

ESARR ADVISORY MATERIAL/GUIDANCE DOCUMENT
(EAM/GUI)

EAM 2 / GUI 5 – ANNEX

**HARMONISATION OF SAFETY
OCCURRENCE SEVERITY AND RISK
ASSESSMENT**

SUMMARY OF MARK SHEETS

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Abstract :		
<p>The objective of this document is to provide a short summary of the severity and risk mark sheets developed as a part of EAM 2 / GUI 5 for compliance with the EUROCONTROL ESARR 2 Severity Classification Scheme.</p> <p>The format has been kept simple and easy to read in order to achieve a common understanding. Consequently it contains components and information that should be appropriate to score severity and risk for safety occurrences as required by ESARR 2.</p>		
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Contact Person(s) :	Tel :	Unit :
Charlie GOVAARTS	+32 2 729 31 22	DGOF/SRU

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F.3 DOCUMENT APPROVAL

The following table identifies all management authorities who have approved this document.

AUTHORITY	NAME AND SIGNATURE	DATE
Quality Control (SRU)	<i>signed by Daniel Hartin</i> (Daniel HARTIN)	31-May-05
Head Safety Regulation Unit (SRU)	<i>signed by Peter Stastny</i> (Peter STASTNY)	31-May-05
Chairman Safety Regulation Commission (SRC)	<i>signed by Ron Elder</i> (Ron ELDER)	31-May-05

Note: For security reasons and to reduce the size of files placed on our website, this document does not contain signatures. However, all management authorities have signed the master copy of this document which is held by the SRU. Requests for copies of this document should be e-mailed to: sru@eurocontrol.int.

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F.4 DOCUMENT CHANGE RECORD

The following table records the complete history of this document.

EDITION NUMBER	EDITION DATE	REASON FOR CHANGE	PAGES AFFECTED
0.01	10-Jan-03	Creation of the first working draft of EAM 2 / GUI 5.	All
0.02	08-Apr-03	Revisions made to EAM 2 / GUI 5 after AST-FP3 meeting inputs and internal SRU review.	All
0.1	05-Jun-03	Document status amended to 'Draft Issue'.	All
0.2	28-Jan-04	Annex created as a result of AST-FP group request to have a simplified version of EAM 2 / GUI 5 in a handout.	All
0.3	10-Mar-04	Amendments introduced following the AST-FP5 meeting held on the 18/20-Feb-04.	All figures, 12
0.4	23-Apr-04	Amendments following AST-FP group contribution and EUROCONTROL AFN business unit contribution to the alerted see and avoid concept.	2.1.1, 2.1.2, 2.1.3, 3
0.5	21-Jun-04	Updates for SRC Consultation following AST-FP6 meeting (2-3 of June 2004).	All
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1.0	31-May-05	Document released following formal SRC consultation and approval (RFC No. 0431).	None

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F.6 EXECUTIVE SUMMARY

The objective of this Annex is to provide a reference for the use of the harmonised severity and risk mark sheets developed by the Safety Regulation Commission (SRC) in compliance with the EUROCONTROL ESARR 2 Severity Classification Scheme.

The format has been kept simple and easy to read in order to achieve a common understanding. Consequently, it contains components and information that should be appropriate to score severity and risk for safety occurrences as required by ESARR 2 – Reporting and Assessment of Safety Occurrences in ATM.

This Annex retains both versions - quantitative and qualitative - of the 3 severity mark sheets developed within EAM 2/GUI 5, including guidance on how to score different criteria.

This document is complemented with two excel files containing the qualitative and quantitative mark sheets.

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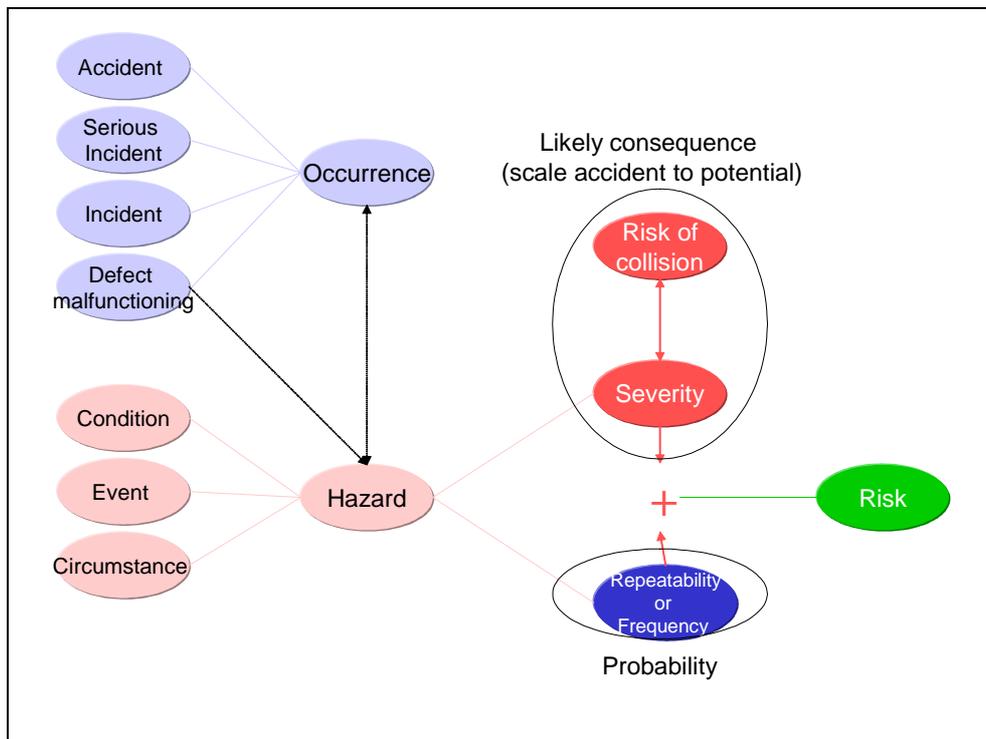
1. KEY TERMS AND CONCEPTS

A comprehensive glossary of terms is retained within the core document of EAM2 / GUI 5. For this Annex, only the following key definitions have been retained:

Term	Definition
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).
Risk	The combination of overall probability, or frequency of occurrence of a harmful effect induced by a hazard and the severity of that effect.

(Table 1 – Key Definitions for the ATM Occurrence Assessment)

The interrelationships of the concepts can be thought of schematically, as represented 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 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 mark sheet 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 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.

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.

2.1 Assessment Procedure

Preliminary Note: Scoring mark sheets are to be seen as a guide to severity and risk assessment rather than as 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.

Scoring Mark Sheet(s)

Number of aircraft involved	
	None (go to section 2.1.3.)
	One (go to section 2.1.2.)
	More than one (go to section 2.1.1.)

(Table 2 – Type of Scoring Mark Sheets)

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2.1.1 More Than One Aircraft Involved

Quantitative Version - More Than 1 Aircraft Involved – SEVERITY Mark Sheet

A. SEVERITY				
1. Risk of collision				
Minimum separation achieved	0			
Separation + 75% minimum	1			
Separation >50%, <=75% minimum	3			
Separation >25%, <=50% minimum	7			
Separation <=25% minimum	10			
Total separation (a)				
Rate of closure NONE	0			
Rate of closure LOW (<=60knots, <=1000ft/mn)	1			
Rate of closure MEDIUM (>60 and <=250 knots, >1000 and <=2000 ft/mn)	3			
Rate of closure HIGH (>250 and <=600 knots, >2000 and <=4000 ft/mn)	4			
Rate of closure VERY HIGH (>600knots, >4000ft/mn)	5			
Total rate of closure (b)				
TOTAL (1) Risk of Collision (a)+(b)	0			
2. Controllability				
	ATM		ATM Ground	
Conflict detected	0		0	
Conflict detected INADEQUATE	3		3	
Conflict NOT detected	5		5	
Plan CORRECT	0		0	
Plan INADEQUATE	3		3	
NO plan	5		5	
Execution CORRECT	0		0	
Execution INADEQUATE	3		3	
NO execution	5		5	
STCA triggered	0		3	
NO STCA warning	5		5	
Recovery CORRECT	0		0	
Recovery INADEQUATE	5		5	
NO recovery or the ATM ground actions for recovery have worsen the situation	10		10	
TCAS triggered (useful RAs only to be considered) or see and avoid pilot decision (in the absence of TCAS)	0		10	
NO TCAS RA	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 or ATC instructions	10		0	
Pilot(s) INCORRECTLY followed RA (or, in the absence of RA, took other inadequate action) or ATC Instructions or NO pilot action at ATC instructions with no further ATM ground controllability margin	25		0	
	TOTAL (2-ATM)	0	TOTAL (2-ATM Ground)	0
TOTAL SEVERITY :				
SEVERITY ATM =(1) + (2-ATM) 0				
SEVERITY ATM Ground = (1) + (2-ATM Ground) 0				

Quantitative Version – More Than 1 Aircraft Involved – GUIDANCE

The overall Severity of one occurrence is built from the risk of collision/proximity (separation and rate of closure) and the degree of controllability over the incident.

For each specific situation the values are not fixed and can be adjusted by the investigator within the provided values.

- 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 (computed before the Closest Point of Approach – CPA between the two aircraft).

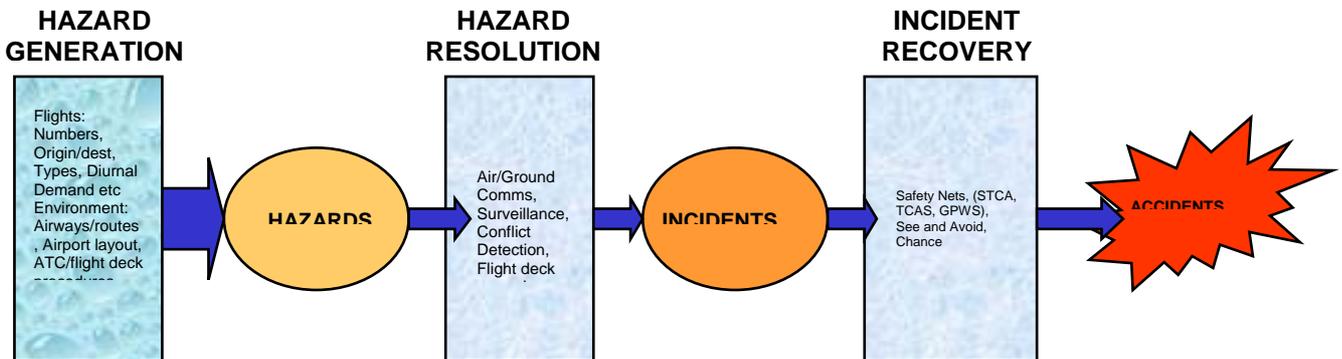
- ◆ The separation sub-criterion refers to the separation, intended or not, as in fact this criterion looks to the physical horizontal and vertical distances achieved between aircraft.
 - ◆ When scoring separation, the "best" value of the infringed horizontal and vertical separation shall be taken in the consideration;
 - ◆ When no separation minima is defined or there is no agreement on the distances between aircraft, then the moderation panel/investigators, based on expert judgment, will either choose a score between 0 and 10 or will not score at all the criterion and as such will affect the reliability indicator
 - ◆ 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, then the moderation panel/investigators, based on expert judgment, will either choose a score between 0 and 5 or will not score at all the criterion and as such will affect the reliability indicator.
- 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 segment 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.

The defence barrier model used is the one introduced by 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 below):

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

For the purposes of this paper 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 3 – Barrier Model)

Detailed guidance and explanation on barrier model is to be found in SOFIA Reference manual section 1.2. There is no intent herewith to reproduce any of the information already available elsewhere in EUROCONTROL, for the sake of brevity of this deliverable. A summary is given in the excel files containing the mark sheets.

For the severity and risk mark sheet scope we have considered the Resolution part broken into DETECTION, PLANNING AND EXECUTION sub-barriers.

- Conflict detection sub-criterion refers to ATM ground detection and therefore column ATM will inherit the same score as ATM ground.
 - ◆ INADEQUATE detection means that ATM ground was too late or detection of a conflict was incomplete and therefore ATM ground did not avoid the occurrence (e.g. too late to avoid a separation minima infringement, or they did not consider the side effects). In cases such as Level Busts or other incidents where ATM ground cannot form an *a priori* plan, Conflict detection criterion is not applicable and a 0 should be scored to maintain the Reliability Indicator tracked.
- Planning sub-criterion refers to ATM ground plan and therefore column ATM will inherit the same score as ATM ground. When assessing the planning “performance” you should look at the timing and efficiency of that planning. 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 “no detection” is scored, automatically you should mark “no plan” as well;
 - ◆ Whenever Conflict detection is not applicable (such as Level bust cases) then Planning sub criterion is not applicable and a 0 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 to ATM ground execution in accordance with the developed plan and therefore column ATM will inherit the same score as ATM ground. Pilot execution will be scored in a separate sub-criterion.
 - ◆ When assessing the execution you should look at the time and efficiency of that execution. ATM ground execution is INADEQUATE when it is not timely and/or not effective. It includes the cases when it is contrary to the prior good planning.
 - ◆ When there is “no conflict” detection and “no planning” then “no execution” should be scored too. No execution comprises also the 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) then Execution criterion of ground ATM is not applicable as well.

When scoring the Execution criterion the plan developed in the step before to solve the hazardous situation should be considered. Execution assessment for the airborne segment has been separated in the overall pilot performance criterion retained for controllability.

- The Ground Safety Nets (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 case of false/nuisance alerts this criterion should be disregarded.
 - ◆ No STCA 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.
- Recovery from actual conflict is the phase requiring immediate actions to restore the "equilibrium" or at least to confine the hazard; this sub-criterion refers to the ATM ground recovery and therefore column ATM will inherit the same score as ATM ground. Pilot recovery will be scored in a separate criterion.
 - ◆ 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 assessing the recovery you should look at the time and efficiency of that recovery.

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.

NOTE: Detection, Planning, Execution and Recovery criteria are related to the ATCO team and therefore the overall ATM column will inherit the same values from the ATM ground. The pilot recovery will be scored in a separate criterion.

- Airborne Safety Nets – TCAS sub-criterion should be scored only for useful TCAS RA (as per ICAO definitions); “No TCAS” 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.
 - ◆ Pilot execution 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 was retained mainly to facilitate the qualitative scheme but also to recall that the system both ground and overall ATM has been penalised already in the “TCAS triggered” sub-criterion above. This criterion also applies when the pilot is correctly following ATM ground useful recovery actions.
 - ◆ Pilot(s) INSUFFICIENTLY followed ATC instructions applies when pilot action is not reacting fully in accordance with ATM ground instructions, but ATM ground has enough controllability over the situation (e.g. level bust where ATM ground still has a margin to recover and instruct accordingly, rate of climb lower than the instructed one, late start of turning when “avoiding action” turn clearance is issued);
 - ◆ Pilot(s) INCORRECTLY followed RA (or, in the absence of RA, took other inadequate action) or ATC Instructions or NO pilot action at ATC instructions with NO further ATM ground controllability margin - this criterion will be scored for overall ATM, whenever the Pilot actions were either missing or contradictory (e.g. incorrect execution of ATM ground instructions or 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 the worst case possible.

NOTE: The use of see and avoid must 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.”

Following the above explained principles and logic an equivalent QUALITATIVE mark sheet has been developed. The qualitative version potentially leaves less flexibility as fixed values are to be ticked when scoring the criteria. See later in fig. 5 the picture reproducing the - Qualitative version - more than 1 aircraft involved – SEVERITY Mark sheet.

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Quantitative Version - More Than 1 Aircraft Involved – REPEATABILITY Mark Sheet

B. REPEATABILITY				
3. Historical data (own or other)				
Numbers NONE				0
Numbers FEW				3
Numbers SIGNIFICANT				5
Numbers VERY HIGH				10
Total (3)				
4. Systemic issues				
	ATM airborne		ATM ground	
Procedures DESIGN	10		10	
Procedures IMPLEMENTATION	5		5	
Procedures LACK OF	5		5	
Equipment DESIGN	10		10	
Equipment IMPLEMENTATION	5		5	
Equipment LACK OF	5		5	
Human resources management (staff planning, staff assignment, training) DESIGN	10		10	
Human resources management IMPLEMENTATION	5		5	
Human resources management LACK OF	5		5	
TOTAL 4a		0	TOTAL 4b	0
Total (4-ATM) = (4a)+(4b)		0		
Total (4-ATM Ground) = (4b)		0		
5. Window of Opportunity				
	Situation			
	Daily routine	Workload peak	Emergency	
Methods normal	4	3	2	
exceptional	3	2	1	
Total (5)				
6. Complexity				
	Timing			
	Irrelevant	Role playing	Indispensable	
Causes/events Many (>5)	3	2	1	
Average (3 , 5)	4	3	2	
Few (1, 2)	5	4	3	
Total (6)				
TOTAL REPEATABILITY :				
ATM =(3) +(4-ATM)+(5)+(6)				0
ATS =(3) +(4-ATM GROUND)+(5)=(6)				0

(Figure 4 – Quantitative Version - More Than 1 Aircraft Involved – REPEATABILITY Mark Sheet)

Quantitative Version – More Than 1 Aircraft Involved - REPEATABILITY Mark Sheet – GUIDANCE

REPEATABILITY criteria compute the probability that a similar occurrence will be recurring in the future.

- Historical data sub-criterion - Refers to similar incidents that may exist in your own or other databases or alternatively collected from operational experience memory. Similarity should be interpreted as classification of type of incident regardless of the type of causes that are to be scored in a different sub-criterion below.
 - ◆ Historical data – FEW – Should be scored when a similar type of occurrence has occurred more than once at the same location but the numbers of occurrences have not yet overcome a certain awareness threshold from which the SMS would require particular attention.
 - ◆ Historical data – SIGNIFICANT - Should be scored when a similar type of occurrence has occurred a significant number of times at the same location. "Significant" should be interpreted based on the type of ATS unit, geographical coverage (number of sectors) vs. type of occurrence etc. The numbers of previous incidents have passed the SMS awareness threshold and this type of occurrence will start to be analysed in greater detail. - See also the difference with very high.
 - ◆ Historical data – VERY HIGH – Should be scored when this type of occurrence is a recognised key issue (own or others, such as Runway Incursions and Level Busts).

When trying to assess if similar incidents occurred at the “same location” an organisation should look not only into his database but into European or world wide repositories. If the issue is a recognised key risk areas (such as runway incursion, unauthorised penetration of airspace, level bust etc) then the historical criterion should look outside the location of occurrence. The same principles will apply also if similar type of occurrences has triggered the organisation SMS threshold.

Finally the recommendation to score this criterion is to benchmark it from very high to few or none using the above guidelines.

- 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 mark sheet 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.
- ◆ Procedures – IMPLEMENTATION -This should reflect issues in the implementation of a procedure, such as implementation done differently from that required by the design. 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.
- ◆ 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.

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.

- “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.

Note: Methods or techniques either normal or exceptional are roughly linked to the type of situations; however what is aimed at being captured here are the circumstances in conjunction with the methods/techniques to be applied.

- The “complexity”- is that sub-criterion that refers to the development of the safety occurrence, i.e. number of DIRECT causes (that had to be present for the collision to occur as opposed to those which just increased or decreased the likelihood of the situation) together with the requirement for their time order and spacing to happen more or less strictly in this way.

- Complexity - Few, Average, Many refer only to the number of DIRECT causes.

A. SEVERITY						
1. Risk of collision						
Ri	Separation	achieved	> 75%	75% - 50%	50% - 25%	<= 25%
Ri	Rate of closure	NONE	LOW	MEDIUM	HIGH	VERY HIGH
2. Controllability						
Ri	Conflict detected	YES	Inadequate	NO		
Ri	Plan	Correct	Inadequate	None		
Ri	Execution	Correct	Inadequate	None		
Ri	STCA	Triggered		None		
Ri	Recovery	Correct	Inadequate	None		
Ri	TCAS/Own initiative see and avoid	Triggered		None		
Ri	Pilot action	Follow RA (or, in absence of RA, took other effective action)	Insufficiently followed RA or ATC instructions	Incorrectly followed RA or ATC instructions	No action	
		SEVERITY ATM		E		
		SEVERITY ATM Ground		E		
B. REPEATABILITY						
3. Historical data (own or other)						
Ri	Numbers	None	Few	Significant	Very high	
4. Systemic issues						
Ri	Procedures - ATM Airborne	Design	Implement	Lack of		
Ri	Procedures - ATM Ground	Design	Implement	Lack of		
Ri	Equipment - ATM Airborne	Design	Implement	Lack of		
Ri	Equipment - ATM Ground	Design	Implement	Lack of		
Ri	Human resources management-ATM Airborne	Design	Implement	Lack of		
Ri	Human resources management-ATM Ground	Design	Implement	Lack of		
5. Window of Opportunity						
Ri	Situation	Daily routine	Workload peak	Emergency		
Ri	Methods	normal	exceptional			
6. Complexity						
Ri	Causes/events	Many	Average	Few		
Ri	Timing	Irrelevant	Role playing	Indispensable		
		REPEATABILITY ATM		5		
		REPEATABILITY ATM Ground		5		

Following the same above explained principles and logic the following equivalent QUALITATIVE mark sheet has been developed. The qualitative version potentially leaves less space for flexibility as fixed values are to be ticked when scoring the criteria. In the cases where more than one controller and/or more than one pilot crew were involved in the incident with different performances, a preference to use the quantitative mark sheet has been found during validation. This is probably because more flexibility in granting marks is allowed when using the quantitative version of the mark sheet

(Figure 5 – Qualitative Version - More Than 1 Aircraft Involved – Overall Mark Sheet)

After assessing the severity and the potential repeatability, you are just one step ahead of risk determination.

More Than One Aircraft - RISK Determination

RISK						
32 to >	1 very frequent	A1	B1	C1	E1	D1
24 to 31	2 frequent	A2	B2	C2	E2	D2
17 to 23	3 occasional	A3	B3	C3	E3	D3
11 to 16	4 rare	A4	B4	C4	E4	D4
0 to 10	5 extremely rare	A5	B5	C5	E5	D5
		A	B	C	E	D
		serious	major	significant	no safety effect	not determined
		>>31	30 to 18	17 to 10	9 to 0	RI too low

(Figure 6 – Risk Classification for More Than One Aircraft)

On the basis of the figures derived from the severity and repeatability assessments, the ESARR2 risk matrix may be used to plot both values - overall ATM and ground ATM.

If not enough information is available for some of the criteria and the Reliability Indicator is too low (less than 70% for the severity part) then the occurrence severity will be declared – D – not determined.

Two Reliability Indicators – RI - are tracked, one for Severity and one for Repeatability.

When the Reliability Indicator(s) can be declared too low? In situations where several criteria are pertinent but the investigation team and/or the moderation panel is not having the information to score them. The investigation team and/or the moderation panel should take a final decision for how many criteria and from which percentage of Reliability Indicator should declare the Occurrence classified as D - Not determined.

The criteria that might not be easy to score are usually in Controllability. Less difficulty is expected for the risk of collision sub-criterion.

However it is recommended that once the RI_S is $\leq 70\%$ the Occurrence is pertinent to be classified as Severity D (RI_S – Reliability Indicator – for Severity part)

The Reliability Indicator for repeatability RI_R will be a parameter to indicate the confidence in the determination of the probability of recurrence. . “Critical” for confidence in the repeatability will be to have RI_R scored at least for historical and complexity criteria.

The overall Reliability Indicator for the occurrence Risk will be the median of the two Reliability Indicators.

$$RI = (RI_S + RI_R) / 2$$

2.1.2 Only One Aircraft Involved

Quantitative Version – Only 1 Aircraft Involved – SEVERITY Mark Sheet

A. SEVERITY			
1. Risk of collision			
Minimum separation between a/c and ground/area/obstacle achieved		0	
Separation + 75% minimum		1	
Separation >50%, <=75% minimum		3	
Separation >25%, <=50% minimum		7	
Separation <=25% minimum		10	
Total separation (a)			
Rate of closure between a/c and ground/area/obstacle NONE		0	
Rate of closure LOW (<=60knots, <=1000ft/mn)		1	
Rate of closure MEDIUM (>60 and <=120 knots, >1000 and <=2000 ft/mn)		3	
Rate of closure HIGH (>120 and <=400 knots, >2000 and <=4000 ft/mn)		4	
Rate of closure VERY HIGH (>400knots, >4000ft/mn)		5	
Total rate of closure (b)			
TOTAL (1) Risk of Collision (a)+(b)			0
2. Controllability			
	ATM		ATM Ground
Proximity to ground/area/obstacle detected	0		0
Proximity to ground/area/obstacle INADEQUATE	3		3
Proximity to ground/area/obstacle NOT detected	5		5
Reaction/plan CORRECT	0		0
Reaction/plan INADEQUATE	3		3
NO reaction/plan	5		5
Execution CORRECT	0		0
Execution INADEQUATE	3		3
Execution NONE	5		5
MSAW or APW triggered	0		3
NO MSAW or APW warning	5		5
Recovery CORRECT	0		0
Recovery INADEQUATE	5		5
NO recovery or the ATM ground actions for recovery have worsened the situation	10		10
GPWS triggered OR see and avoid pilot decision	0		10
NO GPWS warning	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	10		0
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 controllability margin	25		0
	TOTAL (2-ATM)	0	TOTAL (2-ATM Ground)
			0
TOTAL SEVERITY :			
SEVERITY ATM = (1) + (2-ATM)			0
SEVERITY ATM Ground = (1) + (2-ATM Ground)			0

(Figure 7 – Quantitative Version – Only 1 Aircraft Involved – SEVERITY Mark Sheet)

Quantitative Version – Only 1 Aircraft Involved - SEVERITY Mark Sheet – GUIDANCE

The case where only one aircraft is involved covers several possible types of occurrence, such as:

- ❑ Level bust when no other a/c is in the vicinity, in which case the separation infringement criterion will be the deviation from the assigned level i.e. as if there was (had been) another aircraft;
- ❑ Airspace infringement – separation criterion will be the defined horizontal/vertical buffer zone for protection;
- ❑ Near CFIT in which the separation will be the specified terrain clearance (e.g. if the aircraft has gone through the OCL separation will be scored as “0”);
- ❑ Short of fuel situation, where separation criterion could be interpreted as a parameter relating to the time to fuel exhaustion;
- ❑ There might be other cases which are NOT described here; however the examples above give an idea on how the scheme could be used.

Very few differences are naturally introduced between the mark sheet for one aircraft involved and the mark sheet for more than one aircraft involved. These are as follows:

- ❑ In the case of one aircraft, separation criterion is a proximity to ground/obstacles/areas(see above examples)
- ❑ The rate of closure has slightly different parameters; the values for Rate of Closure to terrain are slightly different in one category than in the case for rate of closure between aircraft;
- ❑ Ground Safety Nets are those applicable for detection of proximity to ground/obstacles and areas (MSAW – Minimum Safe Altitude Warning and APW - Area Proximity Warning)
- ❑ Airborne Safety Nets in this case includes GPWS type systems (Enhanced GPWS – ground Proximity Warning Systems and TAWS – Terrain Awareness Warning Systems are included in the term GPWS);

Equally following the same explained principles and logic an equivalent QUALITATIVE mark sheet has been developed. The qualitative version potentially leaves less space for subjectivity as fixed values are to be ticked when scoring the criteria. In the cases where more than one controller and/or more than one pilot crew were involved in the incident with different performances, a preference to use the

quantitative mark sheet has been found during validation. This is probably because more flexibility in granting marks is allowed when using the quantitative version of the mark sheet.

A. SEVERITY						
1. Risk of collision						
RI	Separation	achieved	> 75%	75% - 50%	50%-25%	<= 25%
RI	Rate of closure	NONE	LOW	MEDIUM	HIGH	VERY HIGH
2. Controllability						
RI	Proximity to ground/area/obstacle detected	YES	Inadequate	NO		
RI	Reaction/Plan	Correct	Inadequate	None		
RI	Execution	Correct	Inadequate	None		
RI	MSAW or APW	Triggered		None		
RI	Recovery	Correct	Inadequate	None		
RI	GPWS/Own initiative see and avoid	Triggered		None		
RI	Pilot action	Follow GPWS (or, in absence of GPWS, took other effective action)	Insufficiently followed GPWS or ATC instructions	Incorrectly followed GPWS or ATC Instructions or No action at ATC Instructions		
		SEVERITY ATM	E			
		SEVERITY ATM Ground	E			

(Figure 8 – Quantitative Version – Only 1 Aircraft Involved – SEVERITY Mark Sheet)

Quantitative Version – Only 1 Aircraft Involved – REPEATABILITY Mark Sheet

B. REPEATABILITY				
3. Historical data (own or other)				
Numbers NONE				0
Numbers FEW				3
Numbers SIGNIFICANT				5
Numbers VERY HIGH				10
Total (3)				
4. Systemic issues				
	ATM airborne		ATM ground	
Procedures DESIGN	10		10	
Procedures IMPLEMENTATION	5		5	
Procedures LACK OF	5		5	
Equipment DESIGN	10		10	
Equipment IMPLEMENTATION	5		5	
Equipment LACK OF	5		5	
Human resources management (staff planning, staff assignment, training) DESIGN	10		10	
Human resources management IMPLEMENTATION	5		5	
Human resources management LACK OF	5		5	
		TOTAL 4a	0	TOTAL 4b
				0
Total (4-ATM) = (4a)+(4b)				0
Total (4-ATM Ground) = (4b)				0
5. Window of Opportunity				
	Situation			
	Daily routine	Workload peak	Emer-gency	
Methods				
normal	4	3	2	
exceptional	3	2	1	
Total (5)				
6. Complexity				
	Timing			
	Irrelevant	Role playing	Indispen-sable	
Causes/events				
Many (>5)	3	2	1	
Average (3 , 5)	4	3	2	
Few (1, 2)	5	4	3	
Total (6)				
TOTAL REPEATABILITY :				
ATM =(3) +(4-ATM)+(5)+(6)				0
ATS =(3) +(4-ATM GROUND)+(5)=(6)				0

(Figure 9 - Quantitative Version – Only 1 Aircraft Involved – REPEATABILITY Mark Sheet)

Quantitative Version – Only 1 Aircraft Involved – REPEATABILITY Mark Sheet – GUIDANCE

The criteria are identical for the case with more than one aircraft involved. If you are uncertain please GO TO the case for more than one aircraft involved and follow the same logic for scoring.

Following the same explained principles and logic an equivalent QUALITATIVE mark sheet has been developed. The qualitative version potentially leaves less space for subjectivity as fixed values are to be ticked when scoring the criteria.

B. REPEATABILITY				
3. Historical data (own or other)				
RI Numbers	None	Few	Significant	Very high
4. Systemic issues				
RI Procedures - ATM Airborne	Design	Implement	Lack of	
RI Procedures - ATM Ground	Design	Implement	Lack of	
RI Equipment - ATM airborne	Design	Implement	Lack of	
RI Equipment - ATM Ground	Design	Implement	Lack of	
RI Human resources management-ATM airborne	Design	Implement	Lack of	
RI Human resources management-ATM Ground	Design	Implement	Lack of	
5. Window of Opportunity				
RI Situation	Daily routine	Workload peak	Emergency	
RI Methods	normal	exceptional		
6. Complexity				
RI Causes/events	Many	Average	Few	
RI Timing	Irrelevant	Role playing	Indispensable	
REPEATABILITY ATM		5		
REPEATABILITY ATM Ground		5		

(Figure 10 – Qualitative Version – Only 1 Aircraft Involved – REPEATABILITY Mark Sheet)

Only One Aircraft – RISK Determination

On the basis of the figures derived from the severity and repeatability assessments, the ESARR2 risk matrix may be used for both overall ATM and ground ATM. The two retained figures for overall ATM and ground ATM can then be plotted on a metric like below. The same rationale for Reliability Indicator as in the case with more than one aircraft involved, applies.

RISK						
32 to >	1	A1	B1	C1	E1	D1
24 to 31	2	A2	B2	C2	E2	D2
17 to 23	3	A3	B3	C3	E3	D3
11 to 16	4	A4	B4	C4	E4	D4
0 to 10	5	A5	B5	C5	E5	D5
		A	B	C	E	D
		serious	major	significant	no safety effect	not determined
		>=31	30 to 18	17 to 10	9 to 0	RI too low

(Figure 11 – RISK Determinations for Only 1 Aircraft)

2.1.3 No Aircraft Involved/ATM Specific Occurrences

Quantitative Scheme – No Aircraft Involved – SEVERITY & REPEATABILITY Mark Sheets

A. SEVERITY			
1. Failure criticality			
LOW			1
MEDIUM			5
HIGH			20
TOTAL (1)			
2. Geographical extension of area affected and /or number of flight potentially affected			
LOW (e.g. 1 sector)			1
AVERAGE			5
HIGH (e.g. 1 ATS Unit)			20
TOTAL (2)			
3. Duration until contingency measures are in place or until the occurrences is terminated by itself, before the contingency measures can be effective			
IRRELEVANT			0
SHORT (1 or 2 minute(s))			5
MEDIUM (3 minutes to 10 minutes)			10
LONG (10 minutes to 20 minutes)			15
VERY LONG (approx 20 minutes or more)			20
TOTAL (3)			
TOTAL SEVERITY :			
SEVERITY = (1) + (2) + (3)			0
B. REPEATABILITY			
4. Historical data (own or other)			
Numbers NONE			0
Numbers FEW			3
Numbers SIGNIFICANT			5
Numbers VERY HIGH			10
Total (4)			
5. Systemic issues			
Procedures DESIGN			10
Procedures IMPLEMENTATION			5
Procedures LACK OF			5
Equipment DESIGN			10
Equipment IMPLEMENTATION			5
Equipment LACK OF			5
Human resources management (staff planning, staff assignment, training) DESIGN			10
Human resources management IMPLEMENTATION			5
Human resources management LACK OF			5
Total (5)			0
6. Window of Opportunity			
	Situation		
	Daily routine	Workload peak	Emergency
Methods normal	4	3	2
exceptional	3	2	1
Total (6)			
7. Complexity			
	Timing		
	Irrelevant	Role playing	Indispensable
Causes/events Many (>5)	3	2	1
Average (3 , 5)	4	3	2
Few (1, 2)	5	4	3
Total (7)			
REPEATABILITY :			
TOTAL = (4) + (5) + (6) + (7)			0

(Figure 12 – Quantitative Scheme – No Aircraft Involved – SEVERITY & REPEATABILITY Mark Sheets)

Quantitative Scheme – No Aircraft Involved – SEVERITY & REPEATABILITY Mark Sheet – GUIDANCE

In this latter case the severity issue is built from totally different criteria and a different marking scheme had to be developed.

The criteria used in this later case are:

- criticality of the ATM system element from where the deficiency originates;
- extent within the system and geographical impact;
- duration until contingency measures are in place (until the full serviceability or a degraded situation is established);
- 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 etc.;
- It might be useful to refer to the units' safety cases to identify the criticality of the various functions assessed;
- Extent within the system and geographical impact refers to e.g. the numbers of sectors 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 over flown because of unavailability of an ACC terminal sector)
- Duration until contingency measures are in place (until the full serviceability or a degraded situation is established) or until the occurrence is terminated by itself, before the contingency measures can be effective is a self explanatory criterion and it has been introduced to cover 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).

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.

The criteria for REPEATABILITY have been kept the same as for the previous 2 cases and therefore for any guidance please go to the situation with more than 2 aircraft involved.

Following the same principles and logic as in the previous 2 cases, an equivalent QUALITATIVE mark sheet has been developed. The qualitative version potentially leaves less space for subjectivity as fixed values are to be ticked when scoring the criteria.

Qualitative Scheme - No Aircraft Involved – SEVERITY & REPEATABILITY Mark Sheet Summary

A. SEVERITY						
RI	1. Failure criticality	Low	Medium	High		
RI	2. Geographical extension of area affected and/or numbers of flight potentially affected	Low	Medium	High		
RI	3. Duration until contingency measures are in place or until the occurrences is terminated by itself, before the contingency measures can be effective	Irrelevant	Short	Medium	Long	Very Long
		SEVERITY ATM E				
B. REPEATABILITY						
4. Historical data (own or other)						
RI	Numbers	None	Few	Significant	Very High	
5. Systemic issues						
RI	Procedures	Design	Implement	Lack of		
RI	Equipment	Design	Implement	Lack of		
RI	Human resources management	Design	Implement	Lack of		
6. Window of Opportunity						
RI	Situation	Daily routine	Workload peak	Emergency		
RI	Methods	normal	exceptional			
7. Complexity						
RI	Causes/events	Many	Average	Few		
RI	Timing	Irrelevant	Role playing	Indispensable		
		REPEATABILITY ATM 5				

(Figure 13 Qualitative Scheme – No Aircraft Involved – SEVERITY & REPEATABILITY Mark Sheet)

No Aircraft Involved Case - RISK Determination

RISK						
32 to >	1 very frequent	A1	B1	C1	E1	D1
24 to 31	2 frequent	A2	B2	C2	E2	D2
17 to 23	3 occasional	A3	B3	C3	E3	D3
11 to 16	4 rare	A4	B4	C4	E4	D4
0 to 10	5 extremely rare	A5	B5	C5	E5	D5
		A	B	C	E	D
		Serious inability to provide safe ATM services	Partial inability to provide safe ATM services	Ability to provide safe but degraded services	no effect on ATM services	Not Determined
		>=31	30 to 18	17 to 10	9 to 0	RI too low

(Figure 14 – Qualitative No Aircraft Involved Case – RISK Determination)

The second ESARR 2 classification scheme is to be used when plotting the risk for the case with no aircraft involved.

The same rationale for Reliability Indicator as in the cases with more than one aircraft involved, and one aircraft involved apply.

3. RELIABILITY INDICATOR

The Notion of Reliability Indicator has been introduced for both qualitative and quantitative versions of the mark sheets. The rationale is multi-various:

- the reporting and assessment schemes do not have the same maturity in all ECAC States
- the data will not be available for all safety occurrences to quantify all the criteria
- not all the criteria will be applicable for all safety occurrences
- there is a need to have a certain level of trust when trends analysis is performed with safety data from different sources.

The Reliability Indicator (RI) will measure the level of confidence in the assessment (scoring) done, based on the data available to answer the questions in the mark sheets.

If enough data is available to the investigator to answer all the questions in the mark sheet, then the risk is 'correctly' calculated and Reliability Indicator will measure that confidence (RI=100%).

If data is missing and some questions in the mark sheet cannot be answered, then risk is calculated with less confidence. The value of the RI will then be less than 100%, indicating the degree of confidence in the final value of the risk.

The indicator can be used later in performing meaningful statistics based on consistent data.

What happens when the Reliability Indicator(s) is declared too low? These situations occur when several criteria are pertinent but the investigation team and/or the moderation panel does not have the information to score them. The investigation team and/or the moderation panel should make a decision on how many criteria are pertinent and the percentage level of the Reliability Indicator before classifying the Occurrence as D - Not determined.

The criteria that might not be easy to score are usually in Controllability. It is less difficult to either have the information or to estimate the risk of collision.

However it is recommended that once the $RI_S < 70\%$ the Occurrence is likely to be classified as Severity D (RI_S – Reliability Indicator – for Severity part)

The Reliability Indicator for repeatability RI_R will be a parameter to indicate the confidence in the determination of the probability of recurrence. "Critical" for confidence in the repeatability will be to have RI_R scored at least for historical and complexity criteria.

For the excel version of the mark sheets the Reliability Indicator is calculated based on the number of the questions answered/ filled in.

The overall Reliability indicator is the median of the two referred Reliability indicators:

$$RI = (RI_S + RI_R) / 2$$

As some questions are not relevant for a particular occurrence, they can be marked as "answered" even if no option has been selected, allowing for the correct calculation of the RI. In the quantitative mark sheet the non applicable criteria will receive a zero, while for the quantitative mark sheet it is enough to tick the RI box with a double click.

Tables 3 and 4 describe for each question the weight that contributes to the calculation of the Reliability Indicator.

Table 3 Questions weight for the calculation of the Reliability Indicator for:

Schemes with More than 1 aircraft involved and 1 aircraft involved

	Reliability Indicator (%)
A. SEVERITY	
1. Risk of collision	
Separation	20
Rate of closure	10
2. Controllability	
Conflict detection	10
Plan	10
Execution	10
STCA	10
Recovery	10
TCAS/Own initiative see and avoid	10
Pilot action	10
TOTAL	100
B. REPEATABILITY	
3. Historical data (own or other)	20
4. Systemic issues	
Procedures - ATM Airborne	8
Procedures – ATS	8
Equipment - ATM airborne	8
Equipment – ATS	8
Human resources management - ATM airborne	8
Human resources management – ATS	8
5. Window of opportunity	12
6. Complexity	20
TOTAL	100

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Table 4: Questions weight for the calculation of the Reliability Indicator for:
ATM Specific Occurrences (no aircraft involved) scheme

	Reliability Indicator (%)
A. SEVERITY	
1. Failure criticality	40
2. Geographical extension of area affected and/or numbers of flight potentially affected	30
3. Duration until contingency measures are in place or until the occurrences is terminated by itself, before the contingency measures can be effective	30
TOTAL	100
B. REPEATABILITY	
4. Historical data (own or other)	20
5. Systemic issues	
Procedures – ATM Ground	16
Equipment – ATM ground	16
Human resources management – ATM ground	16
6. Window of opportunity	12
7. Complexity	20
TOTAL	100

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