse task or environmental conditions or absent or failed defences. 'System' is understood in this marksheet to be the aggregation of people, equipment and procedures.

The sub-criteria have been retained consistent with issues in - Design, Implementation and Absence/Lack of:

- Procedures – DESIGN - The procedures are badly designed and are inducing safety issues. Cases involving overloads could be scored here (e.g. for design of the detection of overloads).

- Procedures – IMPLEMENTATION -This should reflect issues in the implementation of a procedure, such as implementation done differently from that required by the design. Cases involving overloads could be scored here (e.g. for implementation issues). All the human aspects that impact on the implementation (lack of training or violation of procedures) shall NOT be scored here but in the Human Resources Management issues.

- Procedures LACK OF - Procedures are needed and are missing. Absence of procedures was identified as a contributory cause to the assessed occurrence. Cases involving overloads could be scored here (e.g. lack of means to detect overloads).

- The same logic used for Procedures is to be followed for Equipment.

Human resources management refers to that part of the system which is concerned with "people". It covers therefore all related issues such as recruitment, training, competency checks as well as staff planning, operational room management etc.

- The Human resources management - DESIGN - causes can range from the manpower planning up to shift roster and design of training etc. Those systemic causes should be retrievable amongst the occurrence causes.

- Human resources management – IMPLEMENTATION – This criterion refers to identified issues regarding: implementation of training; adherence to manpower policies; adherence to the rules of rostering, sector manning etc. They are causes concluded during occurrence analysis.

- Human resources management – LACK OF – Human resource management is needed. Absence of human resources management was identified as a contributory cause to the assessed occurrence.

Other issues include Human Involvement (Human Factors) and active failures that are not necessarily identified as system issues but are contributing factors that led to the occurrence.

- Issues such as hear-back, read-back errors, all the physiological and psychological errors can be included in this category. It is sometimes difficult to identify a contributing factor as a systemic issue, even when 'substitution' test techniques are applied. However, investigators will consider it worth retaining it for subsequent trend analysis.

Systemic Factors. An area is provided (in blue to the right of the Systemic Issues area of the marksheet) where a list of the list of systemic factors can be listed. Two options are available:

- By selecting from a drop-down list provided to choose the relevant option. (Available only for Categories of causes).
- Alternatively a list of causes defined by HEIDI, or a customised list, can be selected by typing CTRL+L to open the selection window, selecting the preferred list and selecting the relevant cause.

Note: More than one cause can be selected by ticking the relevant boxes.

4 Window of Opportunity

Window of Opportunity refers to the possibility of such a situation (traffic, weather and other elements) to exist in the future in conjunction with the working methods that were required to be in use at the time of occurrence.

Note: Methods or techniques either normal, degraded mode or exceptional are roughly linked to the type of situation. However, what is aimed at being captured here are the circumstances in conjunction with the methods/techniques to be applied. This would concern more the medium categories of 'emergency/unusual' and 'workload peak' where there is not necessarily an obvious link with the techniques to be applied. Types of situations that fall under the 'Emergency/unusual' category are those that, at the time of the occurrence, there are already emergency or unusual situations being handled by the position involved, e.g. aircraft hijack, radio communication failure, bomb threat, engine failure etc.

- Normal: The ATM Unit operates under its normal conditions without any contingencies.

- Degraded Mode: The ATM unit is working at a reduced level of service invoked by equipment outage or malfunctions, staff shortage or procedures are becoming inadequate as a knock-on effect of one or several deficient system.

- Contingency: Contingency measures are in place and the ATM unit is operating under exceptional conditions e.g. industrial action, pandemics, closure of airspace for major military exercises or war operations etc.

QUANTITATIVE VERSION – SEVERITY Marksheet

A. SEVERITY

1. Risk of collision	ATM ground		ATM airborne		ATM overall
Safety margin achieved	0		0		
Safety margin infringed minor	1-3		1-3		
Safety margin infringed medium	4-6		4-6		
Safety margin infringed significant	7-9		7-9		
Safety margin infringed critical	10		10		
Total safety margin (a)					0
Rate of closure NONE	0		0		
Rate of closure LOW (<=20knots)	1		1		
Rate of closure MEDIUM (>20 and <=40knots)	2		2		
Rate of closure HIGH (>40 and <=80 knots)	4		4		
Rate of closure VERY HIGH (>80knots)	5		5		
Total rate of closure (b)					0

TOTAL (1-ATM) Risk of Collision (a)+(b)	**0**
TOTAL (1-ATM Ground) Risk of Collision (a)+(b)	**0**

2. Controllability	ATM ground		ATM airborne		ATM overall
Conflict detected	0		0		
Conflict detected late	3		0		
Conflict NOT detected	5		0		0
Plan CORRECT	0		0		
Plan INADEQUATE	3		0		
NO plan	5		0		0
Execution CORRECT	0		0		
Execution INADEQUATE	3		5		
NO execution	5		10		0
Loss of separation detected because of Ground safety net (e.g. A-SMGCS Level 2 safety net)	3		0		
No detection (including by Ground safety net)	5		0		0
Recovery CORRECT	0		0		
Recovery INADEQUATE	5		6		
NO recovery or the ATM ground actions for recovery have worsened the situation or ATM airborne has worsened the situation	10		15		0
See and avoid pilot or driver decision	10		0		
No see and avoid action possible	0		10		0
Pilot/ Driver took other effective action, as a result of see and avoid decision	0		0		
Pilot/ Driver took INSUFFICIENT action as a result of see and avoid	0		10		
Pilot/ Driver INCORRECTLY took other action or NO pilot action with no further ATM ground controlability margin	0		15		0
	TOTAL (2-ATM Ground)	0	TOTAL (2-ATM Airborne)	0	0

TOTAL SEVERITY :	
SEVERITY ATM =(1) + (2-ATM)	**0**
SEVERITY ATM Ground = (1) + (2-ATM Ground)	**0**

QUALITATIVE VERSION – SEVERITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

A. SEVERITY

	1. Risk of collision					
RF	Separation ATM Ground	achieved	minor	medium	significant	critical
RF	Separation ATM Airborne	achieved	minor	medium	significant	critical
RF	Rate of closure ATM Ground	NONE	LOW	MEDIUM	HIGH	VERY HIGH
RF	Rate of closure ATM Airborne	NONE	LOW	MEDIUM	HIGH	VERY HIGH

	2. Controllability			
RF	Conflict detected	YES	Late	NO
RF	Plan	Correct	Inadequate	None
RF	Execution ATM Ground	Correct	Inadequate	None
RF	Execution ATM Airborne	Correct	Inadequate	None
RF	Detection of loss of separation (including ground safety nets, e.g. A-SMGCS Level 2 safety net)	by ATCO	by ground safety net	No detection
RF	Recovery ATM Ground	Correct	Inadequate	None
RF	Recovery ATM Airborne	Correct	Inadequate	None
RF	See and avoid pilot or driver decision	Yes		None possible
RF	Pilot/Driver action as a result of see and avoid decision	Effective	Insufficient	No action with no further ATM ground controllability margin

SEVERITY ATM	E
SEVERITY ATM Ground	E

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY Marksheet Guidance

1 Risk of Collision

Risk of collision criterion refers to the physical space/margins that we have left to a collision and, according to its ICAO definition, it is a PROXIMITY criterion.

Geometry of the encounter is very important and the overall risk of collision will be derived from the achieved separation combined with the rate of closure.

The score for risk of collision, either from the achieved separation or the rate of closure, could be lowered if there is positive visual identification of the pilot with the encounter.

Certain encounters are inherently more severe than others. E.g. encounters with an aircraft and a vehicle, either another aircraft or ground vehicle, on the same runway are more severe than incidents with on aircraft on the runway and the vehicle approaching the runway. Similarly, head-on encounters are more severe than aircraft and vehicle moving in the same direction.

- The safety margin sub-criterion refers to the proximity, intended or not, as in fact this criterion looks to the physical horizontal and/or vertical distances achieved between aircraft and vehicle.
- When no separation minima is defined then the moderation panel/investigators, based on expert judgment, will choose a score between 0 and 10, based on the perceived safety margin achieved. If there is no agreement on the safety margin between the aircraft and vehicle, then the moderation panel/investigators, will not score the criterion at all and **the field should be left blank.** This will be reflected in the value of the Reliability Factor.
- For each specific situation, the values are not fixed and can be adjusted by the investigator within the provided values.
- The rate of closure should be measured at the moment the separation is infringed (not at the closest point of approach). If separation is lost after the crossing point, the rate of closure should be scored as zero.
- The 'worst' value between the horizontal and vertical speed different will be taken into consideration when scoring the rate of closure sub-criterion.
- When no agreement on the values for rate of closure can be achieved between the aircraft and vehicle, then the moderation panel/investigators, should not be scored the criterion at all and **the field should be left blank.** This will be reflected in the value in the Reliability Factor.
- When exercising their professional judgement in establishing the rate of closure and the overall risk of collision, the investigators should pay attention to the approach speed of the aircraft and/or vehicle and the distance to the runway at which, e.g. a go-around was initiated.

❷ Controllability

Controllability is the second major sub-criterion of Severity and describes the 'level of control' that players had over the situation (ATCOs and pilots supported by Safety Nets). ATM, both total aviation and ATM Ground segments have to be considered from the perspective of control over the situation. The purpose of this step is to balance (positively or negatively) the result of the proximity evaluation in the light of the amount of control that the ATM exhibited.

This facilitates an evaluation of the amount of luck or providence intervention that 'saved the day'. The 'logic' is that if there has been some control over the situation, even though the separation was tight, it was nevertheless achieved by the ATM system. For this step it is proposed to follow the typical defence barriers as they apply chronologically. For each specific situation, the values are not fixed and can be adjusted by the investigator, but only within the provided values.

Other factors that could influence the controllability are:

- Available reaction time – encounters that allow the pilot little time to react to avoid a collision are more severe than encounters in which the pilot has ample time to respond.

- Environmental conditions – weather, visibility, surface conditions.

Actions made by vehicles/drivers should also be considered and these should be reflected in the ATM Airborne column. As such, the ATM Ground and ATM Overall scores will be correct, with the understanding that the ATM Airborne will reflect the vehicle/driver assessment.

For guidance on the usage of the barrier model, see Section 3.

Conflict detection sub-criterion refers to ATM ground detection and therefore ATM Overall column will inherit the same score as ATM Ground.

- 'Conflict detected LATE' should also be scored when the conflict is only partially detected and not all the side effects are considered. This criterion should not be scored automatically whenever the separation is infringed or the safety margin is not achieved, but circumstances involved should be considered before a decision to score is taken. The conflict was detected late but there was still time to form a plan and execute it.

- 'Conflict NOT detected' should NOT be scored in cases such as level busts or other incidents where ATM ground cannot form a prior plan. In these cases conflict detection is not applicable and a zero should be scored to maintain the Reliability Factor tracked.

Planning sub-criterion refers to the ATM ground plan and therefore the ATM Overall column will inherit the same score as ATM Ground. When assessing the planning "performance" the timing and efficiency of that planning should be assessed. The plan refers to the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation. This plan will be referred to in the next steps of the Execution but not necessarily in the Recovery step.

- When the planning is either late or does not lead to a timely and effective resolution of the conflict then INADEQUATE planning should be scored.

- When 'Conflict NOT detected' is scored, 'NO plan' should also be scored.

- Whenever Conflict detection is not applicable such as deviation from ATC clearance, (e.g. runway incursion due to pilot deviation from ATC clearance), then Planning sub criterion is not applicable and a zero should be scored.

Execution sub-criterion refers in general to ATM ground execution in accordance with the developed plan and therefore in cases involving no pilot deviation from the instructed plan, the column ATM Overall will inherit the same score as ATM Ground. Pilot execution will be scored in the ATM Airborne column. Execution refers to the execution of the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation. Actions made by vehicles/drivers should also be considered and these should be reflected in the ATM Airborne column. As such, the ATM Ground and ATM Overall scores will be correct, while the ATM Airborne could be seemingly flawed by the vehicle/driver assessment.

- When assessing the execution, the time and efficiency of that execution should be considered. In addition, consideration should be given as to whether visibility 8is relevant.

- ATM ground execution is INADEQUATE when it is not timely or not effective. It refers to the same plan developed in the 'Planning' criterion, prior to the system excursion of the safety envelope. It includes the cases when it is contrary to the prior good planning. The pilot execution is scored separately in the ATM Airborne column.

- When no conflict is detected, 'Conflict NOT detected' should be selected. In addition, 'NO plan' and 'NO execution' should also be selected. No execution also comprises cases when there is a plan but it is not implemented at all.

- Whenever Conflict detection and Planning are not applicable such as deviation from ATC clearance (e.g. runway incursion due to pilot deviation from ATC clearance) then the Execution criterion for ATM ground is also not applicable.

Loss of Separation Detected Because of Ground Safety Net (e.g. A-SMGCS safety net Level 2) sub-criterion should be scored when a controller failed to detect the conflict without the safety net's support and consequently failed to plan and execute a correct resolution (the conflict has been observed due to safety nets - useful safety nets alert). In cases of false/nuisance alerts or units without Ground Based Safety Nets, this criterion should be scored as not applicable and a zero should be given.

- Ground based safety net usage needs careful consideration when scoring this criterion. It needs to make a difference between predictive and current Ground based safety net (e.g. A-SMGCS safety net Level 2) – parameterisation is important.

- 'NO Detection (Including by Ground Safety Net)' should be scored when the conflict was not detected or detected late by the ATM ground and the Ground Based Safety Net warning should have been triggered according to its implemented logic but it failed to function. Hence the ground based safety net barrier did not work as designed.

Recovery from actual conflict is the phase requiring immediate actions to restore the "equilibrium" or at least to confine the hazard. ATM ground recovery would be scored in the ATM Ground column. Pilot and/or driver recovery will be scored in the column ATM Airborne. Recovery is assessing potentially a different plan from the initial one scored in the Planning and Execution criteria. In certain cases (depending on the airspace and type of services ensured) correct recovery can be just the action of passing traffic information.

- The recovery phase is very important in assessing the level of controllability over the occurrence. The INADEQUATE recovery refers to the fact that ATM reaction, after the actual conflict is declared, had not improved the situation. However an accident did not occur.

- When scoring Recovery, time and efficiency of that recovery should be assessed.

- When scoring 'NO recovery…', consideration should be made as to whether a pilot see and avoid action was triggered or not. It could be that the reason for not following the ATC instruction was a see and avoid action. In this case, there should be no penalty on the ATM airborne part.

- When the aircraft are diverging, then the Recovery should be scored as 'Not Applicable' and a zero should be given.

- The Recovery step starts from the moment when the safety margins have been breached (potentially due to the fact that the plan for solving the hazardous situation was inadequate or totally missing). From this step the plan is a new one different from the first plan established in the detection/planning phase and is seeking the performance of bringing the system back within its safety envelope (such as re-establishment of the separation minima). Recovery might include, depending on type of occurrence (e.g. airspace in which occurred and services to be provided), cases where traffic information or avoiding actions was necessary to be issued by ATC.

Airborne Safety Nets – 'See and avoid pilot decision' sub-criterion should be scored only for alerted see and avoid (see note below). 'No see and avoid possible' should be used in situations when the Stop Bars were not functioning or they were not turned on, although they should have been.

- Pilot execution and recovery is a criterion to gather the complementary performance to ATM ground.

- For the criterion 'Pilot took other effective action', the score should be zero as both ground and overall ATM has been penalised already in the previous criterion. This sub criterion is retained to facilitate the qualitative scheme. In cases where the airport and aircraft are equipped with a safety net system (e.g. via Mode S) this should be considered in addition to see and avoid.

- 'Pilot took INSUFFICIENT action as a result of 'see and avoid' applies when pilot actions are not fully effective.

- 'Pilot INCORRECTLY took other action or NO pilot action with no further ATM ground controllability margin' should be scored for overall ATM whenever the Pilot actions were either missing or contradictory to the last resort of see and avoid.

- A contradictory reaction or a non-reaction to the last resort see and avoid is considered the worst case possible.

- Another example here could be some of the runway incursion cases where ATM ground has NO margin to recover and to instruct accordingly and it is only providence that saved the day.

NOTE: The use of see and avoid refers to an "alerted" see and avoid. The following is an extract from the Australian Civil Aviation Safety Authority of what an alerted see-and-avoid concept is. *"Pilots are alerted to the presence of another aircraft, usually by mutual contact (especially for GA pilots). They can then ensure that the aircraft is flown clear of conflicting traffic or can arrange mutual separation. Alerting devices must be guaranteed for the see and avoid to be a dependable line of defence. Also, there must be enough time for pilots to resolve situational awareness and establish alerted see-and-avoid."*

QUANTITATIVE VERSION – REPEATABILITY Marksheet

B. REPEATABILITY

3. Systemic issues	ATM ground		ATM airborne		ATM overall
Procedures DESIGN	12		12		
Procedures IMPLEMENTATION	8		8		
Procedures LACK OF	8		8		0
Equipment DESIGN	12		12		
Equipment IMPLEMENTATION	8		8		
Equipment LACK OF	8		8		0
Human resources management (staff planning, staff assignment, training) DESIGN	12		12		
Human resources management IMPLEMENTATION	8		8		
Human resources management LACK OF	8		8		0
Other contributing factors DESIGN	12		12		
Other contributing factors IMPLEMENTATION	8		8		
Other contributing factors LACK OF	8		8		0
	TOTAL 4a	0	TOTAL 4b	0	0

Total (4-ATM) = (4a)+(4b)	**0**
Total (4-ATM Ground) = (4b)	**0**

4. Window of Opportunity			
	Situation		
Methods	Daily routine	Workload peak	Emergency/ Unusual situations
normal	7	5	3
degraded mode	6	4	2
contingency	3	2	1
Total (5)			

TOTAL REPEATABILITY :	
ATM =(3-ATM)+(4)	**0**
ATM Ground = (3-ATM GROUND)+(4)	**0**

QUALITATIVE VERSION – REPEATABILITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

B. REPEATABILITY

	3. Systemic issues			
RF	Procedures - ATM Ground	Design	Implement	Lack of
RF	Procedures - ATM Airborne	Design	Implement	Lack of
RF	Equipment - ATM Ground	Design	Implement	Lack of
RF	Equipment - ATM Airborne	Design	Implement	Lack of
RF	Human resources management - ATM Ground	Design	Implement	Lack of
RF	Human resources management - ATM Airborne	Design	Implement	Lack of
RF	Other contributing factors - ATM Ground	Design	Implement	Lack of
RF	Other contributing factors - ATM Airborne	Design	Implement	Lack of

	4. Window of Opportunity			
RF	Situation	Daily routine	Workload peak	Emergency/ Unusual situations
RF	Methods	Normal	Degraded mode	Exceptional

REPEATABILITY ATM	5
REPEATABILITY ATM Ground	5

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

REPEATABILITY Marksheet Guidance

❸ Systemic Issues

Systemic Issues sub-criterion refers to absent or failed defences, including the systems, conditions, equipment, situations, procedures, countermeasures or behaviours which normally prevent this type of occurrence. Systemic issues refer also to the Organisational latent system-based factors which were present before the incident, and may have contributed to the occurrence of specific adverse task or environmental conditions or absent or failed defences. 'System' is understood in this marksheet to be the aggregation of people, equipment and procedures.

The sub-criteria have been retained consistent with issues in - Design, Implementation and Absence/Lack of:

- Procedures – DESIGN - The procedures are badly designed and are inducing safety issues. Cases involving overloads could be scored here (e.g. for design of the detection of overloads).

- Procedures – IMPLEMENTATION -This should reflect issues in the implementation of a procedure, such as implementation done differently from that required by the design. Cases involving overloads could be scored here (e.g. for implementation issues). All the human aspects that impact on the implementation (lack of training or violation of procedures) shall NOT be scored here but in the Human Resources Management issues.

- Procedures - LACK OF - Procedures are needed and are missing. Absence of procedures was identified as a contributory cause to the assessed occurrence. Cases involving overloads could be scored here (e.g. lack of means to detect overloads).

- The same logic used for Procedures is to be followed for Equipment.

Human resources management refers to that part of the system which is concerned with "people". It covers therefore all related issues such as recruitment, training, competency checks as well as staff planning, operational room management etc.

- The Human resources management – DESIGN – causes can range from the manpower planning up to shift roster and design of training etc. Those systemic causes should be retrievable amongst the occurrence causes.

- Human resources management – IMPLEMENTATION – This criterion refers to identified issues regarding: implementation of training; adherence to manpower policies; adherence to the rules of rostering, sector manning etc. They are causes concluded during occurrence analysis.

- Human resources management – LACK OF – Human resource management is needed. Absence of human resources management was identified as a contributory cause to the assessed occurrence.

Other issues include Human Involvement (Human Factors) and active failures that are not necessarily identified as system issues but are contributing factors that led to the occurrence.

- Issues such as hear-back, read-back errors, all the physiological and psychological errors can be included in this category. It is sometimes difficult to identify a contributing factor as a systemic issue, even when 'substitution' test techniques are applied. However, investigators will consider it worth retaining it for subsequent trend analysis.

Systemic Factors. An area is provided (in blue to the right of the Systemic Issues area of the marksheet) where a list of the list of systemic factors can be listed. Two options are available:

- By selecting from a drop-down provided to choose the relevant option. (Available only for Categories of causes).
- Alternatively a list of caused defined by HEIDI, or a customised list, can be selected by typing CTRL+L to open the selection window, selecting the preferred list and selecting the relevant cause.

Note: More than one cause can be selected by ticking the relevant boxes.

4 Window of Opportunity

Window of Opportunity refers to the possibility of such a situation (traffic, weather and other elements) to exist in the future in conjunction with the working methods that were required to be in use at the time of occurrence.

Note: Methods or techniques either normal, degraded mode or exceptional are roughly linked to the type of situation. However, what is aimed at being captured here are the circumstances in conjunction with the methods/techniques to be applied. This would concern more the medium categories of 'emergency/unusual' and 'workload peak' where there is not necessarily an obvious link with the techniques to be applied. Types of situations that fall under the 'Emergency/unusual' category are those that, at the time of the occurrence, there are already emergency or unusual situations being handled by the position involved, e.g. aircraft hijack, radio communication failure, bomb threat, engine failure etc.

- Normal: The ATM Unit operations under its normal conditions without any contingencies.

- Degraded Mode: The ATM unit is working at a reduced level of service invoked by equipment outage or malfunctions, staff shortage or procedures are becoming inadequate as a knock-on effect of one or several deficient system.

- Contingency: Contingency measures are in place and the ATM unit is operating under exceptional conditions e.g. industrial action, pandemics, closure of airspace for major military exercises or war operations etc.

QUANTITATIVE VERSION – SEVERITY Marksheet

A. SEVERITY

1. Risk of collision	ATM ground		ATM airborne		ATM overall
Minimum separation between a/c and ground/area/obstacle achieved	0		0		
Separation + 75% minimum	1		1		
Separation >50%, <=75% minimum	3		3		
Separation >25%, <=50% minimum	7		7		
Separation <=25% minimum	10		10		
Total separation (a)					0
Rate of closure between a/c and ground/area/obstacle NONE	0		0		
Rate of closure LOW (<=60knots, <=1000ft/mn)	1		1		
Rate of closure MEDIUM (>60 and <=120 knots, >1000 and <=2000 ft/mn)	3		3		
Rate of closure HIGH (>120 and <=400 knots, >2000 and <=4000 ft/mn)	4		4		
Rate of closure VERY HIGH (>400knots, >4000ft/mn)	5		5		
Total rate of closure (b)					0

TOTAL (1-ATM) Risk of Collision (a)+(b)	**0**
TOTAL (1-ATM Ground) Risk of Collision (a)+(b)	**0**

2. Controllability	ATM ground		ATM airborne		ATM overall
Conflict with ground/area/obstacle detected	0		0		
Conflict with ground/area/obstacle detected late	3		0		
Conflict with ground/area/obstacle NOT detected	5		0		0
Plan CORRECT	0		0		
Plan INADEQUATE	3		0		
NO plan	5		0		0
Execution CORRECT	0		0		
Execution INADEQUATE	3		5		
NO execution	5		10		0
Loss of separation detected because of MSAW or APW (or other similar SNETS e.g. RIMCAS)	3		0		
No detection (including by MSAW or APW)	5		0		0
Recovery CORRECT	0		0		
Recovery INADEQUATE	5		6		
NO recovery or the ATM ground actions for recovery have worsened the situation or ATM airborne has worsened the situation	10		15		0
GPWS triggered OR see and avoid pilot decision	10		0		
NO GPWS warning	0		10		0
Pilot(s) followed GPWS (or, in absence of GPWS warning took other effective action e.g. follow up see and avoid decision)	0		0		
Pilot(s) INSUFFICIENTLY followed GPWS or ATC instructions	0		10		
Pilot(s) INCORRECTLY followed GPWS (or, in the absence of GPWS warning, took other inadequate action) or ATC Instructions or NO pilot action with no ATM ground controlability margin	0		15		0
	TOTAL (2-ATM Ground)	0	TOTAL (2-ATM Airborne)	0	0

TOTAL SEVERITY :	
SEVERITY ATM =(1) + (2-ATM)	**0**
SEVERITY ATM Ground = (1) + (2-ATM Ground)	**0**

QUALITATIVE VERSION – SEVERITY Marksheet

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

A. SEVERITY

	1. Risk of collision					
RF	Separation between a/c and ground/area/obstacle ATM Ground	achieved	> 75%	75% - 50%	50% - 25%	<= 25%
RF	Separation between a/c and ground/area/obstacle ATM Airborne	achieved	> 75%	75% - 50%	50% - 25%	<= 25%
RF	Rate of closure ATM Ground	NONE	LOW	MEDIUM	HIGH	VERY HIGH
RF	Rate of closure ATM Airborne	NONE	LOW	MEDIUM	HIGH	VERY HIGH

	2. Controllability			
RF	Conflict with ground/area/obstacle detected	YES	Late	NO
RF	Plan	Correct	Inadequate	None
RF	Execution ATM Ground	Correct	Inadequate	None
RF	Execution ATM Airborne	Correct	Inadequate	None
RF	Detection of loss of separation, including MSAW or APW (or other similar SNETS e.g. RIMCAS)	by ATCO	by safety nets	No detection
RF	Recovery ATM Ground	Correct	Inadequate	None
RF	Recovery ATM Airborne	Correct	Inadequate	None
RF	GPWS/ Own initiative see and avoid	Triggered		None
RF	Pilot action	Follow GPWS (or, in absence of GPWS, took other effective action)	Insufficien-tly followed GPWS	Incorrectly followed GPWS (or took other inadequate action)

SEVERITY ATM	E
SEVERITY ATM Ground	E

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY Guidance

1 Risk of Collision

Risk of collision criterion refers to the physical space/margins that we have left to a collision with obstacles and/or ground/water etc and, according to its ICAO definition, it is a PROXIMITY criterion.

Geometry of the encounter is very important and the overall risk of collision will be derived from the achieved separation combined with the rate of closure.

The score for risk of collision, either from the achieved separation or the rate of closure, could be lowered if there is positive visual identification of the pilot with the encounter.

- The separation sub-criterion refers to the separation, intended or not, as in fact this criterion looks to the physical horizontal and vertical distances achieved between aircraft and ground/area/obstacles.
- The 'best' value of the infringed horizontal and vertical separation from the ground/area/obstacles should be taken into consideration when scoring.
- When no separation minima is defined, then the moderation panel/investigators, based on expert judgment, will choose a score between 0 and 10.
- When there is no agreement on the distances between the aircraft and ground/area/obstacles, the criterion should not be scored at all and **the field should be left blank.** This will be reflected in the value of the Reliability Factor.
- For each specific situation, the values are not fixed and can be adjusted by the investigator within the provided values.
- The rate of closure should be measured at the moment the separation is starting to be infringed (not at the closest point of approach). If separation is lost with area/obstacles after a crossing/diverging point, the rate of closure should be scored as zero.
- The 'worst' value between the horizontal and vertical speed different will be taken into consideration when scoring the rate of closure sub-criterion.
- When no agreement on the values for rate of closure can be achieved between the aircraft and ground/area/obstacles, then the moderation panel/investigators, should not score the criterion at all and **the field should be left blank.** This will be reflected in the value in the Reliability Factor.

❷ Controllability

Controllability is the second major sub-criterion of Severity and describes the "level of control" that players had over the situation (ATCOs and pilots supported by Safety Nets). ATM, both total aviation and ATM ground, segments have to be considered from the perspective of control over the situation. The purpose of this step is to balance (positively or negatively) the result of the proximity evaluation in the light of the amount of control that the ATM exhibited.

This facilitates an evaluation of the amount of luck or providence intervention that "saved the day". The "logic" is that if there has been some control over the situation, even though the separation was tight, it was nevertheless achieved by the system. For this step it is proposed to follow the typical defence barriers as they apply chronologically. For each specific situation, the values are not fixed and can be adjusted by the investigator, but only within the provided values.

Other factors that could influence the controllability are:

- Available reaction time – encounters that allow the pilot little time to react to avoid a collision are more severe than encounters in which the pilot has ample time to respond.

- Environmental conditions – weather and visibility.

These other factors are particularly important, especially when scoring near-CFIT, which are potentially more severe and risky occurrences. The One Aircraft Marksheet shall be used to score incidents like near-CFIT, but also in the case of level busts and airspace infringements, where a second aircraft was not present. Particular attention should be paid to the evaluation of the near-CFIT incidents to correctly assess the level of control that ATM and aircraft had over the event.

For guidance on the usage of the barrier model, see Section 3.

Conflict detection sub-criterion refers to ATM ground detection and therefore ATM Overall column will inherit the same score as ATM Ground.

- Conflict with ground/area/obstacle detected LATE: this criterion indicates that a conflict was detected late, but there was still time to form a plan and execute it. It should not be scored automatically whenever there is an incident (e.g. unauthorised penetration of airspace); circumstances involved should be considered before a decision to score is taken.

- Conflict with ground/area/obstacle NOT detected: In cases where ATM ground cannot timely detect the proximity to ground/area/obstacles (such as level busts) then this criterion is not applicable and a zero should be scored.

Planning sub-criterion refers to ATM ground plan and therefore the column ATM Overall will inherit the same score as ATM Ground. When assessing the planning "performance" the timing and efficiency of that planning should be assessed. The plan refers to the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation. This plan will be referred to in the next steps of the execution but not necessarily in the recovery step.

- When the planning is either late or does not lead to a timely and effective resolution of the conflict then "Plan INADEQUATE" should be scored.

- When 'Conflict with ground/area/obstacle NOT detected' is scored, 'NO plan' should also be selected.

- Whenever Conflict detection is not applicable such as deviation from ATC clearance, (e.g. runway incursion), then the Planning sub criterion is not applicable and a zero should be scored.

Execution sub-criterion refers in general to ATM ground execution in accordance with the developed plan and therefore in case of no pilot deviation from the instructed plan, the column ATM Overall will inherit the same score as ATM Ground. Pilot execution will be scored in the ATM Airborne column. Execution refers to the execution of the first plan developed by the ATCO team to solve the detected hazardous/conflictual situation.

- When assessing the execution, the time and efficiency of that execution should be assessed.

- ATM ground execution is INADEQUATE when it is not timely or not effective. It refers to the same plan developed in the 'Planning' criterion, prior to the system excursion of the safety envelope. It includes the cases when it is contrary to the prior good planning. The pilot execution is scored separately in the ATM Airborne column.

- When no conflict is detected, 'Conflict NOT detected' should be selected. In addition, 'NO plan' and 'NO execution' should also be selected. No execution also comprises cases when there is a plan but it is not implemented at all.

- Whenever Conflict detection and Planning are not applicable, such as level bust cases, the Execution criterion for ATM ground is also not applicable and a zero should be given.

Loss of Separation Detected Because of MSAW or APW (or other similar SNETS e.g. RIMCAS) triggered. This sub-criterion should be scored when the controller failed to detect the proximity without the safety net's support and consequently failed to plan and execute a correct resolution (the conflict has been observed due to safety nets - useful safety nets alerts). In case of false/nuisance alerts this criterion should be disregarded.

- Ground based safety net usage needs careful consideration when scoring this criterion. It needs to make a difference between predictive and current MSAW or APM – parameterisation is important.

- 'No Detection (including by MSAW or APW)' should be scored where the conflict was not detected either by the ATCO or by the safety nets, in cases where the geometry of the proximity required the MSAW or APW should have been triggered according to its implemented logic but It failed to function. Hence the ground safety net barrier did not work.

Recovery from actual conflict is the phase requiring immediate action to restore the "equilibrium" or at least to confine the hazard. ATM ground recovery would be scored in the ATM Ground column. Pilot recovery will be scored in the ATM Airborne column. Recovery is potentially assessing a different plan from the initial one scored in the Planning and Execution criteria. In certain cases (depending on the airspace and type of services ensured) correct recovery can be just the action of passing traffic information.

- The recovery phase is very important in assessing the level of controllability over the occurrence. INADEQUATE recovery refers to the fact that ATM reaction, after the actual conflict is declared, had not improved the situation. However an accident did not occur. Pilot recovery is scored in the ATM Airborne column.

- When scoring recovery, time and efficiency of that recovery should be assessed.

- When scoring 'NO recovery…', consideration should be made as to whether a GPWS alert or pilot see and avoid action were triggered or not. It could be that the reason for not following the ATC instruction was a GPWS or see and avoid action. In this case, there should be no penalty on the ATM airborne part.

- Recovery step starts from the moment when the safety margins have been breached (potentially due to the fact that the plan for solving the hazardous situation was inadequate or totally missing). From this step the plan is a new one and therefore different from the first plan established in the detection/planning phase and is seeking the performance of bringing the system back within its safety envelope (such as re-establishment of the separation minima). Recovery might include, depending on type of occurrence (e.g. airspace in which occurred and services to be provided), cases where traffic information or avoiding actions was necessary to be issued by ATC.

Airborne Safety Nets – 'GPWS triggers OR see and avoid pilot decision' sub-criterion should be scored only for useful warnings (as per the ICAO definition). GPWS includes enhanced GPWS and TAWS (Terrain Awareness Warning Systems).

- 'GPWS triggered…' should be scored as not applicable (i.e. a score of zero should be given) if adequate ATC instructions are issued before the pilot reaction due to GPWS.

- For cases where GPWS has saved the day, 'GPWS triggered..' will be scored. The score will be assigned in the ATM Ground column to reflect that the ground barrier has failed and because GPWS is considered to be an integrated component of ATM Airborne and ATM Overall.

- 'NO GPWS warning' should be scored when the GPWS should have been triggered but it failed to function.

- 'Pilot followed GPWS…'This sub criterion should be scored as zero as the system, both ground and overall ATM, has been penalised already in other criterion within this marksheet. The sub criterion has been retained to facilitate the qualitative scheme.

- 'Pilot INSUFFICIENTLY followed GPWS' applies when pilot action is not fully in accordance with GPWS.

- 'Pilot INCORRECTLY followed GPWS…..' should be scored for ATM airborne whenever the pilot actions were either missing or contradictory to the GPWS. It could also apply in cases where ATM ground has NO margin to recover and instructs accordingly and only providence saved the day.

NOTE: The use of see and avoid refers to an "alerted" see and avoid. The following is an extract from the Australian Civil Aviation Safety Authority of what an alerted see-and-avoid concept is. *"Pilots are alerted to the presence of another aircraft, usually by mutual contact (especially for GA pilots). They can then ensure that the aircraft is flown clear of conflicting traffic or can arrange mutual separation. Alerting devices must be guaranteed for the see and avoid to be a dependable line of defence. Also, there must be enough time for pilots to resolve situational awareness and establish alerted see-and-avoid."*

QUANTITATIVE VERSION: – REPEATABILITY Marksheet

B. REPEATABILITY

3. Systemic issues	ATM ground		ATM airborne		ATM overall
Procedures DESIGN	12		12		
Procedures IMPLEMENTATION	8		8		
Procedures LACK OF	8		8		0
Equipment DESIGN	12		12		
Equipment IMPLEMENTATION	8		8		
Equipment LACK OF	8		8		0
Human resources management (staff planning, staff assignment, training) DESIGN	12		12		
Human resources management IMPLEMENTATION	8		8		
Human resources management LACK OF	8		8		0
Other contributing factors DESIGN	12		12		
Other contributing factors IMPLEMENTATION	8		8		
Other contributing factors LACK OF	8		8		0
	TOTAL 4a	0	TOTAL 4b	0	0
Total (4-ATM) = (4a)+(4b)	**0**				
Total (4-ATM Ground) = (4b)	**0**				

4. Window of Opportunity			
	Situation		
Methods	Daily routine	Workload peak	Emergency/ Unusual situations
normal	7	5	3
degraded mode	6	4	2
contingency	3	2	1
Total (4)			

TOTAL REPEATABILITY :	
ATM =(3-ATM)+(4)	**0**
ATS = (3-ATM GROUND)+(4)	**0**

QUALITATIVE VERSION: – REPEATABILITY Marksheet

B. REPEATABILITY

	3. Systemic issues			
RF	Procedures - ATM Ground	Design	Implement	Lack of
RF	Procedures - ATM Airborne	Design	Implement	Lack of
RF	Equipment - ATM Ground	Design	Implement	Lack of
RF	Equipment - ATM Airborne	Design	Implement	Lack of
RF	Human resources management - ATM Ground	Design	Implement	Lack of
RF	Human resources management - ATM Airborne	Design	Implement	Lack of
RF	Other contributing factors - ATM Ground	Design	Implement	Lack of
RF	Other contributing factors - ATM Airborne	Design	Implement	Lack of

	4. Window of Opportunity			
RF	Situation	Daily routine	Workload peak	Emergency/ Unusual situations
RF	Methods	Normal	Degraded mode	Exceptional

REPEATABILITY ATM	**5**
REPEATABILITY ATM Ground	**5**

REPEATABILITY Marksheet Guidance

3 Systemic Issues

Systemic Issues sub-criterion refers to absent or failed defences, including the systems, conditions, equipment, situations, procedures, countermeasures or behaviours which normally prevent this type of occurrence. Systemic issues refer also to the Organisational latent system-based factors which were present before the incident, and may have contributed to the occurrence of specific adverse task or environmental conditions or absent or failed defences. 'System' is understood in this marksheet to be the aggregation of people, equipment and procedures.

The sub-criteria have been retained consistent with issues in - Design, Implementation and Absence/Lack of:

- Procedures – DESIGN - The procedures are badly designed and are inducing safety issues. Cases involving overloads could be scored here (e.g. for design of the detection of overloads).

- Procedures – IMPLEMENTATION -This should reflect issues in the implementation of a procedure, such as implementation done differently from that required by the design. Cases involving overloads could be scored here (e.g. for implementation issues). All the human aspects that impact on the implementation (lack of training or violation of procedures) shall NOT be scored here but in the Human Resources Management issues.

- Procedures - LACK OF - Procedures are needed and are missing. Absence of procedures was identified as a contributory cause to the assessed occurrence. Cases involving overloads could be scored here (e.g. lack of means to detect overloads).

- The same logic used for **Procedures** is to be followed for **Equipment**.

Human resources management refers to that part of the system which is concerned with "people". It covers therefore all related issues such as recruitment, training, competency checks as well as staff planning, operational room management etc.

- The Human resources management – DESIGN – causes can range from the manpower planning up to shift roster and design of training etc. Those systemic causes should be retrievable amongst the occurrence causes.

- Human resources management – IMPLEMENTATION – This criterion refers to identified issues regarding: implementation of training; adherence to manpower policies; adherence to the rules of rostering, sector manning etc. They are causes concluded during occurrence analysis.

- Human resources management – LACK OF – Human resource management is needed. Absence of human resources management was identified as a contributory cause to the assessed occurrence.

Other issues include Human Involvement (Human Factors) and active failures that are not necessarily identified as system issues but are contributing factors that led to the occurrence.

- Issues such as hear-back, read-back errors, all the physiological and psychological errors can be included in this category. It is sometimes difficult to identify a contributing factor as a systemic issue, even when 'substitution' test techniques are applied. However, investigators will consider it worth retaining it for subsequent trend analysis.

Systemic Factors. An area is provided (in blue to the right of the Systemic Issues area of the marksheet) where a list of the list of systemic factors can be listed. Two options are available:

- By selecting from a drop-down list provided to choose the relevant option. (Available only for Categories of causes).

- Alternatively a list of caused defined by HEIDI, or a customised list, can be selected by typing CTRL+L to open the selection window, selecting the preferred list and selecting the relevant cause.

Note: More than one cause can be selected by ticking the relevant boxes.

4 Window of Opportunity

Window of Opportunity refers to the possibility of such a situation (traffic, weather and other elements) to exist in the future in conjunction with the working methods that were required to be in use at the time of occurrence.

Note: Methods or techniques either normal, degraded mode or exceptional are roughly linked to the type of situation. However, what is aimed at being captured here are the circumstances in conjunction with the methods/techniques to be applied. This would concern more the medium categories of 'emergency/unusual' and 'workload peak' where there is not necessarily an obvious link with the techniques to be applied. Types of situations that fall under the 'Emergency/unusual' category are those that, at the time of the occurrence, there are already emergency or unusual situations being handled by the position involved, e.g. aircraft hijack, radio communication failure, bomb threat, engine failure etc.

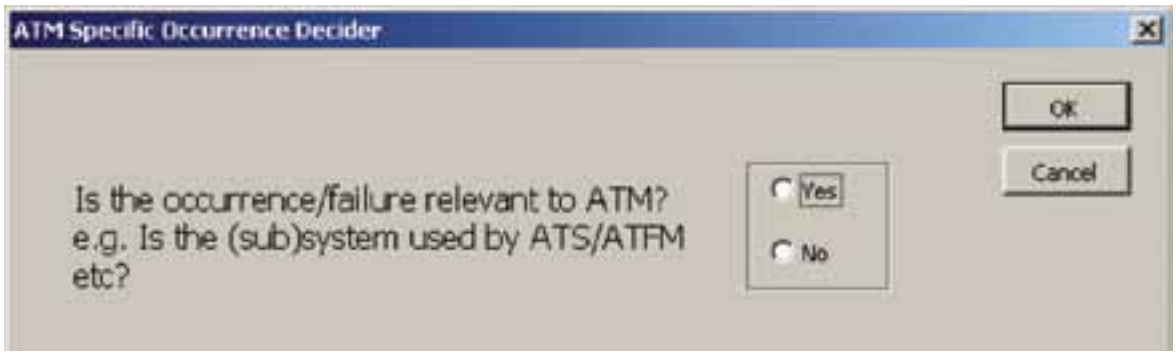
- Normal: The ATM Unit operates under its normal conditions without any contingencies.

- Degraded Mode: The ATM unit is working at a reduced level of service invoked by equipment outage or malfunctions, staff shortage or procedures are becoming inadequate as a knock-on effect of one or several deficient system.

- Contingency: Contingency measures are in place and the ATS unit is operating under exceptional conditions e.g. industrial action, pandemics, closure of airspace for major military exercises or war operations etc.

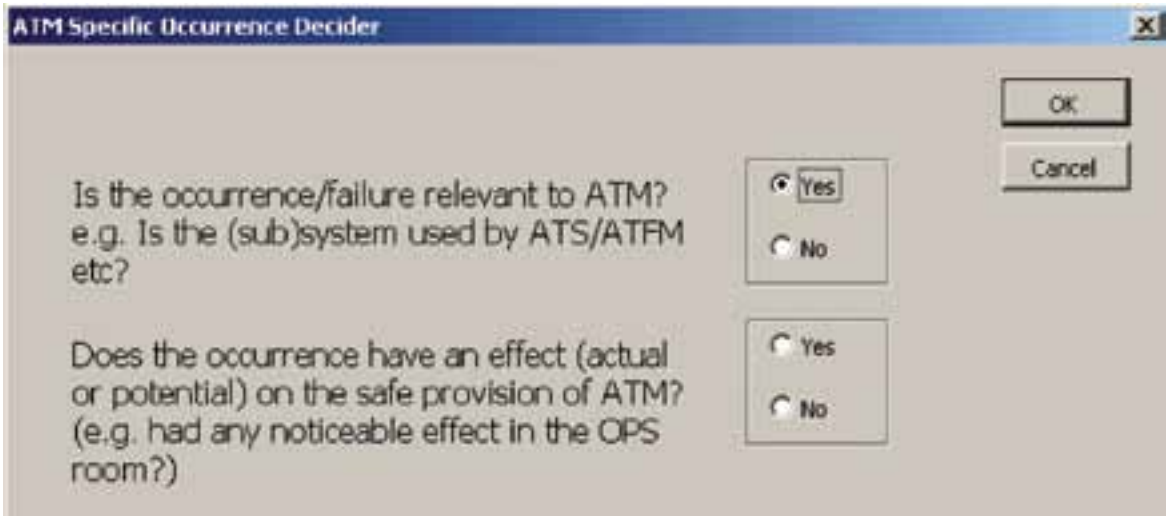
QUANTITATIVE VERSION: – SEVERITY and REPEATABILITY Marksheets

When the ATM Specific Occurrences marksheet is selected, the following decision box will be shown requesting users to selected whether the occurrence or failure is relevant to ATM. A selection must be made prior to using the marksheet.



If 'NO' is selected, a message will be displayed indicating that the occurrence is not an ATM Specific Occurrence and therefore this marksheet is not applicable.

If 'YES' is selected, a further choice will be presented for selection:



If 'YES' is selected, a message will be displayed instructing the user to apply the marksheet to determine the severity and risk of the occurrence.

If 'NO' is selected, a message will be displayed informing the user that the ATM Specific Occurrence has no safety effect (Severity E), and requesting the user to use only the Repeatability section of the marksheet.

A. SEVERITY

	1. Failure criticality	
Generic Function		
Specific Function		
Failure		
	TOTAL (1)	**0**

	2. Extension of the area affected	
ATM Unit(s)/Service Affected		
Extension		
	TOTAL (2)	**0**

	3. Duration until contingency measures are in place or until the occurrences is terminated by itself, before the contingency measures can be effective	
Duration of failure		
	TOTAL (3)	**0**

TOTAL SEVERITY :	
SEVERITY = (1) + (2) + (3)	**0**

B. REPEATABILITY

4. Systemic issues		
Procedures DESIGN	12	
Procedures IMPLEMENTATION	8	
Procedures LACK OF	8	
Equipment DESIGN	12	
Equipment IMPLEMENTATION	8	
Equipment LACK OF	8	
Human resources management (staff planning, staff assignment, training) DESIGN	12	
Human resources management IMPLEMENTATION	8	
Human resources management LACK OF	8	
Other contributing factors DESIGN	12	
Other contributing factors IMPLEMENTATION	8	
Other contributing factors LACK OF	8	
	TOTAL 4	0

5. Window of Opportunity			
	Situation		
normal	7	5	3
degraded mode	6	4	2
contingency	3	2	1
Total (5)			

TOTAL REPEATABILITY :	
ATM GND =(4)+(5)	**0**

QUALITATIVE VERSION: – SEVERITY and REPEATABILITY Marksheets

Following the same principles and logic used in the Quantitative marksheet, an equivalent QUALITATIVE marksheet is available. The Qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria.

A. SEVERITY

1. Failure criticality	
	Generic Function
	Specific Function
	Failure

2. Extension of the area affected	
	ATM Unit(s)/Service Affected
	Extension

3. Duration until contingency measures are in place or until the occurrences is terminated by itself, before the contingency measures can be effective	
	Duration of failure

SEVERITY ATM	E

B. REPEATABILITY

3. Systemic issues			
Procedures - ATM Ground	Design	Implement	Lack of
Procedures - ATM Airborne	Design	Implement	Lack of
Equipment - ATM Ground	Design	Implement	Lack of
Equipment - ATM Airborne	Design	Implement	Lack of
Human resources management - ATM Ground	Design	Implement	Lack of
Human resources management - ATM Airborne	Design	Implement	Lack of
Other contributing factors - ATM Ground	Design	Implement	Lack of
Other contributing factors - ATM Airborne	Design	Implement	Lack of

4. Window of Opportunity			
Situation	Daily routine	Workload peak	Emergency/ Unusual situations
Methods	Normal	Degraded mode	Exceptional

REPEATABILITY ATM	5
REPEATABILITY ATM Ground	5

- To select one option e.g. "75% - 50%", double click on it. The Reliability Factor for the criteria is set to 'ON' automatically (the text in the first column will be turned green in colour).
- To Unselect all options for a specific criteria, double click the title. The Reliability Factor for the criteria will be set to 'OFF' automatically.
- To turn a Reliability Factor 'ON/OFF', double click on the 'RF' in the first column next to the relevant criteria title.

The resulting Severity, Repeatability, Reliability Factor and Risk will be automatically calculated.

SEVERITY and REPEATABIILTY Marksheets Guidance

With respect to ATM Specific Occurrences, the Severity issue is built from totally different criteria and, therefore, a different marking scheme is used.

The criteria used are:

SEVERITY

1 Failure Criticality: This refers to criticality of the ATM system element from where the deficiency originates is to be scored taking into account the following principle: what is the potential of the system component affected to degrade the ability to provide ATM services (radio, radar, personnel, environment,) i.e. type of equipment. The failure criticality would be easier to score if the ATM unit has a Unit Safety Case (USC), in which the ATM system elements' criticality would have been defined. In the absence of a USC, the marksheet already proposes a scoring scheme by using three sub-criteria:

- Generic functions, typical for any ATM environment
- For each Generic function a set of typical systems are proposed
- Finally, a list of typical failures and their associated scores are defined.

A selection must be made from the relevant drop down lists to determine the Generic Function; Specific Function and type of Failure.

The available choices are:

Generic functions	
Air / Ground communication	Radio Navigation Aids.
Ground / Ground Communication	Management of Surface Movements
Air Surveillance	General Information Disposal
FPL / Supplying / Processing / Delivery	Decision Aids, / Tools
Real Time / Duplex Recording Systems	Transversal Services
ATC Environmental Display Tools	Ground Safety Nets
Ops Room Management Tools	Outside Services
Early and Real Time ATFM Tools	Unknown

Specific Function	
Radio System	ATCO Environmental Tools
HF & VHF Frequencies	Work Station Tools
UHF Frequencies	ATFM Tools
Back-up Frequencies	ILS CAT III
Multiple Frequencies	ILS Cat I
Radio Station	Radio-Navigation Management Tools
Data link	Beacons
Ultimate Back-up Radio System	En route Nav. Aids

Specific Function	
Back-up Phone	Surface Radar
Fundamental Coordination	Surface Guidance
Secondary Communication	Lighting
OLDI	Meteorological Information
Phones	Aeronautical Information
Satellite Communication	Technical Aids
Ultimate Back-up Phone System	Supervision / Monitoring
Primary Radars	Time Reference
Secondary Radars	Data Network
Radar Processing	Local Network
Other Sensors	Power / Energy
Display Tools	Air conditioning
Forward Display	Fire / Blaze
Ultimate Radar Back-up System	Simulators
FPL Supplying	Reporting
FPL Processing	Pollution
FPL Supplying	Security
Peripherical Dialog System	Other
Real Time Recording System	Safety Nets
Delay Communication Recording	Outside Services
Archive Processing	

Failure	
Not Detected Incoherence	Quality Worsening
Loss of Usual, Back-up & Ultimate	Too Many Information
Chain / Line loss	Loss of Secondary Function
Loss of Redundancy	Bug involving a Piece of HMI
Loss of Ultimate Back-up System	Combining / splitting
Loss of information	Supervision
Misinformation	Unknown

❷ Geographical extension of area affected: This refers to e.g. the numbers of ATM Units/Service affected; the knock on effect on other sectors/centres should also be taken into account particularly because the effects can be worse on the indirectly affected units/centres. (e.g. an approach being overflown because of unavailability of an ACC terminal sector).

The scoring could vary with the unit size and potentially the flights affected. For some ATS units, one sector could be the size of the ATS unit.

A selection must be made from the relevant drop down lists to determine the type of ATM Unit(s)/Services Affected; and the Extension of the Area Affected.

The available choices are:

Area affected	Extension
Major APP	Unit
ACC + Main APP	Working Position
TWR With Radar	Several Units
TWR Without Radar	ANSP
Unknown	Unknown

❸ Duration until contingency measures are in place or until the occurrence is terminated by itself, before the contingency measures can be effective:

This is a self explanatory criterion and covers the "timing" parameter in the definitions of "Inability to provide services" introduced by the ESARR 2 Classification scheme. The duration interval can be very subjectively scored because 20 minutes or 30 minutes could seem a very long period (sometimes unacceptable) for a failure of a very critical function.

Once the contingency measures are in place the situation is no longer consider critical.

Duration until contingency measures are in place should be considered IRRELEVANT when, after a failure, the contingency measures are already there (e.g. one radar failure in an area with multiple radar coverage).

A selection must be made from the drop down list to determine the duration of failure.

The available choices are:

Duration
Long-term
Medium-term
Short-term
Irrelevant
Unknown

The overall main guideline is to score the 3 criteria in the Severity part by considering all 3 together and their relationship with the unit type and complexity of the traffic and airspace environment.

REPEATABILITY

The criteria for REPEATABILITY are the same as for the previous cases and therefore for any guidance please go to the situation with "More than One Aircraft".

3. BARRIER MODEL

The defence barrier model used is the one introduced by the EUROCONTROL Strategic Performance Framework and further refined by Sequentially Outlining and Follow-up IntegrAted – SOFIA methodology. Hence there are three safety related functions of an ATM system (see Figure 4):

1. Hazard Generation,
2. Hazard Resolution and
3. Incident Recovery.

For the purposes of this guidance document, the term ATM system is taken in its widest possible sense and includes both ground and airborne elements. For the severity purposes we will be looking at Hazard resolution and Incident recovery functions of the model. The third function – Hazard generation – will be looked upon in the systemic issues part and therefore in the repeatability criteria.

Figure 4: Barrier Model

Detailed guidance and explanation on the barrier model is to be found in SOFIA Reference manual section 1.2 and in the HELP spreadsheet. There is no intent herewith to reproduce any of the information already available elsewhere in EUROCONTROL, for the sake of brevity of these guidelines. A summary is given in the excel files containing the mark sheets. For the severity and risk marksheet scope, the Resolution part has been broken down into:

- DETECTION,
- PLANNING and
- EXECUTION sub-barriers.

Refer to each marksheet regarding how to score these sub barriers.

4 RISK CLASSIFICATION AND RELIABILITY FACTORS

On the basis of the figures derived from the Severity and Repeatability assessment, the ESARR2 risk matrix automatically calculates the level of risk for overall ATM risk and ATM ground. The effect can be readily seen at the top of the marksheet being used. However, the ATM ground contribution to a risk is assessed based on information gathered during an investigation, and is not the result of any scoring combination.

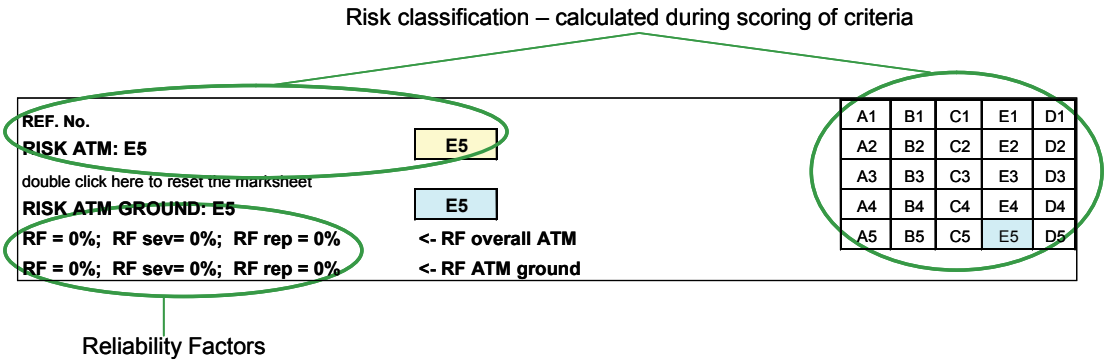


Figure 5: Sample of Risk Classification and Reliability Factors

Two Reliability Factors (RF) are tracked, one for Severity and one for Repeatability.

The notion of a Reliability Factor is multifold:

- The reporting and assessment scheme does not have the same maturity in all ECAC States;
- Not for all safety occurrences will the data be available to quantify all the criteria;
- Not for all safety occurrences will all the criteria be applicable;
- There is a need to have a certain level of trust when trend analysis is performed with safety data from different sources.

The Reliability Factor will measure the level of confidence in the assessment (scoring) undertaken, based on the data available to answer the questions in the marksheets.

If enough data are available to the investigator to answer all the questions in the marksheet, then the risk is correctly calculated and the Reliability Factor will measure that confidence (RF=100%).

Whenever a criterion is scored, the RF will automatically be computed. Whenever the criterion for one reason or another is not applicable for a certain occurrence (e.g. if the conflict was detected by an ATCO, then the STCA criterion is N/A) then that criterion should be scored as zero.

If the criterion is applicable but some information is missing or there are disputes/no agreements on which values are to be recorded, then the criterion should not be scored and no value attributed. **It is important that the field is left blank**, otherwise, if a value of e.g. 0 is recorded, then the criterion will be interpreted as not applicable, or the barrier has worked perfectly.

If not enough information is available for some of the criteria and the Reliability Factor is too low (less than 70% for the Severity part) then the occurrence severity will be manually classified as D – not determined – as can be seen in Figure 6.

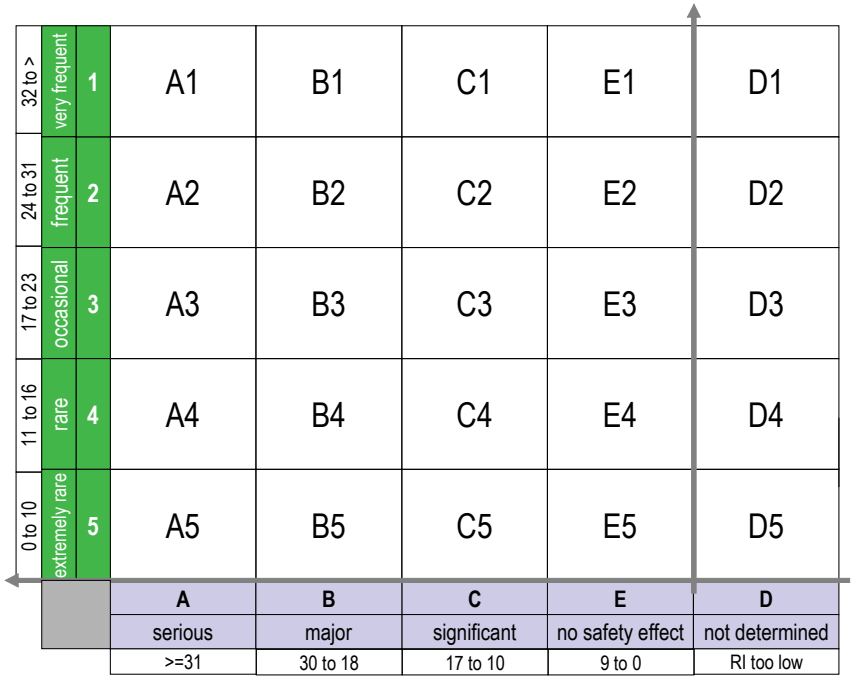


Figure 6: – Sample Risk Classification Chart

Situations when the Reliability Factor(s) can be declared as being too low are where several criteria are pertinent but the investigation team and/or the moderation panel does not have sufficient information to be able to score them. The investigation team and/or the moderation panel should make a final decision for how many criteria and from which percentage of Reliability Factor should declare the Occurrence classified as D - Not determined.

The type of criteria that might not be easy to score are usually those in the Controllability section of the marksheet. There is less difficulty in scoring the risk of collision sub-criterion.

However, it is recommended that once the RF_S is < = 70% the Occurrence is pertinent to be classified as Severity D (RF_S is the Reliability Factor for the Severity part). The Reliability Factor for Repeatability (RF_R) will be a parameter to indicate the confidence in the determination of the likelihood of recurrence.

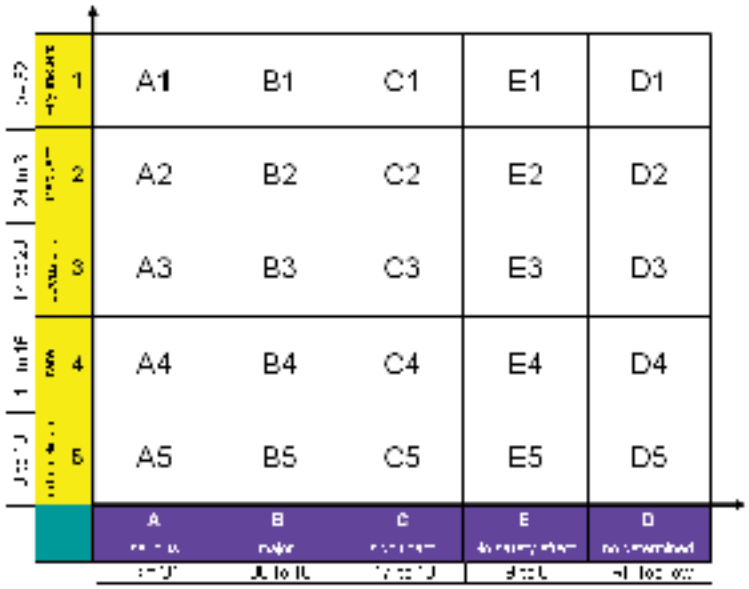
The overall Reliability Factor for the occurrence Risk will be the median of the two Reliability Factors.

$RF = (RF_S + RF_R) / 2$

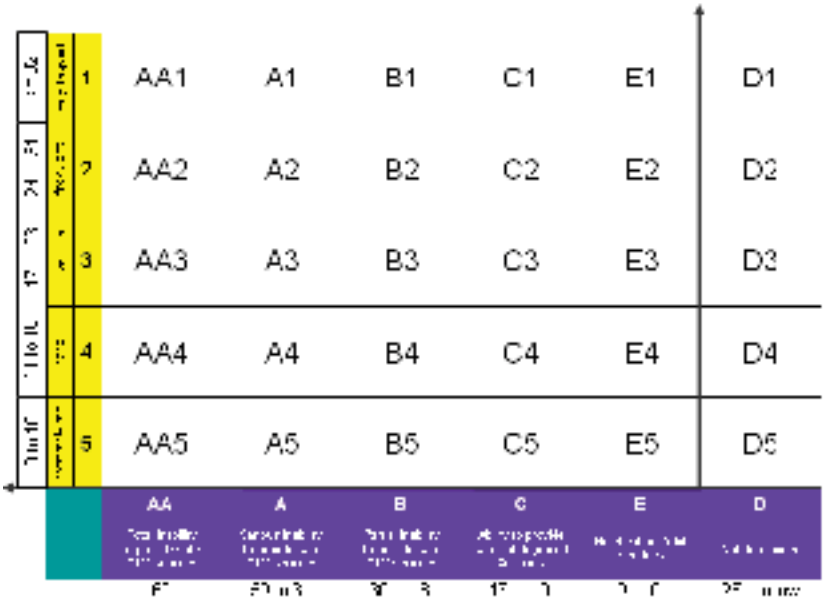
Risk Classification Charts

The following Risk Classification chart is applicable for the following marksheet:

- More than One Aircraft
- Aircraft – Aircraft Tower
- Aircraft with Ground Movement
- One Aircraft Involved



The following Risk Classification chart is applicable for the ATM Specific Occurrence marksheet:



APPENDIX 1 – SYSTEMIC/CONTRIBUTING FACTORS

The assessment/investigation of the occurrence will enable the determination of the chain of events that led to the occurrence and enable the identification of the various reasons why each event took place, thus enabling the development of remedial measures, corrective actions and safety interventions or recommendations.

Selecting CTRL-L while in the Blue area of the Systemic/Contributing Factors area of the marksheets will enable users to select the appropriate contributing factor/s. More than one contributing factor can be selected from the three different lists: Categories; HEIDI; or Custom (user-defined list).

The selected contributing factors will be listed in the blue area, starting with the cell selected before pressing the CTRL+L.

Figure 7: – Sample Contributing Factor Screens

Contributing Factors that combined to result in the occurrence could be classified according to the following high level categories:

Category of Contributing Factors – AST
Physical/Physiological/Psychological/Psychosocial
Interface- working environment
Operational tasks demand
Other (ATM Services Personnel)
Operational ATC procedures
Other operational ATM service procedures
Engineering and maintenance procedures
Other (ATMServices personnel operating procedures and instructions)
Interface between ATM service units
Hardware issues
Software issues
Integration Issues
Aerodrome layout and infrastructure
Other (ATM Services infrastructure Facilities/technical systems)
Route structure

Category of Contributing Factors – AST
Capacity
Sectorisation
ATS airspaces
Other (Airspace Structure)
AIRAC Non-Adherance
ATS Route Description Inconsistencies
Other (AIS)
Safety Management System
Management/personnel policy
Institutional arrangements
Operational line management
Other (Company Structure and Management Policy)
Regulation
Approval Process
Other (Regulatory activity)
Other
Safety Nets

The Green lines in the Systemic Factors spreadsheet allows the user to expand the list of high level categories, should the list not be sufficient. An example being presented in the above table with regard to Safety Nets.

However, the assessment/investigation of the occurrence may require a significant breakdown of those categories in order to better identify the reasons why the occurrence took place and to take adequate prevention measures. The user can select a detailed contributing factor from the list extracted from the HEIDI taxonomy (identical to the list provided for the ESARR2 Annual Summary Template.

Detailed Contributing Factors – HEIDI
ATS related issues
Air/ground Communication -> Hearback omitted
Air/ground Communication -> Readback Pilot
Air/ground Communication -> Phraseology
Air/ground Communication -> R/T monitoring sector
Transfer of communications
Radio communication failure One way
Radio communication failure Two ways
Transmission/reception quality
Blocked microphone
Simultaneous transmissions
Relay/relayed message
Handling of Radio communication failure/unusual situations -> Other
Unlawful radio communication transmission
Ground/ground -> Phraseology
Use of equipment/Equipment verification/testing -> Radar display
Use of equipment/Equipment verification/testing -> FPS display

Detailed Contributing Factors – HEIDI
Use of equipment/Equipment verification/testing -> ATC communication equipment
Use of equipment/Equipment verification/testing -> Other equipment
Co-ordination issues -> Internal co-ordination
Co-ordination issues -> With sectors same unit
Co-ordination issues -> With positions within ATC suite
Co-ordination issues -> External co-ordination
Co-ordination issues -> Special co-ordination procedures
Information on the airport -> ATIS
Information on the airport -> Transition Altitude/level
Information on the airport -> Runway condition
Weather Information at Aerodrome provided -> METAR
Weather Information at Aerodrome provided -> ATIS/VOLMET
Weather Information at Aerodrome provided -> TAF
Weather Information at Aerodrome provided -> SPECI
Weather Information at Aerodrome provided -> SNOWTAM
Weather Information at Aerodrome provided -> Volcanic activity report
Weather -> Aerodrome warning
Weather -> Wind shear warning
Weather -> Weather En-route
Weather -> SIGMET information
Weather -> AIRMET information
Weather -> Pilot(s) report(s)
Regional Pressure reference datum (en-route/regional)
En-route navaids serviceability
NOTAM
Minimum Safe Flight level/altitude/height/sector altitude
Operational Information provision -> Delay
Warnings passed -> MSAW
Warnings passed -> STCA
Warnings passed -> APW
Warnings passed -> Other
Operational Information provision -> Abnormal situations
Information acknowledgement -> Pilot
Information acknowledgement -> ATCO
Handling of unusual/emergency situation -> Acknowledge the call
Handling of unusual/emergency situation -> Identify relevant a/c
Handling of unusual/emergency situation -> Separate/maintain separation form other traffic
Handling of unusual/emergency situation -> Maintain silence on the frequency
Handling of unusual/emergency situation -> Inform supervisor
Handling of unusual/emergency situation -> Inform other positions/sector/units concerned
Handling of unusual/emergency situation -> Support to the pilots
Handling of unusual/emergency situation -> Time given to the pilot
Handling of unusual/emergency situation -> Information exchange
Acknowledgement of flight plan information
Update flight plan information

Detailed Contributing Factors – HEIDI
Flight progress information sorting criteria/classification
Handing over/taking over -> Weather briefing
Handing over/taking over -> Aerodrome
Handing over/taking over -> Airspace
Handing over/taking over -> Navaids
Handing over/taking over -> Equipment Interaction
Handing over/taking over -> Handing over briefing
Transfer of traffic -> Initiate
Transfer of traffic -> Accept
Transfer of traffic -> Standard
Transfer of traffic -> Non Standard
Conflict detection and resolution
Conflict detection and resolution
Short/medium term ATC "Planning"
Conflict detection and resolution
Conflict detection and resolution -> Monitoring of activities
ATC Clearance/instruction/information/advice
Assess team fitness for work
Check Medical and Competence
Rostering/sector opening in relation with expected traffic
Team briefing
Monitor sector traffic load
Coordination with technical department
OPS room management
Handling of accident, incident and emergencies -> Assist ATCOs in recovering control of traffic
Handling of accident, incident and emergencies -> Remove controller from position
Handling of accident, incident and emergencies -> Other
Airspace structure
Interface between ATM service units
Route structure
LAHSO
SIRO
Capacity
Sectorisation
Aerodrome layout and infrastructure
Issue related to operational ATM support service procedures
Issues related to Engineering and maintenance procedures
Issues related to ATM service personnel operating procedures and Instructions
Failure of COMMUNICATION function -> Radio communication system
Failure of COMMUNICATION function -> Telephone system
Failure of COMMUNICATION function -> Intercom
Failure of COMMUNICATION function -> Datalink system
Failure of COMMUNICATION function -> Data exchange network
Failure of COMMUNICATION function -> Recording
Failure of COMMUNICATION function -> Other

Detailed Contributing Factors – HEIDI
Radar source
Radar data processing system
Radar data processing system
Traffic display system
Other -> Hardware issues
Other -> Software issues
Other -> Integration issues
Failure of SURVEILLANCE function -> Airborne element of ATM
Failure of Data Processing and Distribution function
Failure of Data Processing and Distribution function
Failure of Support Information function
Failure to provide NAVIGATION function
Power supply system
AIS up to date
Aeronautical Information Service (AIS) related issues
AIS erroneous data
Flight deck/Pilot and ATM using different data
Documentation/charts
Evaluate traffic demand
Regulate traffic
ATM Service related factors
Licensing – medical
Illness
Incapacitation
Collapse
Health and fitness
Nutrition
Hydration
Exercise
Pain
Stress
Other health issues
Impairment
Alcohol & Smoking
Illicit drugs
Prescription drugs
Fatigue
Sleep loss
Sleep disturbance
Tiredness
Tiredness -> acute
Tiredness -> chronic
Other fatigue issues
Other physiological issues
Lapses

Detailed Contributing Factors – HEIDI
Receipt of information
failed to hear message
failed to see message
Identification of Information
misread
mishear
Identification of Information -> Other
Perception of information
Read-back error
Hear-back error
misperceive
no perception
Perception of information -> Other
Detection
late detection
no detection
Detection -> Other
Misunderstanding
Attention
late recognition
misrecognition
late identification
no identification
Attention -> Other
Monitoring
Monitoring -> forget
Monitoring -> fixate
Monitoring -> channelled
Monitoring -> Other
Timing
Timing -> response
Timing -> Other
Distraction
Distraction -> over short time
Distraction -> over long time
Distraction -> Other
Forgetting
Forgetting -> action already done
Forgetting -> information received or being used
Forgetting -> Other
Loss of Awareness
Loss of Awareness -> of traffic
Loss of Awareness -> of equipment mode
Loss of Awareness -> Other
Slips

Detailed Contributing Factors – HEIDI
Response errors
selecting object
selecting object -> similar look
selecting object -> similar function
selecting object -> Other
positioning
positioning -> overshoot
positioning -> undershoot
positioning -> Other
movement
movement -> wrong type
movement -> wrong direction
movement -> wrong sequence
movement -> no action
movement -> Other
timing
timing -> too early
timing -> too late
timing -> too long
timing -> too short
timing -> Other
recording
recording -> incorrect
recording -> inaccurate
recording -> failed to record
recording -> Other
interruption
interruption -> from own thoughts
interruption -> from environment
interruption -> Other
slip of tongue/pen
Mistakes
Information wrongly associated
Signal information confused
Signal information confused -> spatially close
Signal information confused -> looked/sound alike
Signal information confused -> Other
Workload issues
Workload issues -> too much
Workload issues -> too little
Workload issues -> transition
Workload issues -> Other
Fixation on important/prominent information
Information not detected after searching
Failure to monitor

Detailed Contributing Factors – HEIDI
Failure to monitor -> people
Failure to monitor -> information
Failure to monitor -> automation
Failure to monitor -> Other
Recall of information
Recall of information -> ailed
Recall of information -> inaccurate
Recall of information -> rare information
Recall of information -> past information
Recall of information -> Other
Mis stored or insufficiently learned information
Judgement
Judgement -> separation
mis judged information
Planning
Planning -> insufficient
Planning -> incorrect
Planning -> failed
Planning -> Other
Decision making
Decision making -> incorrect
Decision making -> late
Decision making -> none
Decision making -> Other
Task shedding
Assumptions
Assumptions -> faulty
Assumptions -> wrong
Assumptions -> Other
Mindset
Violations
Violations -> Routine
Violations -> Exceptional
Mental/Emotional/Personnality issues
Mental capacity
Mental capacity -> loss of picture
Mental capacity -> loss of SA
Mental capacity -> Other
Confidence
Confidence -> in self
Confidence -> in others
Confidence -> in equipment
Confidence -> in information
Confidence -> in automation
Confidence -> Other

Detailed Contributing Factors – HEIDI
Complacency
Motivation/Morale
Attitudes to others
Personality traits
Personality traits -> aggressive
Personality traits -> assertive
Personality traits -> under confident
Personality traits -> risk taking
Personality traits -> Other
Emotional status
Emotional status -> stressed
apprehension
anxiety
panic
boredom
Emotional status -> Other
Skills
Skill maintenance
Lack of practice
Inadequate transfer
Techniques
Abilities
Experience
Qualifications
Qualifications -> licence
Qualifications -> ratings
Qualifications -> endorsements
Qualifications -> Other
Inexperience on position
Unfamiliar task/novel situation
Knowledge
Knowledge -> Inadequate
Knowledge -> Regulatory requirements
Knowledge -> Aeronautical
Knowledge -> Procedures
Knowledge -> Met.
Knowledge -> Other
Spoken communications
With aircrew
With aircrew -> language/accent
With aircrew -> situation not conveyed by pilots
With aircrew -> pilots breach of R/T
With aircrew -> high R/T workload
With aircrew -> misunderstanding/interpretation
With aircrew -> other pilot problems

Detailed Contributing Factors – HEIDI
Call sign confusion
Noise interference
Ground-ground communication
Ground-ground communication -> misunderstanding/interpretation
Ground-ground communication -> poor /no coordination
Ground-ground communication -> Other
Other spoken information
Written communication
Written communication -> Data link
Written communication -> Handwriting
Written communication -> Marking of strips
Written communication -> Other written information
Visual signals
Transfer of responsibility
Transfer of responsibility -> Handover/takeover
Transfer of responsibility -> Co ordination
Transfer of responsibility -> Poor communication
Team management -> Returning to sector after break
Team management -> Temporary unmanned position
Team management -> team allocation
Team management -> working methods/responsibilities
High administrative workload
Team dynamics
Team dynamics -> Poor team relations
Team dynamics -> Trust in others
Team dynamics -> Inadequate assertiveness
Team dynamics -> Cultural issues
Team dynamics -> Duty of care
Supervisory problems
Supervisory problems -> Poor/no planning
Supervisory problems -> decision making
Supervisory problems -> feedback
Supervisory problems -> quality control
Poor/inadequate support -> Flight data
Poor/inadequate support -> Maintenance
Other team issues
Traffic load/complexity
Traffic load/complexity -> Excessive load
Traffic load/complexity -> Fluctuating load
Traffic load/complexity -> Unexpected demands
Traffic load/complexity -> Complex mix
Traffic load/complexity -> Unusual situations
Traffic load/complexity -> Abnormal time pressure
Traffic load/complexity -> Underload
Traffic load/complexity -> Similar confusable call signs

Detailed Contributing Factors – HEIDI
Airspace problems
Flights in non controlled and controlled air space
Airspace problems
Airspace problems
Traffic and Airspace
Pilot problems
Pilot problems -> Language
Pilot problems -> Culture
Pilot problems -> Experience
Ambient environment
Ambient environment -> Noise
Ambient environment
Distraction
Ambient environment -> Air quality
Ambient environment -> Lighting
Ambient environment -> Pollution/fumes
Ambient environment -> Radiation
Ambient environment -> Other problems
Problems in work environment
General understaffing
Roster/rest day times
Poor splitting/collapsing sectors
Work scheduling
Terms and condition
Union/professional issues
Administrative workload problems
Poor relations/confidence in management
Job insecurity
Low morale/job satisfaction
Problems in work environment -> Other
Company/commercial pressure
Company/commercial pressure -> Unsafe operations
Company/commercial pressure -> Failure to correct problems
Management problems
Management problems -> Poor/no planning
Management problems -> Poor/no decision making
Management problems -> Poor/no feedback
Management problems -> Other
Organisation problems
Organisation problems -> Organisational change
Organisation problems -> Poor/no planning
Organisation problems -> Poor/no decision making
Organisation problems -> Poor/no feedback
Organisation problems -> Other
Regulatory problems

Detailed Contributing Factors – HEIDI
Regulatory problems -> Poor/no planning
Regulatory problems -> Poor/no decision making
Regulatory problems -> Poor/no feedback
Regulatory problems -> Other
Workplace design -> Poor console layout
Workplace design -> Visibility
Radar problems
Radar problems -> Failure
Radar problems -> SSR label
Changes in radar range
A/C on edge of radar
Transponder problems/failure
Radar problems -> Other
Workplace design
R/T failure
R/T failure -> A/C stuck transmitter
R/T failure -> R/T interference
R/T failure -> Head set problems
R/T failure -> Land line problems
Equipment problems
Lack of equipment
Equipment problems -> Unreliability
Other HMI problems
Other HMI problems -> Recently introduced hardware/software
Other HMI problems -> Visibility
Other HMI problems -> Consistency
Other HMI problems -> Precision demands
Other HMI problems -> Access
Other HMI problems -> Feedback
Other HMI problems -> Other
Information problems
Information problems -> Unavailable
Information problems -> Suppressed
Information problems -> Inaccessible
Information problems -> Mode confusion
Information problems -> Trust in automation
Procedures -> Poor/wrong/no procedures
Procedures -> Written materials
Documentation -> Poor/wrong/no documentation
Poor/wrong/no documentation -> operations manuals/charts
Poor/wrong/no documentation -> advisory manuals
Poor/wrong/no documentation -> inappropriate regulations and standards materials
Poor/wrong/no documentation -> Other
Other procedures/documentation problems
Training -> Inadequate mentoring

Detailed Contributing Factors – HEIDI
Inadequate specialist training
Inadequate specialist training -> OJTI
Inadequate specialist training -> Emergency
Inadequate specialist training -> TRM
Inadequate specialist training -> Recurrent
Inadequate specialist training -> Other
Check and Training
Controller under training
Controller under examination/check
Check and Training -> Inadequate/no manuals
Check and Training -> Other

Should the above list not contain the required systemic contributing factor, or the user is not a HEIDI Taxonomy adopter, the list can be expanded by manually adding in the empty area of the table of the Systemic Factors spreadsheet. An example is provided in the table below:

Detailed causes custom
My Cause 1
My Cause 2
My Cause 3
My Cause 4
My Cause 5
Cause 6
Cause 7
Cause 8

APPENDIX 2 – GLOSSARY

Acronym or Term	Meaning
A-SMGCS	Surface Movement Guidance and Control System
ANSP	Air Navigation Service Provider
APW	Area Proximity Warning
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
CFIT	Controlled Flight Into Terrain
ESARR	EUROCONTROL Safety Regulatory Requirement
EUROCONTROL	European Organisation for the Safety of Air Navigation
GA	General Aviation
GPWS	Ground Proximity Warning System
HEIDI	Harmonisation of European Incident Definition Initiative for ATM
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IMC	Instrumental Meteorological Conditions
MSAW	Minimum Safe Altitude Warning
RA	Resolution Advisory
RF	Reliability Factor
RFR	Reliability Facror for Repeatability
RFS	Reliability Factor for Severity
RIMCAS	Runway Incursion Monitoring and Conflict Alerting System
R/T	Radio Telephony
SAFREP	Safety Data Reporting and Data Flow Task Force
SNETS	Safety Nets
SOFIA	Sequentially Outlining and Follow-up Integrated Analysis
STCA	Short Term Conflict Alert
TCAS	Traffic alert and Collision Avoidance System
TAWS	Terrain Awareness Warning System
TWR	Tower
VFR	Visual Flight Rules

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