SOUTH AMERICAN AIG REGIONAL COOPERATION MECHANISM (ARCM)

FOURTH MEETING OF AIG AUTHORITIES
(Brasilia, Brazil, 23 to 25 May 2017)

Item 9: 2016 ARCM Safety Report

RESULTS OF THE ANALYSIS CONDUCTED BY THE RUNWAY EXCURSIONS (RE) WORKING GROUP

(Presented by Argentina)

Summary

This working paper (WP) provides information on the results of the analysis conducted by the ARCM runway excursions (RE) working group on the contributing factors or system deficiencies that are present in accidents or incidents related to runway excursions (REs), and on the preventive measures that should be implemented forthwith in order to enhance safety in the region, based on the preliminary reports of RE-related accidents and incidents occurred in 2016 in the SAM Region, involving aircraft of any weight.

References

- Annex 13 – Aircraft accident and incident investigation
- Annex 14 – Aerodromes
- Preliminary reports of runway excursion accidents occurred in 2016 in the SAM Region.
- ICAO 2016 safety report, available at: www.icao.int
- FAA Advisory Circular (AC) No. 91-79A: Mitigating the Risks of a Runway Overrun upon Landing, available at: https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1025626
- State AIG regulation, developed by the ARCM.
- AIG regulations of SAM States.
- Study conducted by the Air Transport Group (*Grupo de Transporte Aéreo* - GTA) of the School of Engineering of the *Universidad de la Plata*, Argentina.
- Study conducted by CENIPA Brazil – Runway excursions, 2004 to 2013.
- AIG-SAM/RE working paper dated 2 November 2016.

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1. Introduction

1.1 The participants at the First ARCM Accident Investigators' Workshop, held in Lima, Peru, on 20-24 June 2016, addressed different issues, including occurrences related to REs that had taken place in 2016 in the SAM Region. The issue was addressed given the significant increase in the number of accidents in this category in the SAM Region during 2016. Likewise, ICAO has assigned higher priority to the treatment of this type of occurrence, which takes place when an aircraft veers off, or overruns or undershoots the designated runway during landing or take-off, resulting in an accident or incident. Consideration was given to the working paper prepared by the AIG-SAM/RE task force and presented at the ARCM in November 2016.

1.2 RE-related occurrences continue to be a high-risk trend in South America. Consequently, it was necessary to address this issue based on 2016 occurrences, taking into account occurrence categories and all aircraft types, so as to enable the ARCM to take measures to improve safety in its member States.

1.3 In order to carry out this task, research was done on occurrences reported by all SAM States in order to identify factors contributing to RE events and where they occurred, in order to focus improvement efforts. Likewise, the aim is to identify measurable and comparable indicators in order to determine the impact of mitigation actions over time. To this end, based on the information provided by ARCM members, the factors that contributed to the occurrences under study and the mitigation actions proposed for each case were determined and distributed.

1.4 Appendix A to this working paper contains a breakdown of findings for aircraft above and below 2,250 kg, and explains how the indicator shown in this working paper is obtained.

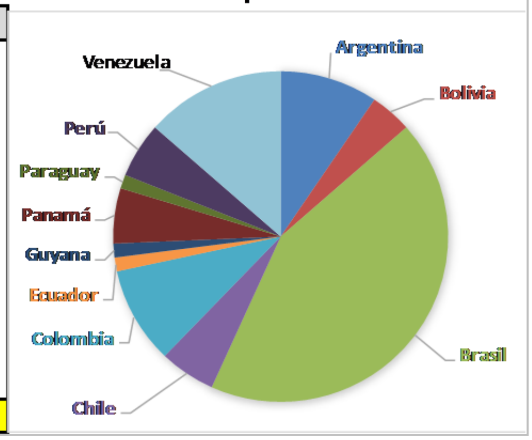
2. Analysis of factors associated to runway excursion (RE) events

2.1 This working paper builds upon the working paper presented to the ARCM on 2 November 2016. That working paper analysed the global situation, establishing the link with occurrences in the South American Region up until July 2016. A special attempt was made to compare the collected information with the factors identified in each study case, which were classified as repetitive or concurrent.

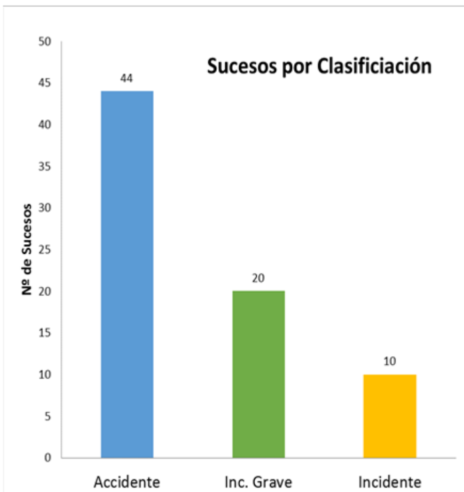
2.2 In order to determine the factors associated to RE occurrences, the aforementioned working paper posed the need to know and study the factors that contributed to the accidents recorded in each SAM State during 2016. The members of the task force described the problem in statistical terms in relation to accidents and incidents occurred in the region as follows:

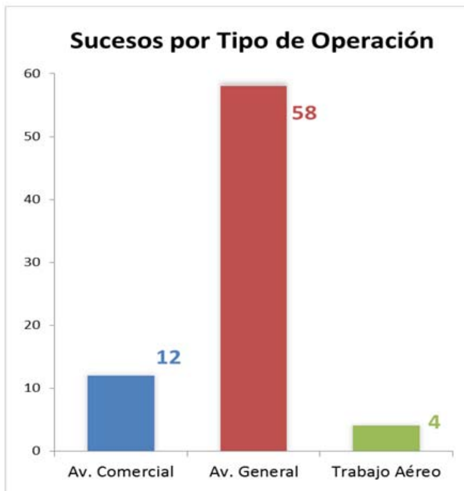
Cantidad de Sucesos por País

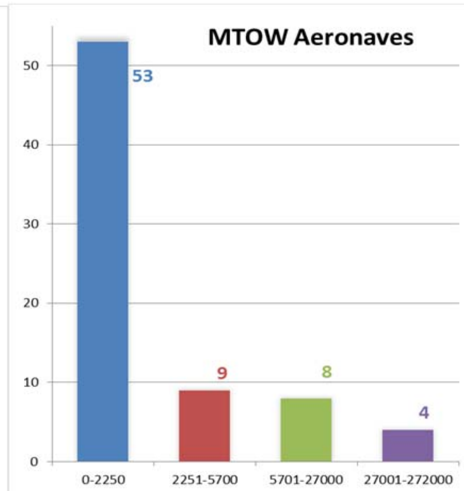
País	Sucesos
Argentina	7
Bolivia	3
Brasil	32
Chile	4
Colombia	7
Ecuador	1
Guyana	1
Panamá	4
Paraguay	1
Perú	4
Venezuela	10
Total:	74



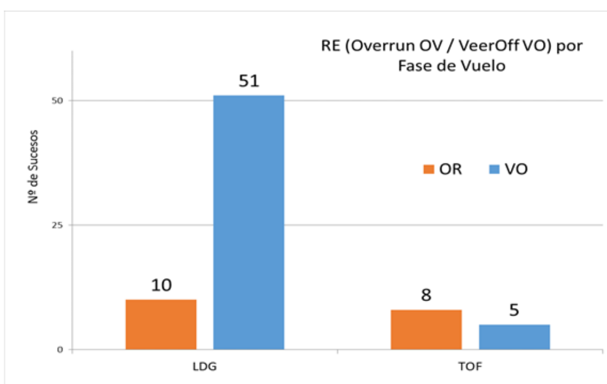
2.3 Occurrences are classified according to different criteria as follows:



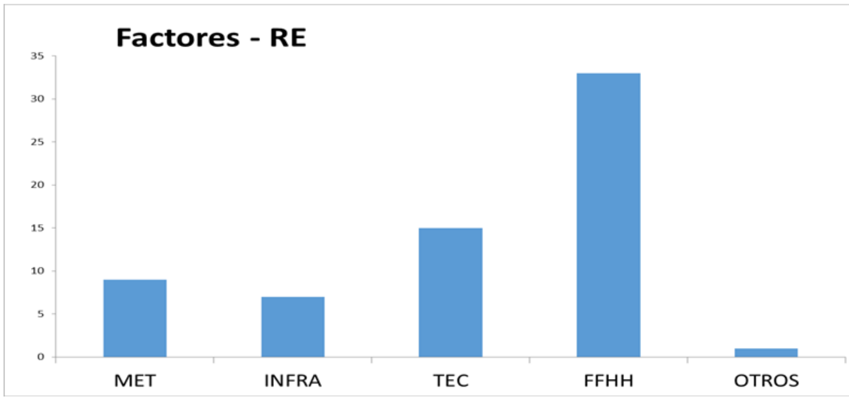




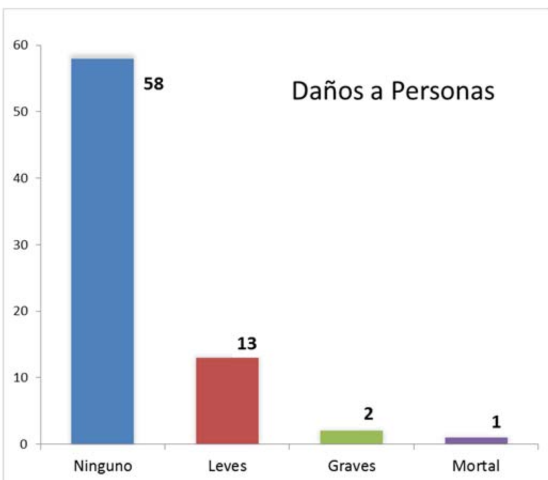
2.4 Taking into account the flight phase in which the RE occurred, the following may be noted:

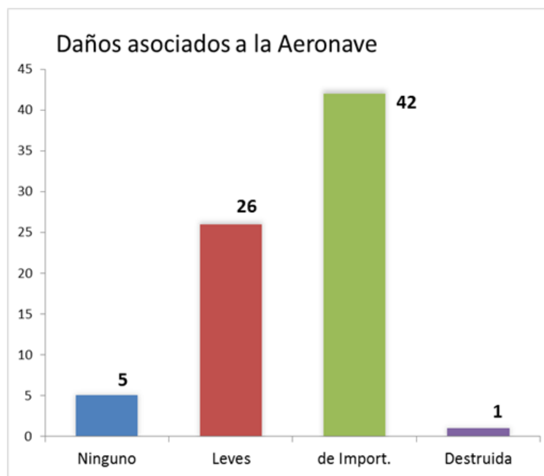


2.5 There are 4 main factors[1] involved in a runway excursion, and are distributed among occurrences as follows:



2.6 The distribution of aircraft damage and personal injuries was as follows:

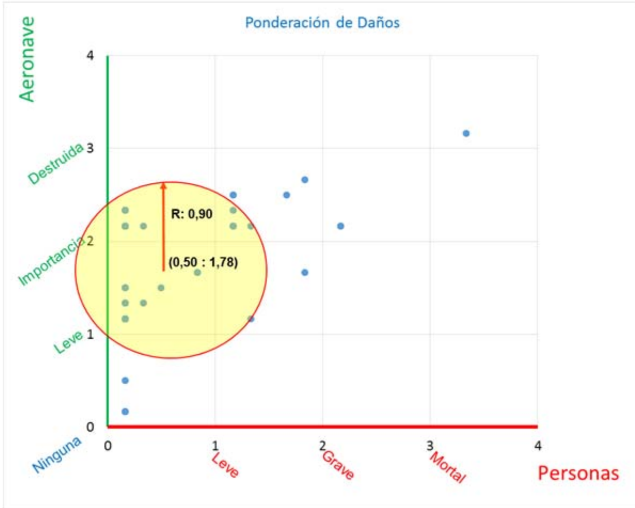




3. **Considerations**

3.1 In order to have an indicator to measure the impact of mitigation measures, the following graph uses the data shown in paragraph 3.5. The Appendix to this working paper elaborates on the construction, use, and description of this tool, which shows that the average of aircraft damage falls under the "Significant" category (1.78) and personal injury falls under the "None" or "Minor" categories (0.50), with a probability of grouping 68% of cases in a radius (R: 0.90):

[1]It is important to note that the information on occurrences is based on preliminary reports, and thus the definition of the factors observed in each case is based on an initial appraisal. It should also be stressed that not all countries provided the classification, and an occurrence may involve several factors.



3.2 It is proposed that the RE monitoring project should be sustainable over time and that the ARCM should be capable of having a positive impact, reducing the rate of this type of accidents through the dissemination and monitoring of the implementation of the proposed preventive measures. To this end:

- ✓ The ARCM RE task force should work on a continuous basis;
- ✓ A brochure should be prepared and circulated addressing the study of RE occurrences in the SAM Region during 2016 and subsequent years;
- ✓ Virtual meetings should be held with AIG and civil aviation authorities of ARCM member States to follow up on the implementation of preventive measures agreed upon at regional level; and
- ✓ Regional seminars should be organised to address RE occurrences in the SAM Region.

4. Conclusions[2]

4.1 This work expands the number of cases under consideration as compared to those covered in the ARCM-SAM RE working paper, although the general concepts observed in the reference studies were also observed in the study cases. Accordingly, 4 general groups of factors can be identified: Human factors: those related to appropriate crew performance; Technical factors: all mechanical failures that affect the defensive technological barriers available on board; Meteorological factors: which affect the environment in which REs occur; and Infrastructure factors: that directly contribute to the occurrence of the RE or affect the severity of the damage caused by the RE.

4.2 In those study cases in which the RE occurred during the landing phase, it was found that a repetitive or recurrent element identified was the fact that the pilot failed to recognise being in a destabilised approach, and that he could have made the decision to go around. It was noted that this situation was the result of lack of experience, lack of training, or improper use of CRM, possibly due to inadequate knowledge of these concepts.

[2] The Appendix to this WP contains remarks, conclusions, and mitigation measures in relation to cases involving aircraft above and below 2,250 kg.

4.3 In those study cases in which a technical failure triggered the situation, it was a conditioning factor of the pilot’s behaviour.

4.4 The same applies to those study cases in which weather conditions had previously affected the runway surface or were present at the moment of the occurrence and adversely affected landing conditions, preventing the crew from performing normal landing procedures.

5. Proposed mitigation measures

5.1 It may be noted that airline managers, especially those in charge of training, can take action to mitigate the problems observed in the study cases, providing crews with more tools to address the factors that can trigger a runway excursion.

5.2 Appropriate training action should be taken during the initial or recurrent training stage, so that crews may identify and act upon the variables that trigger a runway excursion. Training should take into account the analysis of the specific location of the flight, aircraft types, and type of engine.

5.3 For proper training planning, the variables that make up the factors involved in a runway excursion should be known and weighed, and an assessment made of the preparedness of crews to identify and act upon them properly. Based on these concepts, an SMS will permit the generation of guidelines describing the objectives and competencies to be achieved by the crew.

- END -

APPENDIX A

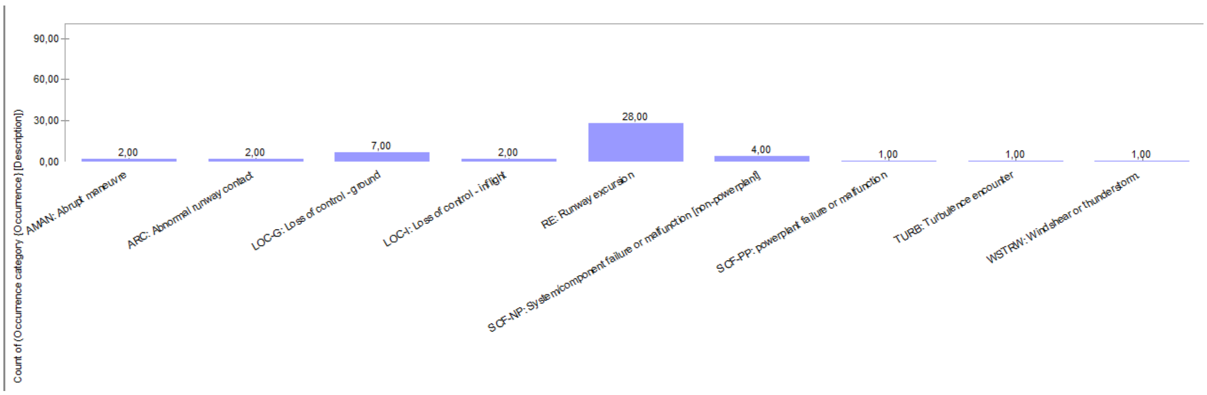
STUDY CASES RELATED TO RE OCCURRENCES

This Appendix elaborates on the concepts presented in the working paper, describing in detail the methods used for obtaining the results and special considerations derived from the results obtained.

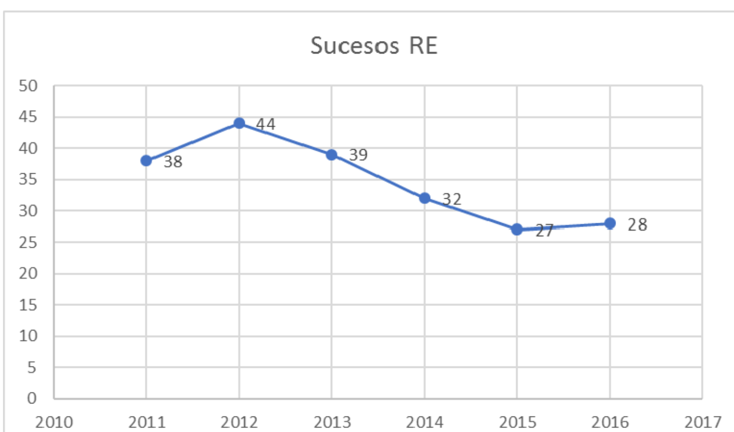
1. Analysis of factors associated to runway excursion (RE) occurrences

1.1 The ARCM-SAM members provided information on all occurrences that took place in their countries, from which a sample of 74 occurrences that took place in the SAM Region in 2016 was derived. There were 53 occurrences involving aircraft above 2,250 kg and 21 occurrences involving aircraft below that weight. The following graphs show the composition of such occurrences:

It is important to mention the other categories to which runway excursions are associated in order to identify the contributing factors. The following graph corresponds to the ARCM SDPCS for 2016, and shows that 28 occurrences were reported out of a total of 74. By way of example, it may be noted that loss of control - ground (LOC-G) or system/component failure or malfunction - non-powerplant (SCF-NP) are more associated to runway excursions.

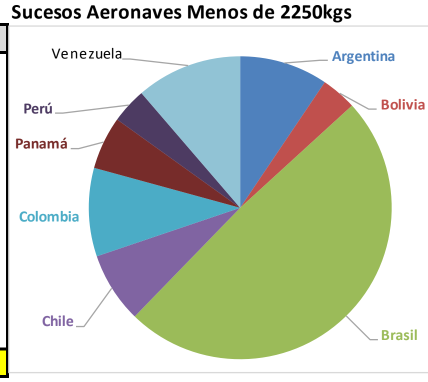


Another important piece of data is the evolution of the category over time (2010-2016). The SDCPS graph is shown below:



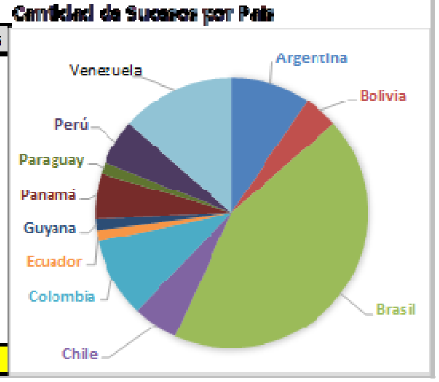
Sucesos Aeronaves Menos de 2250kgs

País	Sucesos
Argentina	5
Bolivia	2
Brasil	26
Chile	4
Colombia	5
Ecuador	
Guyana	
Panamá	3
Paraguay	
Perú	2
Venezuela	6
Total:	53



Cantidad de Sucesos por País

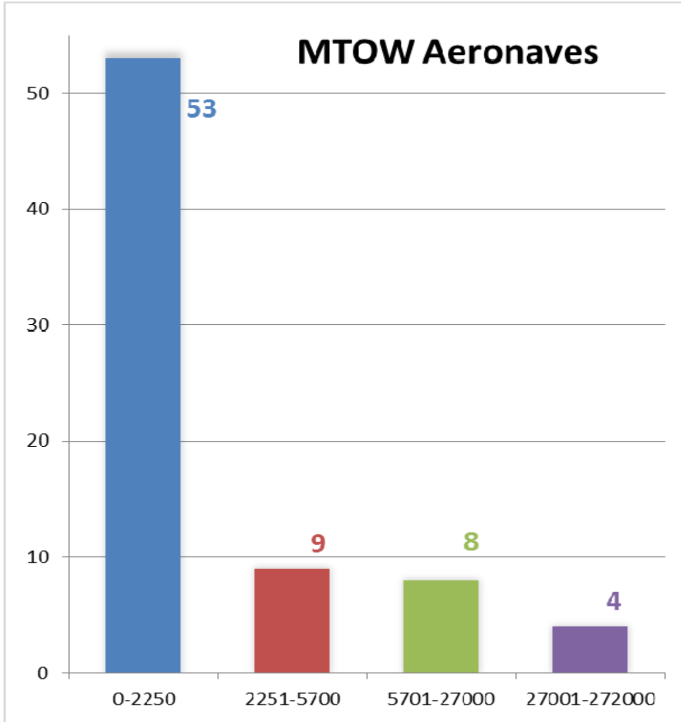
País	Sucesos
Argentina	7
Bolivia	3
Brasil	32
Chile	4
Colombia	7
Ecuador	1
Guyana	1
Panamá	4
Paraguay	1
Perú	4
Venezuela	10
Total:	74



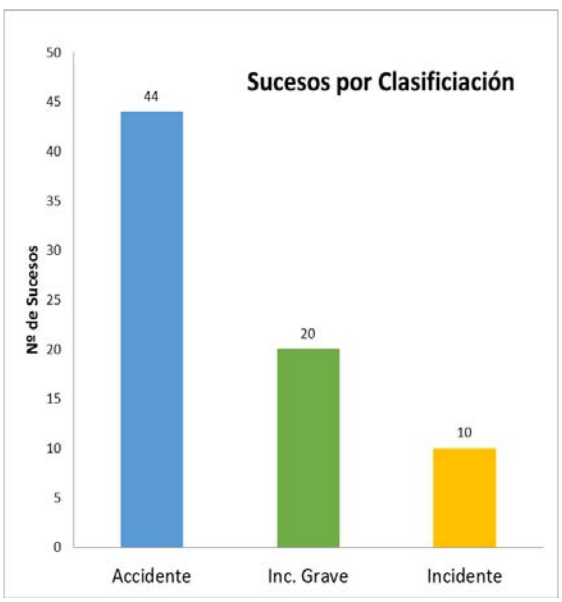
Sucesos Aeronaves Más de 2.250kgs

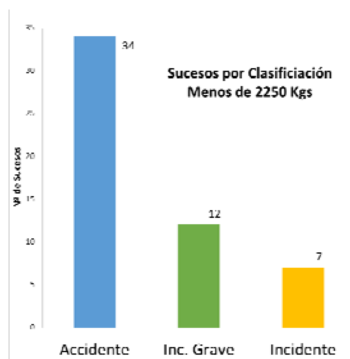
País	Sucesos
Argentina	2
Bolivia	1
Brasil	6
Chile	
Colombia	2
Ecuador	1
Guyana	1
Panamá	1
Paraguay	1
Perú	2
Venezuela	4
Total:	21

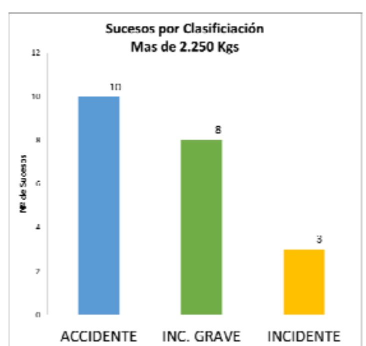
1.2 The distribution of occurrences by maximum take-off weight (MTOW) appears in the following graph, which shows that more than half of REs involve aircraft below 2,250 kg and that the categories of aircraft above that weight do not add up to 50% of the former. Thus the convenience of dividing the variables and factors analysed into 2 categories: above and below 2,250 kg:



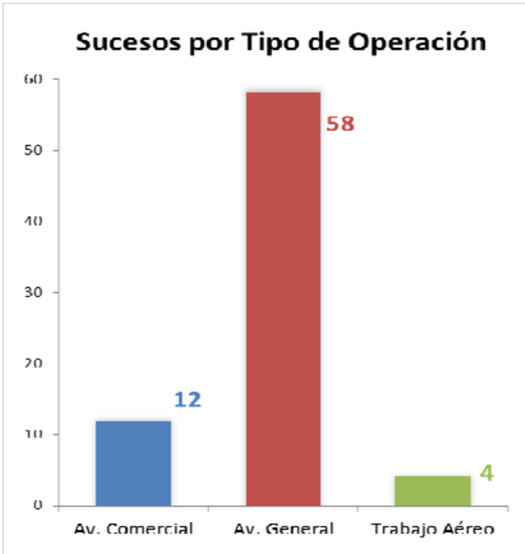
1.3 The distribution by class of occurrence shows that runway excursions (REs) have caused more accidents than serious incidents or incidents. The distribution remains the same for aircraft above and below 2,250 kg.

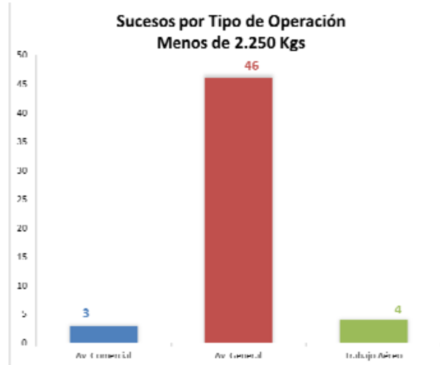


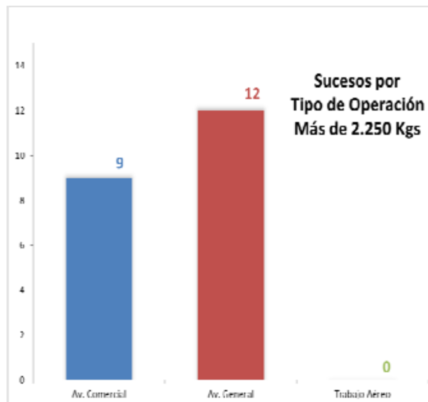




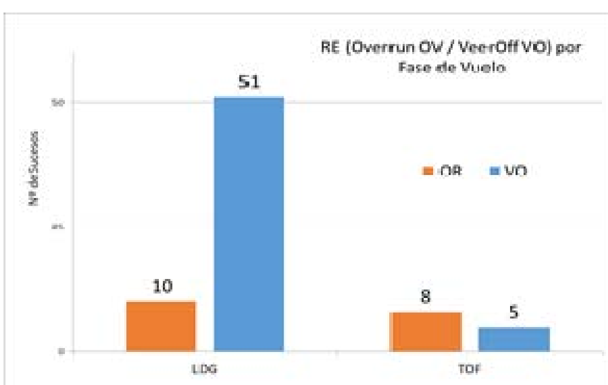
1.4 If we consider the classification by type of operation, general aviation has more occurrences, especially involving aircraft below 2,250 kg. And, as expected in aircraft above 2,250 kg, commercial aviation increases the distribution of its category.

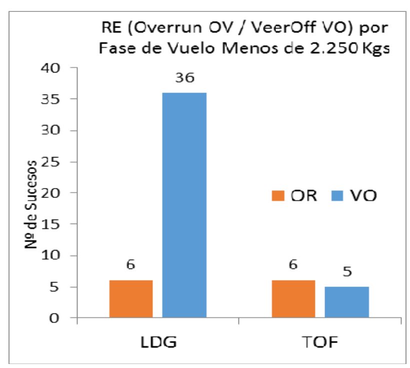


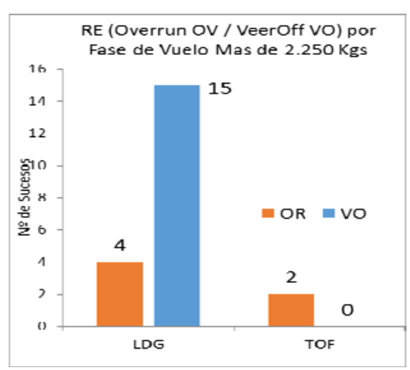




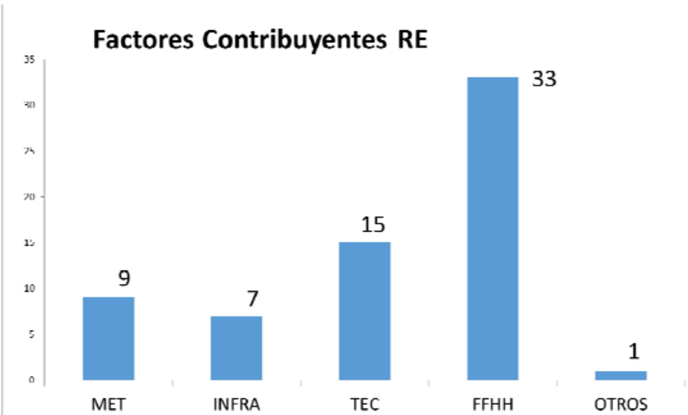
1.5 Taking into account the flight phase in which the RE occurred, it may be noted that most occurrences take place during landing (LDG) and, among these, most are of the Veer Off (VO) type, which applies to both aircraft above and below 2,250 kg:

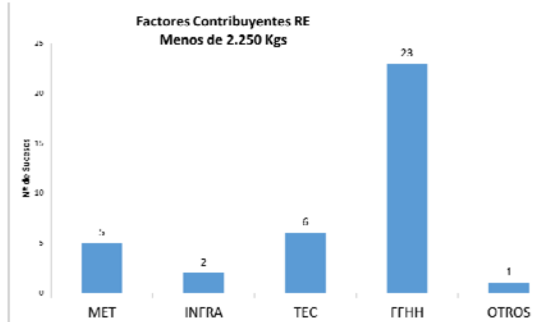


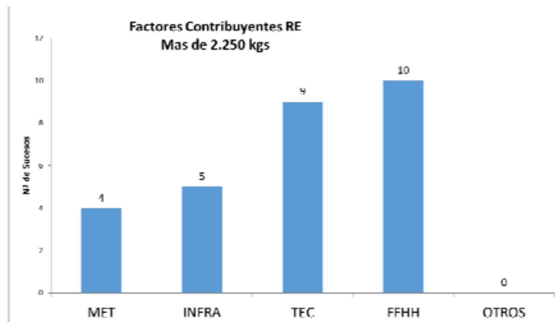




1.6 Knowing that most occurrences are under investigation and only preliminary information is provided thereon, it was proposed that experts, on a voluntary basis and by way of initial assessment, identify those factors they consider were involved in the occurrences. Based on the groups of factors defined in working paper ARCM-SAM-RE presented on 4/11/16, their distribution among occurrences is shown in the following graphs:

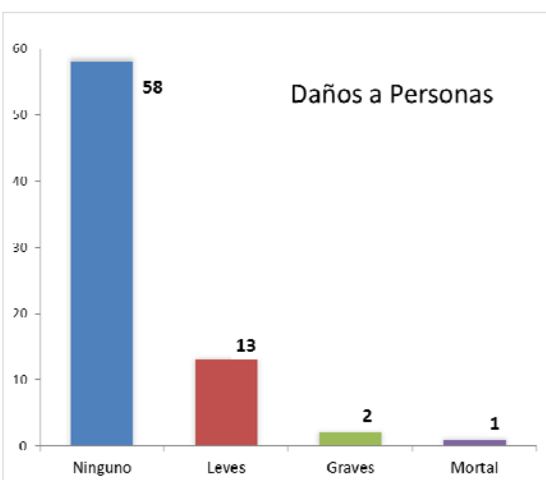


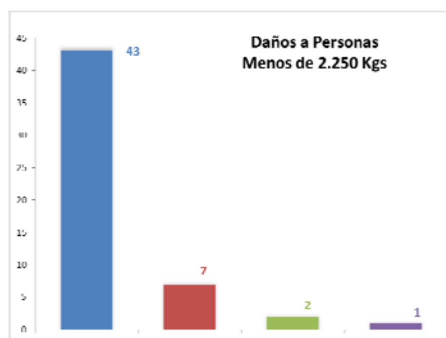


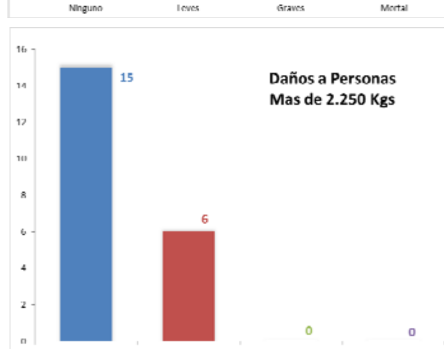


In most of the occurrences classified with factors (in one case, more than one factor could be proposed), it is noted that the human factor participates actively at the end of the chain of events to minimise or increase the results, where meteorology (MET), infrastructure (INFRA), or technology (TECH) condition the environment in which the runway excursion occurs.

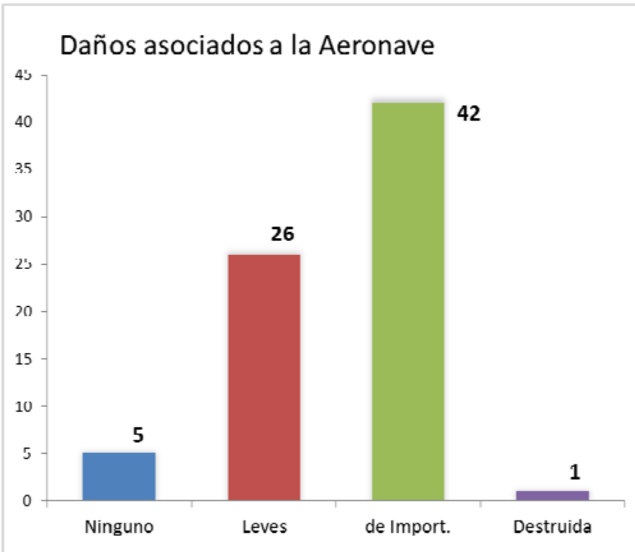
1.7 The distribution of personal injuries reveals that the highest probability is for individuals not to suffer any injury:

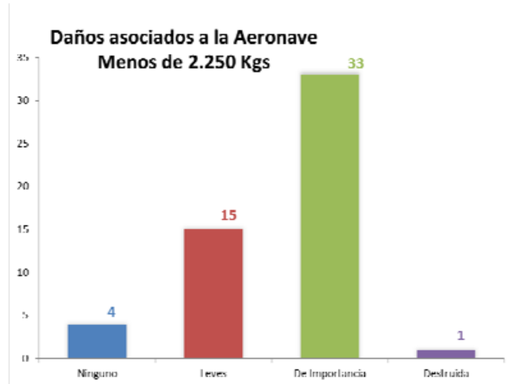


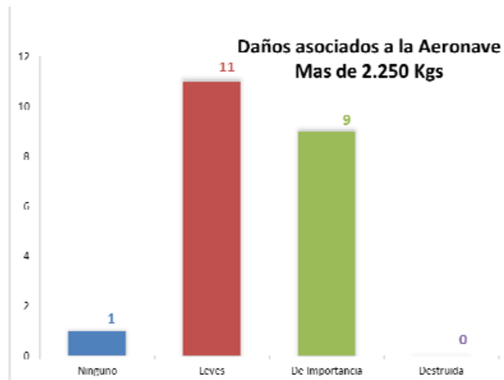




1.8 Regarding damage to aircraft, it may be noted that runway excursions mostly cause significant damage, minor damage or no damage. In aircraft below 2,250 kg, the damage was recorded as “significant”, and in heavier aircraft, it was recorded as “minor” damage.







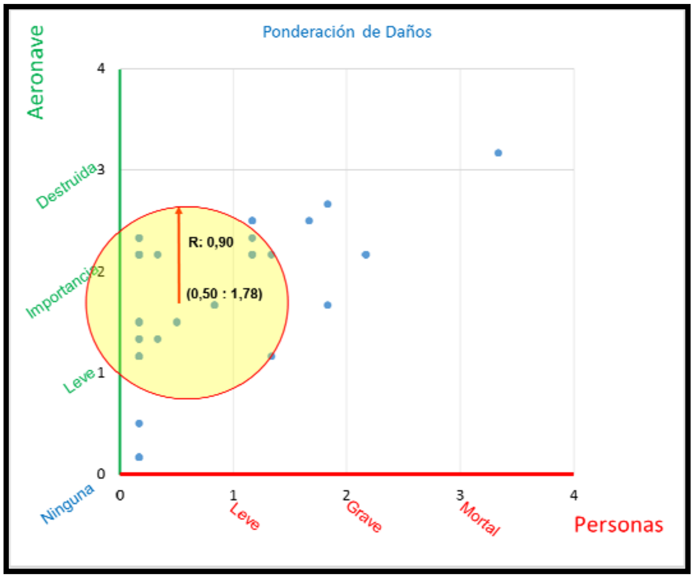
2. **Considerations**

2.1 In order to have an indicator to measure the impact of mitigation measures, the following method uses data obtained in paragraph 3.5. This indicator draws from the combination/graphical representation of two coefficients, one related to “personal injuries” and the other to “damage to aircraft”, weighing each separately, taking into account:

- **Coefficient for personal injuries:** An abstract number was developed as follows: the integer part is the highest type of injury suffered by persons on the aircraft (where “0” is none, “1” is minor, “2” is serious, and “3” is mortal); and in the decimal part, a category was determined based on the number of persons on board (where “1” is up to 5, “2” up to 20, “3” up to 40, “4” up to 60, and “5” more than 80 persons on board, which is then divided by “6” so as not to arrive at an entire unit). For example, a value of 2.17 means that there were “2” serious injuries, which make up the integer part of the value, and there were up to 5 persons on board “1”, divided by “6”, that is “1/6=0.17”, which is the decimal part of the value.

- **Coefficient for damage to the aircraft:** An abstract number was developed as follows: the integer part shows the damage suffered by the aircraft (where “0” means no damage, “1” means minor damage, “2” means significant damage, and “3” means destroyed); and the decimal part shows the “MTOW” category (where “1” is from 1 to 2,250 kg, “2” is from 2,251 to 5,700 kg, “3” is from 5,701 to 27,000 kg, “4” is from 27,001 to 272,000 kg, and “5” is more than 272,001 kg, which is then divided by “6” so as not to arrive at the entire unit). For example, a value of 1.17 implies that there were minor damages “1”, which makes up the integer part of the value, and the aircraft had an MTOW between 1 and 2,250 kg “1”, divided by “6”, that is “1/6=0.17”, which makes up the decimal part of the value.

2.2 For purposes of this study, it may be stated that the average damage to aircraft involves the categories between “Minor” and “Significant” (1.78) and that personal injuries are between “None” and “Minor” (0.50) with a probability of grouping 68% of cases in a radius (R: 0.90):



No large variations are observed for the categories of aircraft below 2,250 kg (0.44:1.75 and R: 0.93) and above that weight (0.63:1.84 R: 0.84).

2.3 If this method is applied to another period for comparison purposes, an improvement will be observed if the middle point (0.50:1.78) is shifted downwards and to the left; on the contrary, the situation will be more unfavourable if it is shifted upwards and to the right.

2.4 It is proposed that the RE monitoring project should be sustainable over time and that the ARCM should be capable of having a positive impact, reducing the rate of this type of accidents through the dissemination and monitoring of the implementation of the proposed preventive measures. To this end:

- ✓ The ARCM RE task force should work on a continuous basis;
- ✓ A brochure should be prepared and circulated addressing the study of RE occurrences in the SAM Region during 2016 and subsequent years;
- ✓ Virtual meetings should be held with AIG and civil aviation authorities of ARCM member States to follow up on the implementation of preventive measures agreed upon at regional level; and
- ✓ Regional seminars should be organised to address RE occurrences in the SAM Region.

2.5 Recalling that stated in the ARCM-SAM-RE working paper submitted on 4 November 2016, recurrent factors present in RE occurrences include:

- Meteorological factors, which generate the conditions under which the aircraft operates (cross-wind – tailwind) or impact other factors that, in the end, also affect aircraft operation (rain – snow with formation of ice on the runway), both generating conditions in which the pilot must show skills in identifying the situation and operating the aircraft in the best possible way.
- Airport infrastructure can also be a conditioning factor of REs (runway with accumulation of water or mud – Negative slopes that increase landing run), or, as seen in more than one case, can magnify the damage suffered by the aircraft as a result of a runway excursion.
- In some cases, technical failure was the origin of a sequence of events that resulted in the RE. And, as in the previous cases, the human factor must deal with the arising situation.
- Human factors are involved in all cases. This covers errors made by the pilot, as well as causes that define the environment in which human factors operate, such as organisational decisions by operators under which the crews operate, team work in the cockpit, as well as the execution of standard operating procedures (SOPs).

Depending on the investigation stage, the investigator in charge must determine the factors involved, identifying the underlying facts. This will serve as a guiding tool to define mitigation actions and "defensive barriers", which will probably be aimed at the development of standards, procedures, technology, and training for managing the variables of factors that trigger runway excursions.

3. Conclusions

3.1 The 74 study cases provided by ARCM-SAM member countries do not escape to the general concepts observed in the reference work, confirming 4 groups of general factors: Human factors: which include all those related to appropriate pilot performance; Technical actors: all mechanical failures that affect the defensive technological barriers available on board; Meteorological factors: which affect the environment in which REs occur; and Infrastructure factors: that directly contribute to the occurrence of the RE or affect the severity of the damage caused by the RE.

3.2 In those study cases in which the RE occurred during the landing phase, it was found that a repetitive or recurrent element identified was the fact that the pilot failed to recognise being in a destabilised approach, and that he could have made the decision to go around. It was noted that this situation was the result of lack of experience, lack of training, or improper use of CRM, possibly due to inadequate knowledge of these concepts.

3.3 In those cases in which a technical failure triggered the situation, it was a conditioning factor of the pilot's behaviour.

3.4 The same applies to those study cases in which weather conditions had previously affected the runway surface or were present at the moment of the occurrence and adversely affected landing conditions, preventing the crew from performing normal landing procedures.

3.5 This study analysed the findings in aircraft below 2,250 kg and in those above that weight:

- **Below 2,250 kg**: These are the aircraft in which the crews normally acquire experience, both during training as well as in the initial flights in which they consolidate the acquired knowledge. They are also used for minor aerial work that do not involve significant safety paradigms. The results presented in previous paragraphs show that this category (53 occurrences) defines the trends that are then replicated in heavier aircraft. The experts conducting the study made the following observations:

- In general, the crews of these aircraft do not reinforce their training with the use of flight simulators.
- In general, initial training is on the ground, in a training centre. There is no recurrent/periodic training to introduce new techniques and reinforce initial training.
- Training runways generate habits that may be detrimental when applied to new runways where operations are to take place.
- CRM concepts taught to private or new crews are not formalised during recurrent training.
- These aircraft operate largely in uncontrolled aerodromes where runways are normally short and made out of dirt, grass, gravel, with no radio or visual aids.
- These aircraft have less technological resources, such as autopilot, flight manager, navigator, braking systems (Antiskid), thrust reverser, and aerodynamic brakes (spoilers) that significantly contribute to landing run control.

• **Above 2,250 kg:** This category shows the same distribution as for lighter aircraft. But this type of aircraft has more technological means used as defensive barriers and for recognising external factors (MET, INFRA, TECH) that abnormally affect the conditions under which an RE may occur. But it is the human factor that must recognise this conditioning environment in order to know how it can be countered, mitigated or acted upon in order to avoid it. This last defensive barrier that falls upon the human factor can be improved in advance, before the crews are assigned to a larger aircraft or during recurrent training to re-train them on how to operate in face of these negative factors, using the flight material at hand.

4. Proposed mitigation measures

4.1 It may be noted that aviation entities (airlines, institutions, flight schools, etc.) can mitigate the negative factors identified and observed in this study, providing crews with more and better defensive barriers against situations that could result in a runway excursion.

4.2 Executives/operators may focus their actions on ensuring that their crews acquire more and better experience so that they can operate large aircraft based on proper training during the initial or periodic/recurrent training phase. Thus, crews will be prepared to identify and act upon the variables that trigger a runway excursion.

4.3 For proper training planning, the variables that make up the factors involved in a runway excursion should be known and weighed, and an assessment made of the preparedness of crews to identify and act upon them properly. Based on these concepts, an SMS will permit the generation of guidelines describing the objectives and competencies to be achieved by the crew.

4.4 It is also important to expand and improve the study described herein in order to be able to model the factors and variables associated to an RE, its characteristics and modes of action. This analysis will determine the sensitivity of each factor and variable, and how they are all reinforced when they occur together. Based on mitigation measures, it should be able to measure the results using reliable indicators. Based on the knowledge acquired on this topic, it is essential to set up a team of advisors that may be aware of new occurrences and contribute to their solution.

4.5 It would be advisable for the ARCM to send this working paper to all the areas responsible for the SSP so that it may be used as guidance for proactive safety management.

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