70 YEARS 1945—2015
Flying better. Together.

IATA

Runway Safety Accident Analysis Report

2010-2014

1st Edition

NOTICE

Senior Vice President
Safefy & Flight Operations
International Air Transport Association
800 Place Victoria
P.O. Box 113
Montreal, Quebec
CANADA H4Z 1M1

IATA Runway Safety Accident Analysis Report
ISBN 978-92-9252-776-1

Montreal—Geneva

Table of Contents

Section 1—Introduction 1

Section 2—Data Source 2

Section 3—Exclusions 2

Section 4—Scope 2

Section 5—Global Accident Data 3

Section 6—Definitions 7

6.1 Runway Safety Definition 7
6.2 Runway Excursion Definition 7
6.3 Unstable Approach Definition 7

Section 7—Runway Safety Accident Data 8

7.1 Accidents by Aircraft Propulsion 11
7.2 Accidents by IOSA Versus Non-IOSA Registry 14
7.3 Accidents by Phases of Flight 15
7.4 Runway Safety Severity 21
7.5 Impact of Types of Service 24
7.6 Accidents Regional Analysis 26
7.7 Runway Safety Accidents by Regional Aviation Safety Group (RASG) Regions 30
7.8 Runway Safety Contributing Factors 34

Section 8—Unstabilized Approaches 38

Section 9—Mitigations 39

Section 10—Accident Scenarios of Interest 41

Section 11—Conclusion 42

Appendix A—Phase of Flight Definitions 43

Appendix B—IATA Regions 44

Appendix C—RASG Regions 47

List of Figures

Figure 1: Global Accident Categories Breakdown 3
Figure 2: Percentage of Commercial Accident Categories in Relation to Total Accidents 3
Figure 3: Distribution of IOSA Registry Accidents Versus Non-IOSA Registry in Relation to Total Accidents per Year 4
Figure 4: Distribution of IOSA Registry Accident Rates Versus Non-IOSA Registry Accident Rates in Relation to Total Accident Rates per Year 4
Figure 5: Number of Fatal Accidents per Accident Category 5
Figure 6: Frequency of Fatal Accidents per Year 5
Figure 7: High Risk Accident Category 6
Figure 8: Distribution of Runway Safety Accidents per Category 8
Figure 9: Number of Runway Safety Accidents per Year 8
Figure 10: The Distribution of Runway Safety Accident Categories per Year 9
Figure 11: Runway Safety Accident Rates 9
Figure 12: Runway Excursion Accident Count 10
Figure 13: Runway Excursion Accident Rates per Year 10
Figure 14: Frequency of Runway Excursion Accidents by Type 11
Figure 15: Frequency of Runway Safety Accidents by Aircraft Propulsion 12
Figure 16: Distribution of Jet/Turboprop Runway Safety Accident Rates 12
Figure 17: Frequency of Runway Excursion Accidents by Aircraft Propulsion 13
Figure 18: Distribution of Jet/Turboprop Aircraft Runway Excursion Accident Rates 13
Figure 19: Distribution of Runway Safety Accidents by Phases of Flight 15
Figure 20: Contributing Factors to Landing Runway Safety Accidents 16
Figure 21: Distribution of Jet Versus Turboprop Runway Safety Accidents per Phase of Flight 17
Figure 22: Frequency of Landing Runway Safety Accident Categories per Year 17
Figure 23: Distribution of Aircraft Propulsion for Runway Safety during Landing Phase of Flight 18
Figure 24: Frequency of Landing Excursions by Type 18
Figure 25: Landing Overrun Fatal Accidents per Aircraft Propulsion 19
Figure 26: Contributing Factors to Landing Excersions – Overrun and Veer-offs 20
Figure 27: Distribution of Runway Safety by Severity 21
Figure 28: The Distribution of Fatal to Non-Fatal Runway Safety Hull Loss Accidents 22
Figure 29: Distribution of Runway Safety by Severity 23
Figure 30: The Distribution of Fatal to Non-Fatal Runway Excursion Hull Loss Accidents 23
Figure 31: Distribution of Runway Safety Accidents by Region of Operator 26
Figure 32: Runway Safety Accident Rates by IATA Region of Operator 26
Figure 33: Non-Fatal Versus Fatal Runway Safety Accidents by Region of Operator 27
Figure 34: Fatal Versus Non-Fatal Runway Safety Accident Rates by Region of Operator 27

Figure 35: IATA Regional Operators Involved in Runway Safety Accidents by Aircraft Propulsion....28
Figure 36: A Comparison of the Aircraft Propulsion Runway Safety Accident Rates by Region of Operator....28
Figure 37: Regional Breakdown of Runway Safety Performance for IOSA Registered Airlines Versus Non-IOSA Registered Airlines....29
Figure 38: Distribution of Runway Safety Accidents by Service Type and Operator Region....29
Figure 39: Percentage of Runway Excursion by Region of Operator....30
Figure 40: Runway Excursion Accident Rates by Region of Operator....30
Figure 41: Runway Safety Accidents by RASG Region of Operator....31
Figure 42: Runway Safety Accident Rates by RASG Region of Operator....31
Figure 43: Runway Safety Accident Count by RASG Region of Operator and Aircraft Propulsion....32
Figure 44: RASG Regional Runway Safety Accident Rates by Aircraft Propulsion....32
Figure 45: Runway Excursion Accident Count by RASG Region of Operator and Aircraft Propulsion....33
Figure 46: Distribution of Runway Safety Accidents by RASG Region of Operator Versus Region of Occurrence....33
Figure 47: Contributing Factors to Runway Safety Accidents....34
Figure 48: Latent Conditions Contributing to Runway Safety Accidents....35
Figure 49: Environmental and Airline Threats Contributing to Runway Safety Accidents....36
Figure 50: Flight Crew Errors Contributing to Runway Safety Accidents....36
Figure 51: Undesired Aircraft States Contributing to Runway Safety Accidents....37

List of Tables

Table 1: Top Three Fatal Accident Categories 6

Table 2: Comparison Frequency of Runway Excursion Types for the Different Phases of Flight 11

Table 3: Comparison Frequency of Runway Excursion Types for the Different Phases of Flight and Aircraft Propulsion 14

Table 4: IOSA Versus Non-IOSA Registered Accident Rates 14

Table 5: Runway Safety Accident Rates for Operators of Turboprop and Jet Aircraft on the IOSA Registry Versus Non-IOSA Registry 15

Table 6: Runway Safety Accidents by Severity 21

Table 7: Distribution of Fatal Runway Safety Accidents 22

Table 8: Runway Safety Fatal Accident Counts and Survibility by Aircraft Propulsion 22

Table 9: Jet Versus Turboprop Hull Loss Runway Excursion Accident Rates/Count 23

Table 10: Runway Excursion Fatal Accident Count and Survivability by Aircraft Propulsion 24

Table 11: Runway Safety Accidents by Type of Operation and Service 24

Table 12: Runway Safety Fatal Accidents by Type of Operational Service 24

Table 13: Distribution of Runway Safety Accidents by Scheduled Versus Non-Scheduled 25

Table 14: Distrubution of IOSA Registered Carriers Involved in Runway Safety Accidents by Operational Service 25

Section 1—Introduction

The International Air Transport Association (IATA) is dedicated to implementing a data driven approach to the evaluation of aviation safety risks and the development of potential solutions.

Runway safety has become a significant area of interest for the industry due to the frequency of accidents in the runway environment; these include runway excursions, runway collisions, undershoot/overshoots, tailstrikes and hard landing events.

Runway/taxiway excursion is the most frequent category of accidents, representing 22 percent of all accidents over the period of 2010 – 2014. There is an average of 18 runway/taxiway excursions to commercial air transport aircraft worldwide per year. Excursions can lead to loss of life and/or injury to persons either on board the aircraft or on the ground and can result in damage to aircraft, airfield or off-airfield equipment including other aircraft, buildings or other items struck by the aircraft.

In total, there were 90 runway/taxiway excursions accidents identified over the five (5)-year period emphasizing a need to prioritize preventive measures.

Close cooperation between aviation's major stakeholders has already led to a number of solutions, including the Runway Excursion Risk Reduction Toolkit (RERR Toolkit), which was developed by IATA in collaboration with Flight Safety Foundation (FSF). The second edition of this toolkit was a collaboration between IATA and ICAO with contributions from ACI, CANSO, IFATCA, EUROCONTROL, NLR, FSF, and Australian Transport Safety Bureau. More recently the Runway Safety Implementation Kit (Runway Safety i-Kit) was developed in collaboration with IATA, ICAO, ACI, CANSO, ICCAIA, FSF, IFALPA, IFATCA, IBAC, IAOPA, FAA, EASA and EUROCONTROL. These tools provide runway safety information, training modules, presentations, animations and best practices.

Despite these and other efforts, the runway excursion rate has shown only slight improvement. Although runway excursions are the most common type of accident, the associated fatality rate is much lower than in other accident categories such as Loss of Control In-Flight (LOC-I) or Controlled Flight Into Terrain (CFIT). Analysis in this report evaluates the risk factors from runway safety accidents and presents information designed to aid industry in the implementation of mitigation strategies. The data set includes aircraft over 5,700 kg maximum take-off weight engaged in commercial operations according to the IATA definition.

Section 2—Data Source

This report is focused on commercial aircraft operations using data from the IATA Global Aviation Data Management (GADM) accident database over the period of 2010-2014.

Section 3—Exclusions

This report specifically excludes the accidents involving the following types of operations:

- Private (general) aviation
- Business or military aviation
- Flights as part of illegal activities
- Humanitarian relief flights
- Crop spraying or other agricultural flights
- Security-related events (e.g. hijackings)
- Experimental or other test flights[1]

Section 4—Scope

The report is designed to inform the aviation industry and provide detailed information and understanding of global accidents, runway safety and runway excursion accident statistics during the five (5) years (2010-2014) to support the industry with safety improvement initiatives. The report also identifies causal and contributory factors that may lead to a runway safety event and from which preventive measures can be formulated.

[1] Such as post maintenance functional check flights

Section 5—Global Accident Data

This analysis report is generated from worldwide reports of accidents resulting in hull loss or substantial damage to all jet and turboprop aircraft, greater than 5,700 kg, from January 2010 to December 2014 inclusive.

There were a total of 415 accidents worldwide during the period analyzed. Of these accidents, 90 were classified as runway/taxiway excursions and form the primary focus for this report. Figure 1 illustrates the frequency of global accidents across all categories. It should be noted that 409 (99 percent) of all accidents could be assigned an accident category or End State[2], while the remaining six (6) accidents lacked sufficient information for classification.

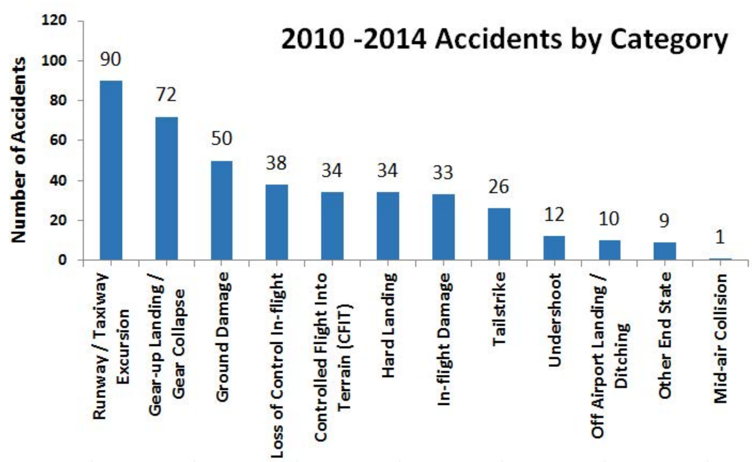

Figure 1: Global Accident Categories Breakdown

The percentage of commercial accident categories worldwide in relation to the total accidents is shown in figure 2.

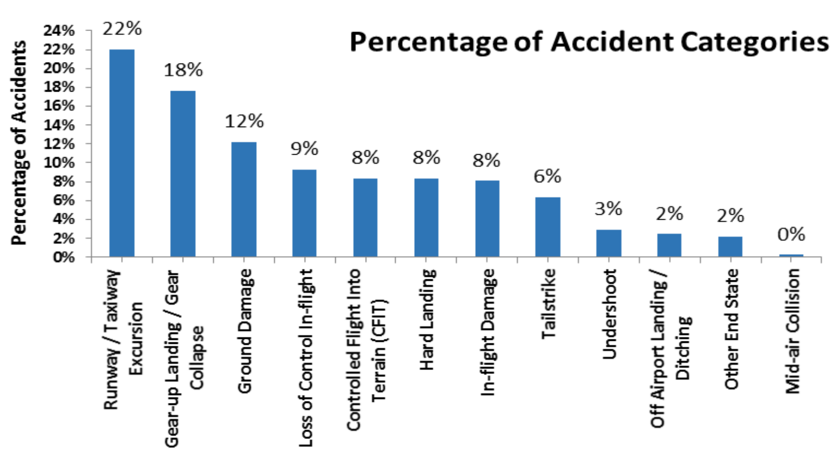

Figure 2: Percentage of Commercial Accident Categories in Relation to Total Accidents

[2] An End State is a reportable event. An End State is unrecoverable, also known as the Accident Category.

Over the period, the IATA Operational Safety Audit (IOSA) program has demonstrated positive results for IOSA registered airlines, when all accidents were broken-down to show the frequency for IOSA registered airlines compared to the frequency for operators not on the IOSA registry. Figure 3 presents the frequency of IOSA Registry accidents versus Non-IOSA Registry in relation to the total accidents per year.

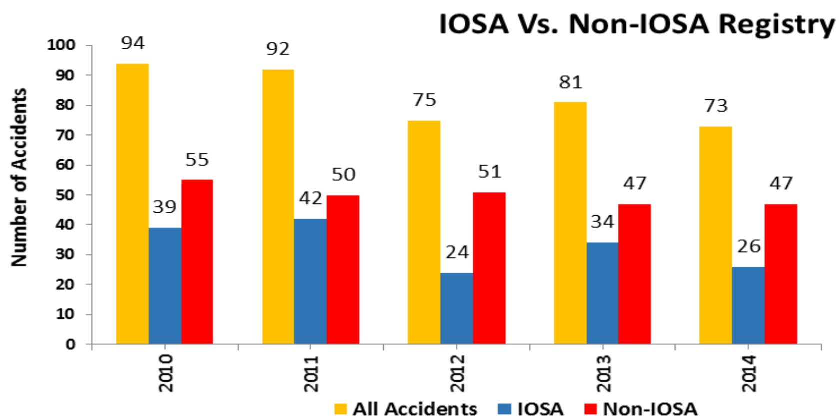

Figure 3: Distribution of IOSA Registry Accidents Versus Non-IOSA Registry in Relation to Total Accidents per Year

The overall accident rate per million sectors flown for IOSA registered airlines is approximately three (3) times lower than that for non-IOSA registered airlines for the period between 2010 and 2014. Figure 4 shows the IOSA versus the Non-IOSA registered accident rates in relation to the total accident rates.

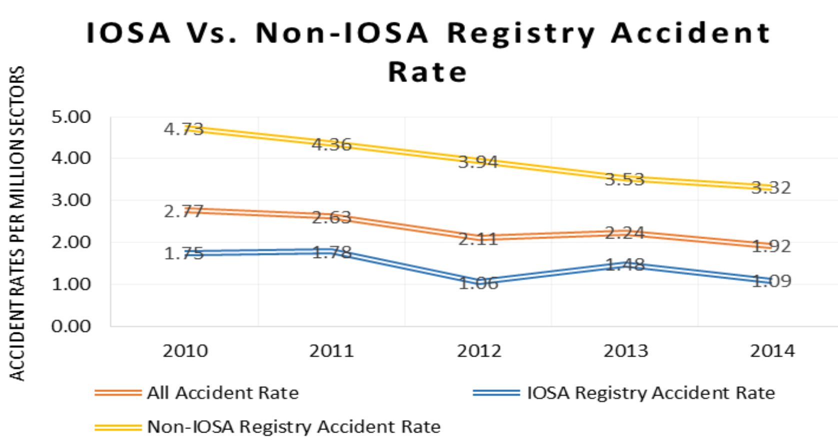

Figure 4: Distribution of IOSA Registry Accident Rates Versus Non-IOSA Registry Accident Rates in Relation to Total Accident Rates per Year

Of the 415 accidents between 2010 and 2014, 88 accidents were fatal resulting in 2,541 total fatalities. The breakdown of fatal accidents by occurrence category is shown in Figure 5. Note that 86 were assigned an End State.

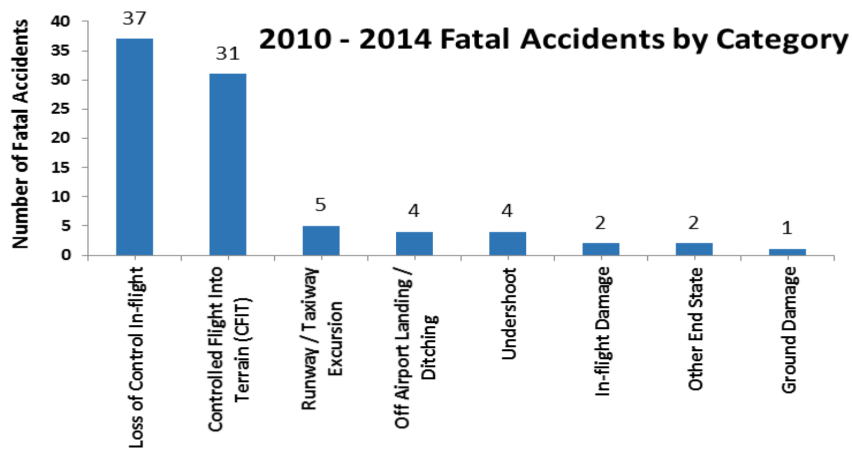

Figure 5: Number of Fatal Accidents per Accident Category

The relative percentage of fatal accidents remained fairly constant from 2010 through 2014, at three to six percent (3 to 6%) of the total number of commercial accidents. Although the number of commercial fatal accidents fluctuated year to year, the number of fatal accidents between 2010 and 2014 declined overall from 23 to 12. Figure 6 presents the frequency of fatal accidents per year.

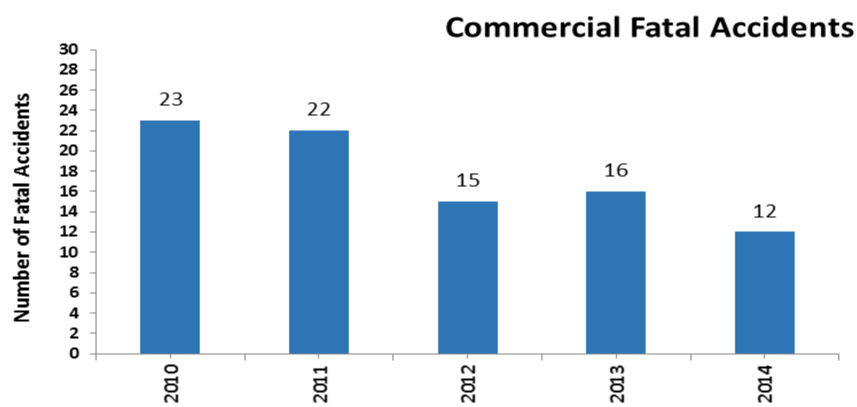

Figure 6: Frequency of Fatal Accidents per Year

The most common and most survivable accident category is runway/taxiway excursions with 98% survivability; runway/taxi excursions represented seven (7) percent of total fatalities over the five (5) years (174 out of 2,541).

Figure 7 presents the concept of high-risk accident categories. This was designed to expand beyond the traditional method of using accident frequency as the single metric for prioritization of mitigation efforts and to introduce a metric for accident outcome related to survivability.

In figure 7, each accident category is plotted by the average number of occurrences per year and the percentage of fatalities relative to the total number of people on board. The bubble size increases as the absolute number of fatalities for the category increases; empty bubbles indicate no fatalities for that accident category. From this analysis Runway Excursions, Loss of Control In-Flight, and Controlled Flight Into Terrain were identified as the top three high risk categories to be addressed by IATA.

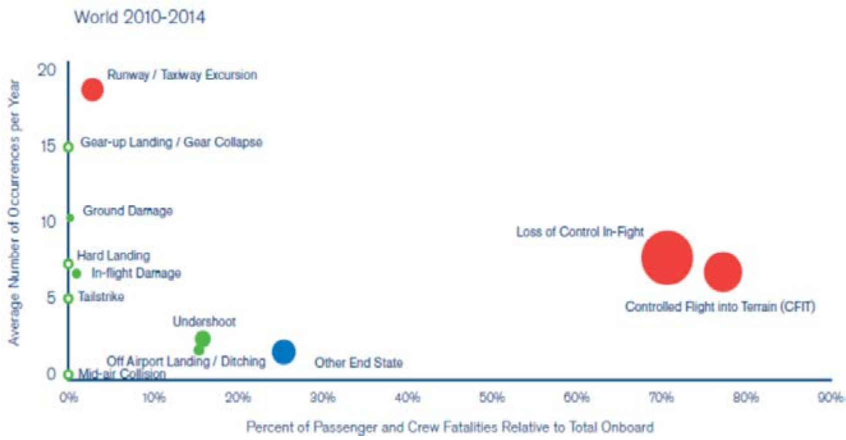

Figure 7: High Risk Accident Category

As shown in Table 1, runway excursion has the highest accident frequency but the lowest number of fatalities. LOC-I was the primary cause of commercial aviation fatalities between 2010 and 2014, followed by Controlled Flight into Terrain (CFIT). The improving trends in the other accident categories have resulted in LOC-I becoming the leading cause of fatal accidents in air transportation worldwide.

Accident Category	Number of Accidents	Fatal Accidents	Fatalities
Loss of Control In-flight (LOC-I)	38	37	1,242
Controlled Flight Into Terrain (CFIT)	34	31	707
Runway / Taxiway Excursion	90	5	174

Table 1: Top Three Fatal Accident Categories

The remainder of this paper focuses on runway safety and runway excursion accidents.

Section 6—Definitions

6.1 Runway Safety Definition

For the purpose of this report, runway safety includes runway excursions, runway collision, undershoot/overshoot, tailstrike and hard landing events.

6.2 Runway Excursion Definition

For the purposes of this report, a runway excursion event occurs when an aircraft on the runway surface departs the end or side of the runway surface during takeoff or landing.

They consist of two types of events:

- Veer Off: A runway excursion in which an aircraft departs the side of a runway
- Overrun: A runway excursion in which an aircraft departs

It excludes both accidents where the aircraft did not initially land on a runway surface, and takeoff excursions that did not start on a runway (e.g., inadvertent takeoffs from taxiways).

6.3 Unstable Approach Definition

Unstabilized approaches have been identified as a critical safety factor in many runway safety accidents, in particular runway excursion accidents. In accordance to the IATA Safety Report 2014, the definition of an Unstable Approach is an approach where Accident Classification Task Force has identified vertical, lateral or speed deviations in the portion of the flight close to landing.

Note – This definition includes the portion immediately prior to touchdown and in this respect the definition might differ from other organizations. However, accident analysis provides evidence that loss of stabilization just prior to touchdown has contributed to accidents.

Section 7—Runway Safety Accident Data

From 2010 – 2014, 159 accidents or 39 percent of all commercial accidents occurred in the runway environment. The most frequent type was runway excursion with 87 accidents, representing 55 percent of all runway safety accidents over the period. There were no overshoot or runway collision accidents during the period. Figure 8 shows the breakdown of runway safety accident categories.

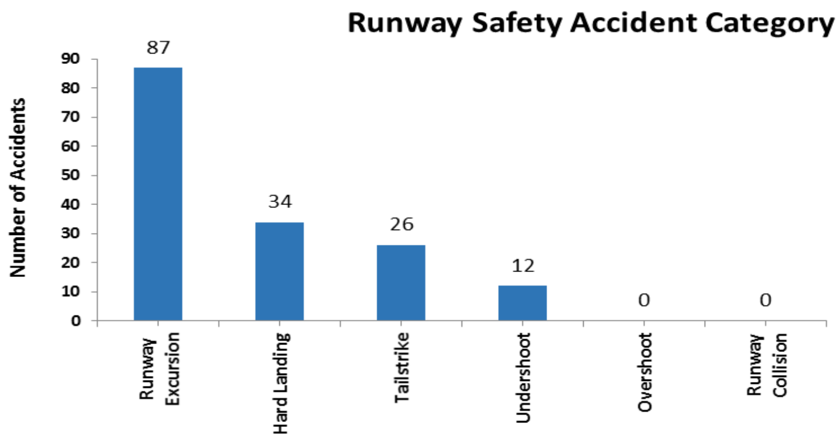

Figure 8: Distribution of Runway Safety Accidents per Category

In the five (5) year period, there was an average of (31.8) runway safety accidents per year. Figure 9 shows the frequency of runway safety accidents by year between 2010 and 2014. The lowest number occurred in 2014 when there were 28 runway safety accidents. The 28 accidents were below the five-year average.

Figure 9: Number of Runway Safety Accidents per Year

Furthermore, the data shows that the five-year average number of commercial aircraft for runway excursion accidents was 17.4 per year, while the average number for hard landing accidents was 6.8 per year, 5.2 per year for tailstrike, and 2.4 per year for undershoot. Figure 10 illustrates the distribution of runway safety accident categories per year for 2010-2014.

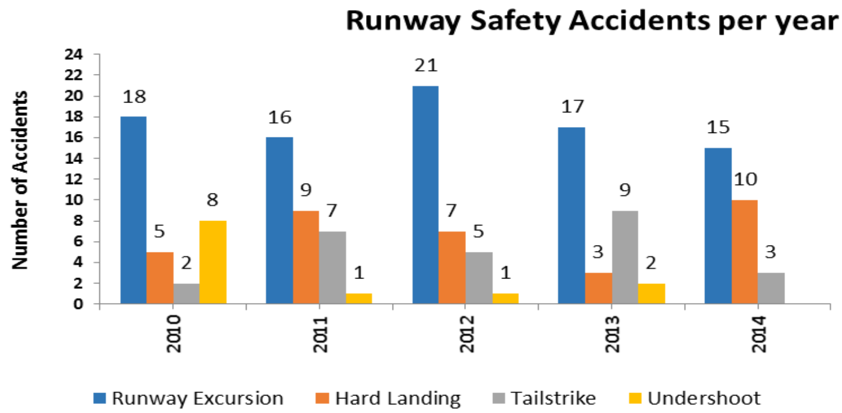

Figure 10: The Distribution of Runway Safety Accident Categories per Year

Absolute numbers of accidents are seldom a good indication of safety performance and are of limited comparative value unless they are normalized by the number of sectors[3] flown per year to create an accident rate. Figure 11 shows the runway safety accident rates per million sectors flown per year.

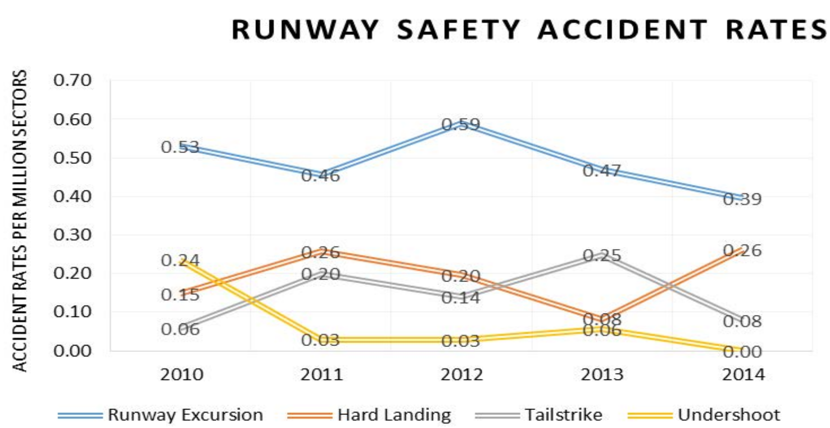

Figure 11: Runway Safety Accident Rates

The analysis revealed that runway excursion accidents were the highest single occurrence category. The lowest number of runway excursions occurred in 2014 when there were 15 accidents. The 15 accidents were below the five-year average. Figure 12 illustrates the number of runway excursion accidents per year.

[3] IATA defines "sector" as the aircraft between takeoff at one location and landing at another location (other than a diversion).

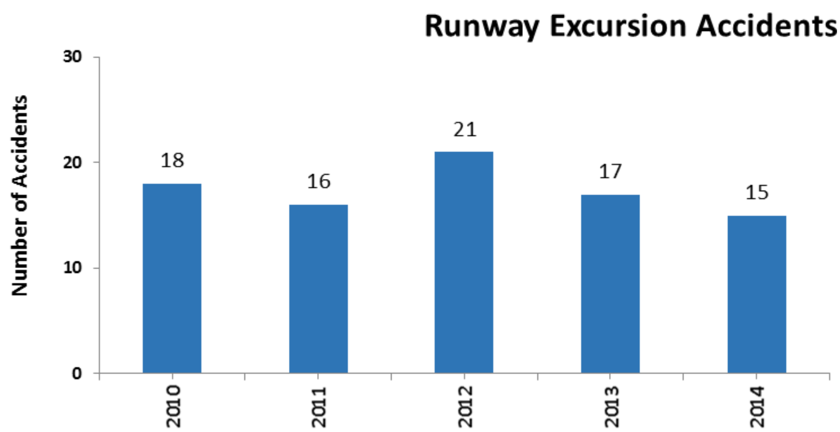

Figure 12: Runway Excursion Accident Count

The analysis indicated that the existing mitigations are having some effect as there has been a decline in the runway excursion accident rates over the period. Figure 13 illustrates the runway excursion accident rates per year.

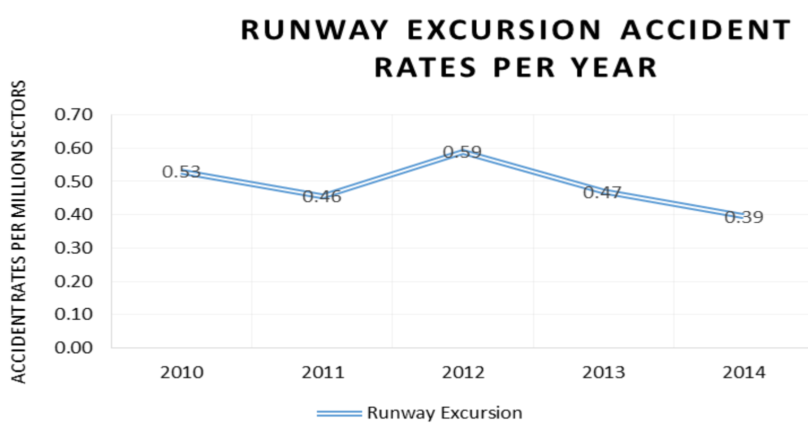

Figure 13: Runway Excursion Accident Rates per Year

In terms of runway excursion type, veer-off was the more frequent, accounting for 53 percent of runway excursion accidents, while the remaining 44 percent were overruns. Three (3) percent had insufficient information to determine the type. Figure 14 shows the frequency of runway excursion accidents by type. Only in 2010 were there more overrun accidents than veer-off accidents.

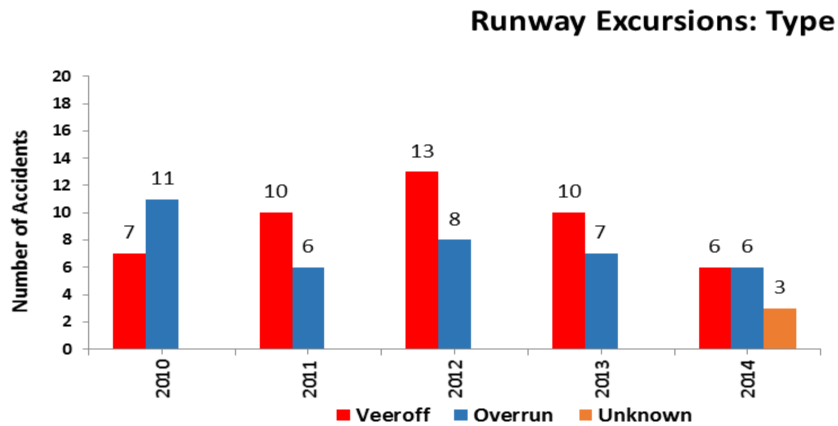

Figure 14: Frequency of Runway Excursion Accidents by Type

Table 2 shows an overview of the frequency of occurrence of the different types of runway excursions for the different flight phases. This table also shows that runway excursions occurred most often during the landing phase of flight. The definitions for each flight phase used in this report are presented in Appendix A.

Runway Excursion Type	Number of Accidents	Phase of Flight	Number of Fatal Accidents
Overrun	1	Take-off	0
Overrun	35	Landing	5
Overrun	2	Rejected Take Off	0
Veer-offs	5	Take-off	0
Veer-offs	41	Landing	0

Table 2: Comparison Frequency of Runway Excursion Types for the Different Phases of Flight

7.1 Accidents by Aircraft Propulsion

This section breaks down runway safety accidents by aircraft propulsion. Over the five (5) years covered in this report, commercial jet aircraft were involved in 99 runway safety accidents or 62 percent of the total runway safety accidents and 45 percent of all jet aircraft accidents, while turboprop aircraft were involved in 60 accidents or 38 percent of the total runway safety accidents and 31 percent of all turboprop aircraft accidents. The data also shows an average of 19.8 runway safety accidents per year involving commercial jet aircraft, and 12 runway safety accidents per year involving commercial turboprop aircraft. Figure 15 illustrates the distribution of runway safety accidents per year per aircraft propulsion.

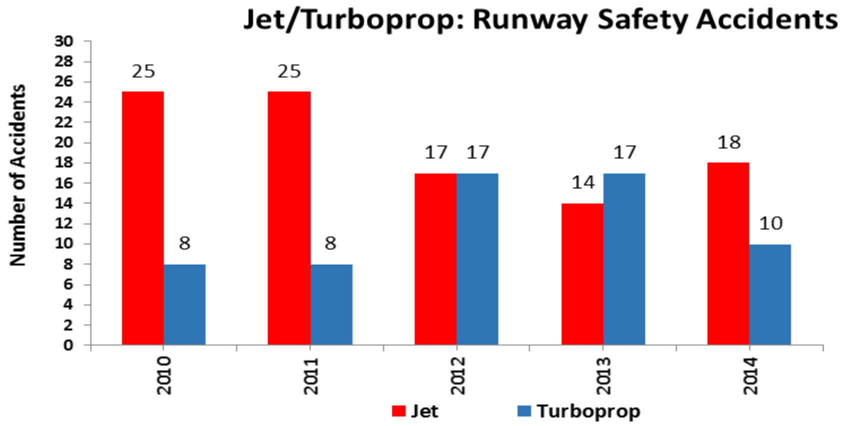

Figure 15: Frequency of Runway Safety Accidents by Aircraft Propulsion

When analyzed by aircraft propulsion, turboprop aircraft had a higher rate of runway safety accidents than jet aircraft (1.65 accidents per million flights as opposed to 0.70). Figure 16 illustrates the distribution of accident rates per year broken-down by turboprop and jet propulsion.

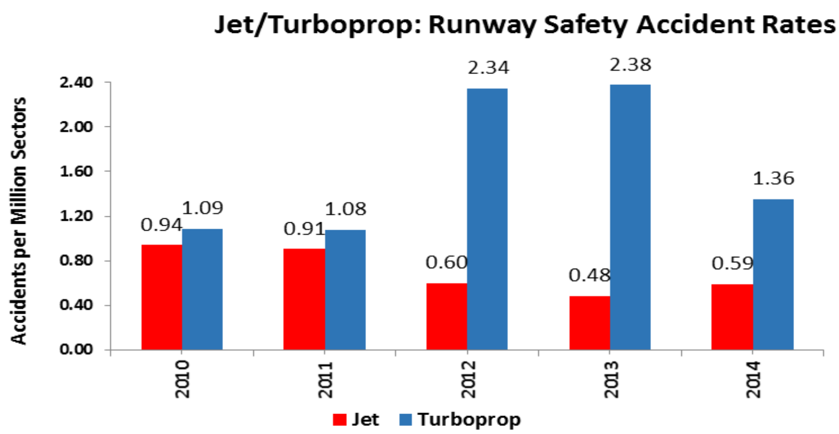

Figure 16: Distribution of Jet/Turboprop Runway Safety Accident Rates

Commercial jet aircraft were involved in 47 runway excursion accidents or 47 percent of the total jet aircraft runway safety accidents, an average of 9.4 excursion accidents per year. Turboprop aircraft were involved in 40 excursion accidents or 67 percent of the total turboprop aircraft runway safety accidents, an average of eight (8) excursion accidents per year. Figure 17 illustrates the distribution of jet/turboprop aircraft involved in runway excursion accidents per year.

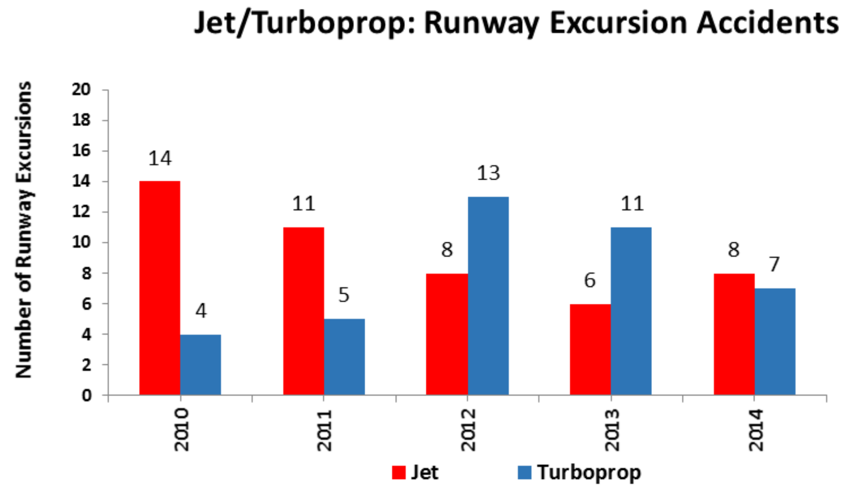

Figure 17: Frequency of Runway Excursion Accidents by Aircraft Propulsion

Figure 18 illustrates the distribution of jet/turboprop aircraft runway excursion accident rates per million sectors. Turboprop aircraft had a higher rate of runway excursion accidents than jet aircraft (1.10 accidents per million flights as opposed to 0.33).

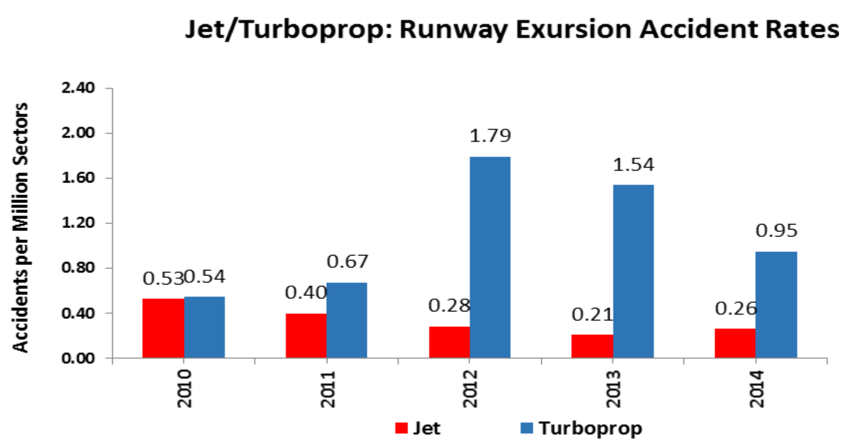

Figure 18: Distribution of Jet/Turboprop Aircraft Runway Excursion Accident Rates

Runway overrun and runway veer-off accidents involving jet and turboprop aircraft were analyzed; three (3) accidents had insufficient data and therefore could not be included. In terms of the runway excursion type, there were 20 veer-off accidents involving jet aircraft and 26 accidents involving turboprops. 25 runway excursion overrun accidents involved jet aircraft and 13 accidents involved turboprop aircraft. Runway overruns account for 100% of all fatal runway excursion accidents over the same period. There were five (5) runway excursion fatal accidents in total, three (3) of which involved jet aircraft, and two (2) involved turboprop resulting in multiple fatalities. Table 3 presents the comparison frequency of runway excursion types for the different phases of flight and the different aircraft propulsion.

Runway Excursion Type	Number of Accidents	Phase of Flight	Jet	Number of Fatal- Jet Accidents	Turboprop	Number of Fatal – Turboprop Accidents
Overrun	1	Take-off	1	0	0	0
Overrun	35	Landing	24	3	11	2
Overrun	2	Rejected Take-off	0	0	2	0
Veer-offs	5	Take-off	1	0	4	0
Veer-offs	41	Landing	19	0	22	0

Table 3: Comparison Frequency of Runway Excursion Types for the Different Phases of Flight and Aircraft Propulsion

7.2 Accidents by IOSA Versus Non-IOSA Registry

The IATA Operational Safety Audit (IOSA) program is an internationally recognized and accepted evaluation system designed to assess the operational management and control systems of an airline. All IATA members are IOSA registered and must remain registered to maintain IATA membership. Increasingly non-IATA members are applying for registry.

The positive results of IOSA are illustrated when all accident rate is broken-down to show the rates for IOSA registered airlines compared to the rates for operators not on the IOSA registry. The average overall accident rate for IOSA registered airlines is almost three (3) times lower than that for non-IOSA registered airlines for the period between 2010 and 2014. Table 4 shows the IOSA versus the Non-IOSA registered runway safety accident rates.

Category	Hard Landing	Runway Excursion	Tailstrike	Undershoot
All Accident	0.19	0.49	0.15	0.07
IOSA	0.12	0.23	0.16	0.01
Non-IOSA	0.32	0.95	0.11	0.17

Table 4: IOSA Versus Non-IOSA Registered Accident Rates

IOSA also demonstrated a positive impact on aviation safety, when comparing jet and turboprop safety performance. The runway safety accident rate is broken-down to show the runway safety accident rates of the different types of aircraft propulsion in relation to IOSA versus non-IOSA registered jet and turboprop aircraft operators. Table 5 shows the runway safety accident rates for operators of turboprop and jet aircraft on the IOSA registry versus Non-IOSA registry.

Category	Hard Landing	Runway Excursion	Tailstrike	Undershoot
Accidents – Jet	0.15	0.33	0.15	0.06
IOSA – Jet	0.11	0.21	0.17	0.01
Non-IOSA – Jet	0.29	0.68	0.10	0.18
Accidents – Turboprop	0.33	1.09	0.11	0.11
IOSA – Turboprop	0.27	0.44	0.09	0.00
Non-IOSA – Turboprop	0.36	1.38	0.12	0.16

Table 5: Runway Safety Accident Rates for Operators of Turboprop and Jet Aircraft on the IOSA Registry Versus Non-IOSA Registry

7.3 Accidents by Phases of Flight

A runway safety event can take place on take-off, rejected take-off, approach, go-around or landing. Landing runway safety accidents outnumbered takeoff runway safety occurrences for both jet and turboprop aircraft. The data identified 159 runway safety accidents and of those, 131 were associated with landing and form the focus for the remainder of this section. Figure 19 illustrates the distribution of runway safety accidents per phase of flight.

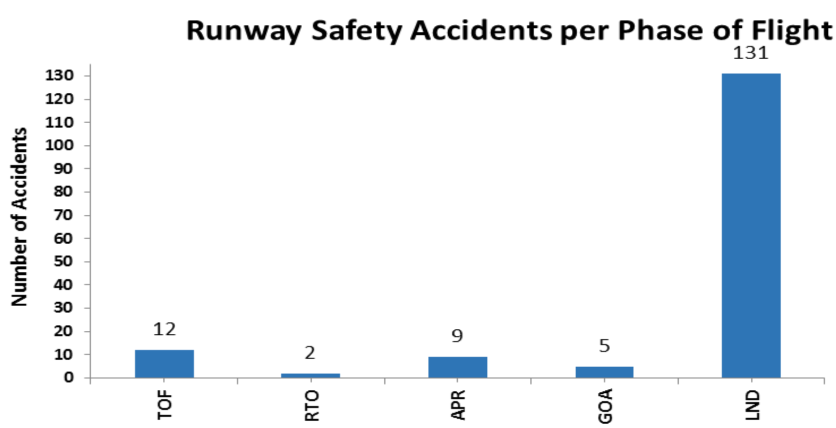

Figure 19: Distribution of Runway Safety Accidents by Phases of Flight

A range of contributing factors were identified in the runway safety accidents during the landing of flight. These include but were not limited to environmental factors, flight crew performance and airline threats. Frequent contributing factors to landing runway safety accidents are illustrated in figure 20.

Latent Conditions (deficiencies in...)	
Regulatory Oversight	24%
Safety Management	20%
Flight Operations	18%
Flight Ops: Training Systems	18%
Flight Ops: SOPs & Checking	6%
Environmental Threats	
Meteorology	36%
Wind/Windshear/Gusty wind	23%
Airport Facilities	20%
Contaminated runway/taxiway - poor braking action	15%
Nav Aids	12%
Airline Threats	
Aircraft Malfunction	11%
Brakes	3%
Contained Engine Failure/Powerplant Malfunction	2%
Gear / Tire	2%
Maintenance Events	2%

Errors (related to…)	
Manual Handling / Flight Controls	43%
SOP Adherence / SOP Cross-verification	19%
Failure to GOA After Destabilized Approach	17%
Intentional	11%
Unintentional	7%
Undesired Aircraft States	
Long/floated/bounced/firm/off-center/crabbed land	47%
Vertical / Lateral / Speed Deviation	18%
Unstable Approach	16%
Continued Landing after Unstable Approach	15%
Loss of aircraft control while on the ground	8%
Countermeasures	
Overall Crew Performance	25%
Monitor / Cross-check	19%
Contingency Management	13%
Taxiway / Runway Management	7%
Leadership	5%

Figure 20: Contributing Factors to Landing Runway Safety Accidents

Analysis shows an average of 19.8 runway safety accidents per year involving jet aircraft, 15.6 of which occurred in the landing phase. Turboprops suffered 10.6 runway safety accidents during landing on average per year. Figure 21 illustrates the distribution of jet versus turboprop runway safety accidents per phase of flight.

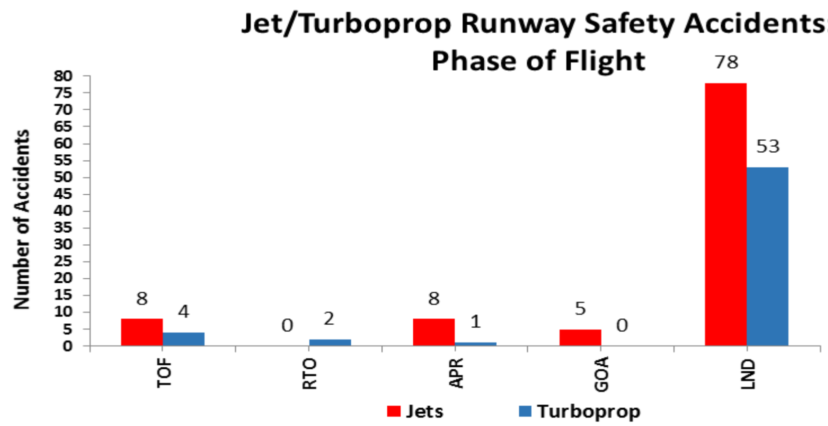

Figure 21: Distribution of Jet Versus Turboprop Runway Safety Accidents per Phase of Flight

Landing excursion occurrences outnumbered takeoff excursion occurrences for both jet and turboprop aircraft. Over the period, the highest number of runway excursion accidents during landing was recorded in 2012, with 18 accidents. The highest number of landing accidents of tailstrike was in 2013 with seven (7) accidents, while the average was 3.2 accidents per year. Likewise, the highest number of hard landing accidents was in 2014 with ten (10) accidents, compared to the average of 6.8 accidents per year. Figure 22 presents the frequency of landing runway safety accident categories per year.

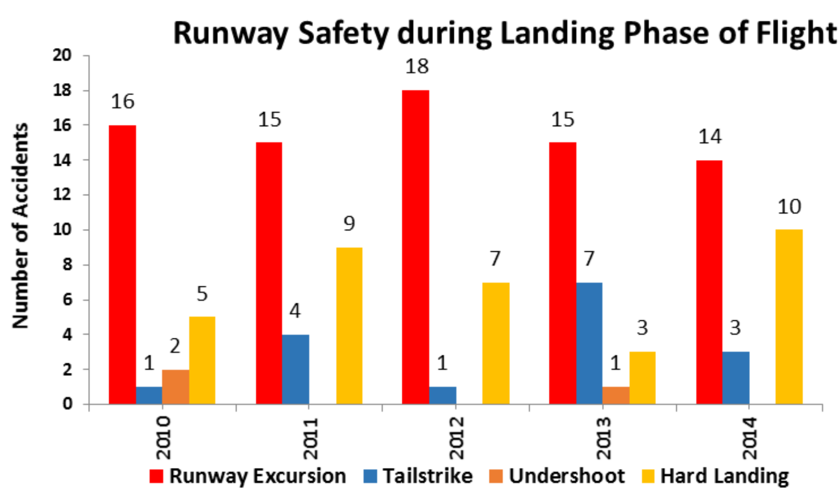

Figure 22: Frequency of Landing Runway Safety Accident Categories per Year

Data shows an average of 9.4 runway excursion accidents per year involving jet aircraft, 8.8 of which were during the landing phase, and an average 6.8 landing phase excursion accidents for turboprop aircraft per year. It also shows an average of 9.4 tailstrike accidents per year involving jet aircraft – 3.0 of them during the landing phase of flight, and 2.0 tailstrike accidents for turboprop aircraft per year. There were an average of 1.5 undershoot accidents per year involving turboprop aircraft, and nil undershoots for jet aircraft. Finally, an average of 4.4 hard landing accidents per year involving commercial jet aircraft occurred per year, and 2.4 hard landing accidents for turboprop aircraft. Figure 23 illustrates the distribution of jet and turboprop aircraft during landing phase of flight for runway safety accident categories.

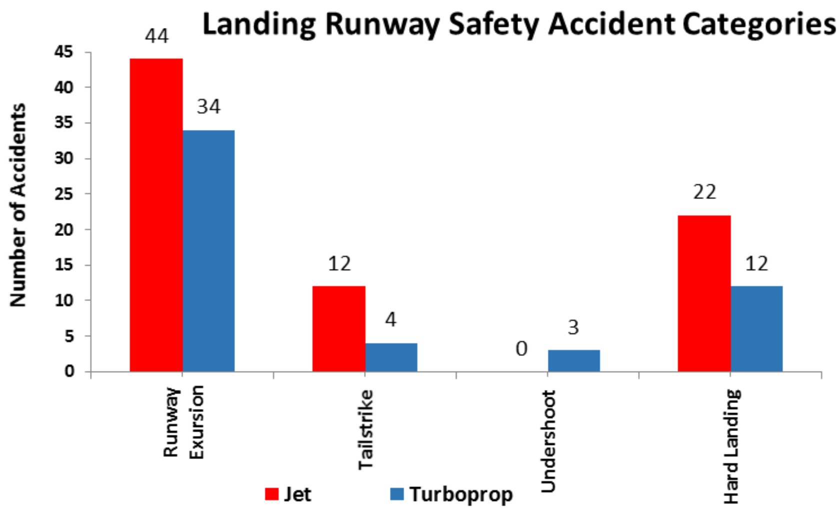

Figure 23: Distribution of Aircraft Propulsion for Runway Safety during Landing Phase of Flight

The highest annual number of runway excursion accidents during landing was recorded in 2012, with 11 veer-off accidents and seven (7) overrun accidents, two (2) of which were fatal. Eight (8) of these accidents involved jet aircraft, of which four (4) accidents were overruns and four (4) were veer-offs. Figure 24 illustrates the frequency of runway excursion accidents during landing by type.

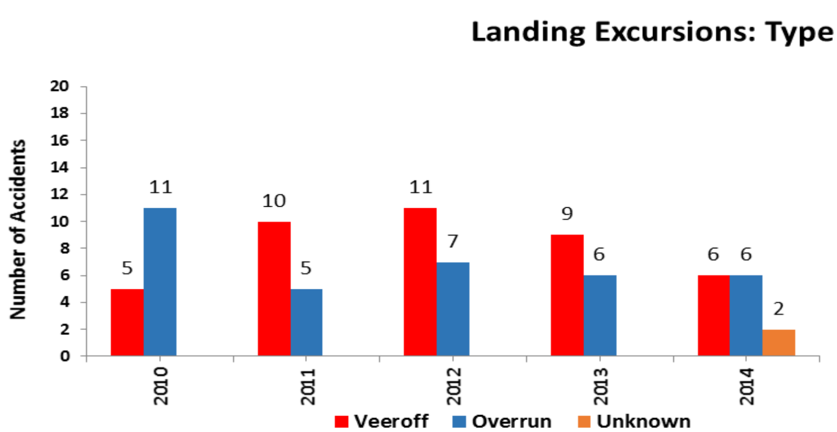

Figure 24: Frequency of Landing Excursions by Type

Of the 78 landing excursions recorded, five (5) resulted in fatalities to the aircraft occupants with the loss of 174 passengers and crew. All fatal accidents on landing were overruns. Frequency of overrun fatal accidents during landing by aircraft propulsion, 2010 to 2014 is illustrated in figure 25.

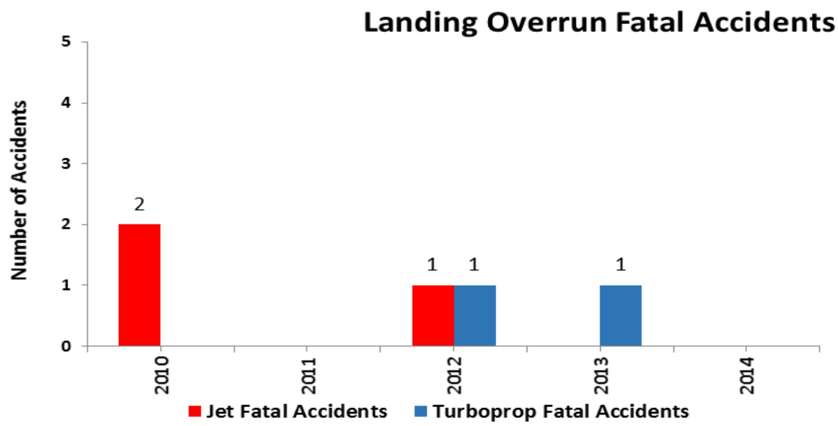

Figure 25: Landing Overrun Fatal Accidents per Aircraft Propulsion

The accident data identified a number of contributing factors to each of the runway excursion accident types. Figure 26 illustrates the contributing factors to landing runway overruns and veer-offs.

Latent Conditions (deficiencies in...)	Overrun	Veer-off
Regulatory Oversight	31%	29%
Safety Management	29%	20%
Flight Operations	14%	15%
Flight Ops: Training Systems	14%	15%
Flight Ops: SOPs & Checking	14%	
Maintenance Ops: SOPs & Checking		5%
Environmental Threats	**Overrun**	**Veer-off**
Meteorology	34%	39%
Wind/Windshear/Gusty wind		22%
Airport Facilities	31%	34%
Contaminated runway/taxiway - poor braking action	31%	20%
Nav Aids	20%	12%
Airline Threats	**Overrun**	**Veer-off**
Aircraft Malfunction	14%	20%
Brakes	3%	7%
Contained Engine Failure/Powerplant Malfunction	3%	5%
Flight Controls	3%	
Gear / Tire		5%
Maintenance Events	3%	5%

Errors (related to…)	Overrun	Veer-off
Manual Handling / Flight Controls	34%	27%
Failure to GOA After Destabilized Approach	26%	15%
SOP Adherence / SOP Cross-verification	17%	27%
Intentional	9%	22%
Pilot-to-Pilot Communication	6%	
CallOuts		5%
Undesired Aircraft States	**Overrun**	**Veer-off**
Long/floated/bounced/firm/off-center/crabbed land	63%	32%
Unstable Approach	20%	12%
Brakes / Thrust Reversers / Ground Spoilers	17%	
Continued Landing after Unstable Approach	17%	17%
Vertical / Lateral / Speed Deviation	11%	17%
Loss of aircraft control while on the ground		17%
Countermeasures	**Overrun**	**Veer-off**
Overall Crew Performance	29%	27%
Monitor / Cross-check	26%	15%
Contingency Management	14%	10%
Taxiway / Runway Management	14%	7%
Leadership	11%	
Automation Management		5%

Figure 26: Contributing Factors to Landing Excursions – Overrun and Veer-offs

As we have seen in figure 26 above there were multiple contributing factors to runway overruns and veer-offs, some relating to the preceding approach and others relating to the ground roll. On the approach these include unstable approaches and the effect of wind, whilst on the ground there were cases of insufficient runway remaining, runway contamination, late deployment of retardation devices or loss of aircraft control. The data also revealed a significant increase in landing excursion risks when one of the following contributing factors is present:

- Aircraft malfunction,
- Wind/windshear/gusty wind,
- Poor visibility/IMC,
- Long/floated/bounced/firm/off-center/crabbed landing,
- Continued landing after unstable approach,
- Loss of aircraft control while on the ground,
- Vertical/lateral/speed deviation,
- Non-adherence to standard operating procedure (SOP) and deficient SOP cross-verification,
- Airport facility deficiencies.

7.4 Runway Safety Severity

Many runway safety accidents have resulted in aircraft hull loss and multiple fatalities, of the 159 runway safety accidents recorded, 37 percent were hull losses accidents. Six (6) percent of those were fatal accidents, resulting in 278 fatalities. Table 6 presents the summary of runway safety by severity.

	No. of accidents	Jet aircraft	Turboprop aircraft
Substantial Damage	100	69	31
Hull Loss	*59*	30	29
Fatal Accidents	9	6	3
Fatalities	278	257	21

Table 6: Runway Safety Accidents by Severity

The distribution of runway safety accidents by severity (hull loss versus substantial damage) per year is shown in figure 27.

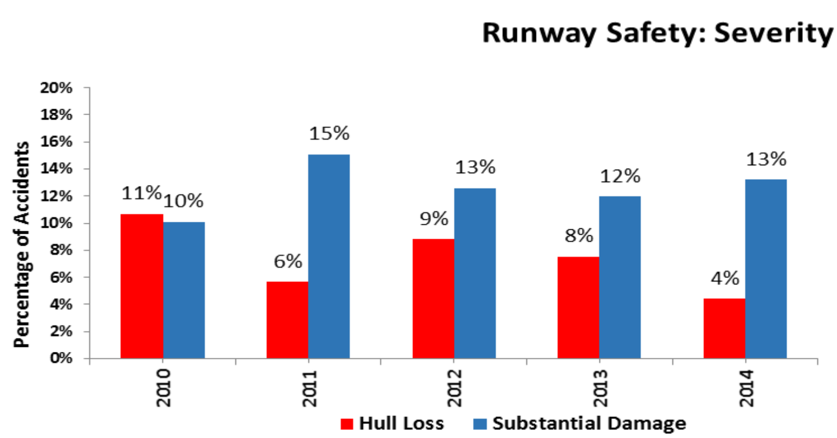

Figure 27: Distribution of Runway Safety by Severity

The proportion of fatal to non-fatal hull loss accidents was relatively low compared to other accident categories (like CFIT and LOC-I) with only 15 percent of hull loss accidents resulting in fatalities. Figure 28 illustrates the distribution of fatal to non-fatal hull loss runway safety accidents.

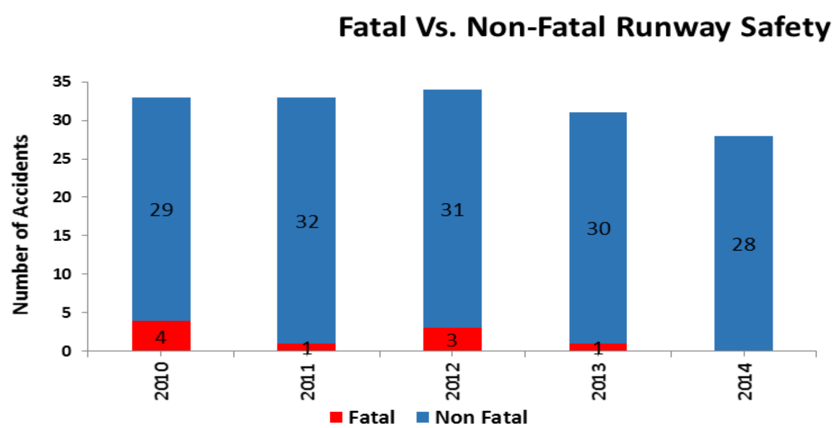

Figure 28: The Distribution of Fatal to Non-Fatal Runway Safety Hull Loss Accidents

The distribution of the nine (9) fatal runway safety accidents by type is illustrated in table 7.

Runway Safety by type	Fatal Accident Count	Phase of flight	Fatalities
Runway Excursion	5	Landing	174
Undershoot	4	Approach	104

Table 7: Distribution of Fatal Runway Safety Accidents

In terms of accident severity it can be useful to understand how many people onboard survived a fatal runway safety accident. The survivability percentage, comparing the number of people who survived with the total number of people onboard illustrates the relative severity of different groups of fatal accidents. Table 8 presents the runway safety fatal accident count and rate by aircraft class.

Class	Fatal Accident Count	Fatal Runway Safety Accident Rate	Fatalities	Survivability
Jets	6	0.04	257	45%
Turboprops	3	0.08	21	55%

Table 8: Runway Safety Fatal Accident Counts and Survibility by Aircraft Propulsion

A total of 38 percent of all runway excursions resulted in a hull loss and one or more fatalities among the passengers or crew. Figure 29 illustrates the distribution of runway excursion accidents involved hull loss and substantial damage for all runway excursion accidents between 2010 and 2014.

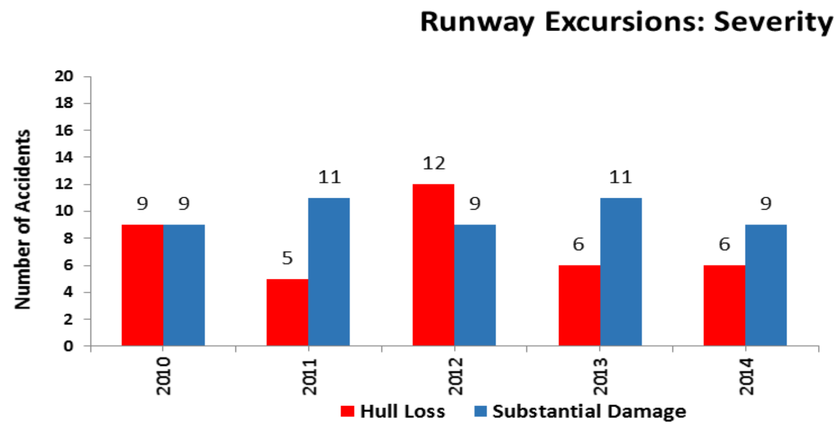

Figure 29: Distribution of Runway Safety by Severity

5.8 percent of runway/taxiway excursion accidents caused fatalities, and are the third most frequent fatal accident category. However, runway excursion was the highest accident category for hull losses with 23 percent of total hull loss accidents during the period 2010 to 2014.

Figure 30 illustrates the distribution of fatal to non-fatal hull loss runway excursion accidents. It was noted that there were no fatal accidents in this category in 2011 and 2014.

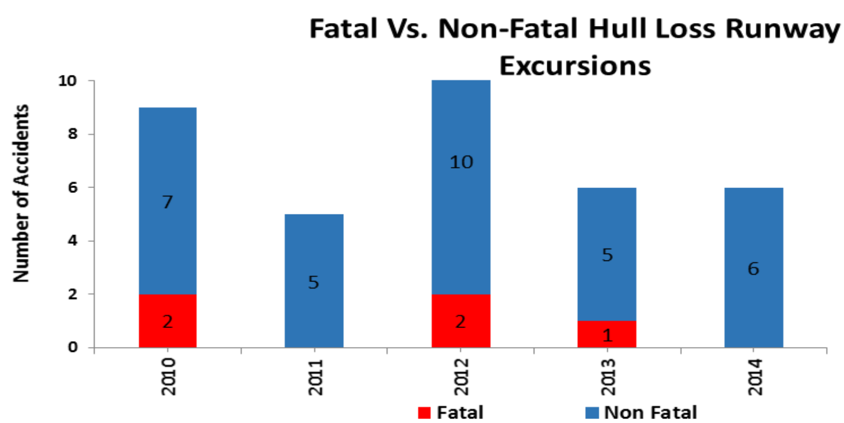

Figure 30: The Distribution of Fatal to Non-Fatal Runway Excursion Hull Loss Accidents

Of the 38 runway excursion hull loss accidents, 18 involved jet aircraft, as opposed to 20 involving turboprops. Table 9 summarizes the count and the rate of hull loss accidents by aircraft propulsion and year.

	Jet hull loss accidents	Jet hull loss rates	Turboprop hull loss accidents	Turboprop hull loss rates
2010	7	0.26	2	0.27
2011	3	0.11	2	0.27
2012	3	0.11	9	1.24
2013	2	0.07	4	0.56
2014	3	0.10	3	0.41

Table 9: Jet Versus Turboprop Hull Loss Runway Excursion Accident Rates/Count

The survivability percentage, comparing the number of people who survived with the total number of people onboard illustrates the relative severity of accidents to aircraft of different propulsion type. Table 10 presents the runway excursion fatal accident count and rate by aircraft propulsion.

Class	Fatal Runway Excursion Accident Count	Fatal Runway Excursion Accident Rate	Fatalities	Survivability
Jets	3	0.02	165	47%
Turboprops	2	0.05	9	72%

Table 10: Runway Excursion Fatal Accident Count and Survivability by Aircraft Propulsion

The following section provides insight into the impact of the type of operational service on runway safety and runway excursion accidents. Accidents are broken down by scheduled/unscheduled and cargo/passenger services for all aircraft categories.

7.5 Impact of Types of Service

Different operational service types and/or the familiarity of the operating environment can influence the potential for a runway safety accident. This section presents the type of operational service, in terms of cargo or passenger operations and scheduled or unscheduled operations. Note that one (1) percent of the accidents involved ferry operations. The majority (84 percent) of runway safety accidents involved passenger flights, while cargo accounted for 14 percent.

Of those passenger service accidents, 86 in total or 64 percent were operating domestic flights and 48 accidents or 36 percent were engaged in international operations. Of the 86 accidents during domestic operations, six (6) were fatal accidents, resulting in 108 fatalities, and the one (1) fatal accident during international operation resulted in 158 fatalities. Table 11 presents the distribution of runway safety accidents per type of operation and operational service.

Service	Total accidents	Domestic flights	International flights
Passenger	134	86	48
Cargo	23	11	12
Ferry	2	0	0

Table 11: Runway Safety Accidents by Type of Operation and Service[4]

Of the 134 runway safety accidents which involved passenger services, a total of seven (7) accidents or four (4) percent were fatal, resulting in 266 fatalities with a 97 percent survivability rate. One (1) accident or one (1) percent of all the runway safety accidents involved cargo flights, resulting in seven (7) fatalities with 95 percent of survivability. Table 12 illustrates the distribution of fatal accidents and survivability by type of service.

Service	Total accidents	Fatal	Fatalities	Survivability
Passenger	134	7	266	97%
Cargo	23	1	7	95%
Ferry	2	1	5	69%

Table 12: Runway Safety Fatal Accidents by Type of Operational Service

[4] The higher number of passenger runway safety accidents reflects the high volume of flights in this category

When the type of operation was broken-down by scheduled and non-scheduled operations, it was apparent that scheduled passenger operations had a higher number of accidents (almost by a factor of 6) compared to non-scheduled passenger operations, while the scheduled cargo operations had an accident factor of 1.6 times higher than non-scheduled cargo operations. Table 13 summarizes the number of accidents by scheduled versus non-scheduled operations. Note that these numbers are not necessarily meaningful, unless they are compared to the number of flights flown in the period.

Service	All	Fatal	Fatalities	Survivability
Passenger				
Scheduled	116	6	265	97%
Non-scheduled	18	1	1	99%
Cargo				
Scheduled	14	0	0	100%
Non-scheduled	9	1	7	88%

Table 13: Distribution of Runway Safety Accidents by Scheduled Versus Non-Scheduled[5]

Furthermore, when the type of operational service was further analyzed by IOSA registered carriers versus non-IOSA registered carriers, it was evident that the IOSA registered carriers had better performance than non-IOSA registered carriers. Table 14 presents the distribution of IOSA registered carriers by type of operational service.

Service	All	Fatal	Fatalities	Survivability
Passenger	134	7	266	97%
IOSA Registered Carriers	52	0	0	100%
Non-IOSA Registered Carriers	82	7	266	97%
Scheduled	48			
Non-scheduled	4			
Domestic	22			
International	30			
Cargo	23	1	7	95%
IOSA Registered Carriers	9	0	0	100%
Non-IOSA Registered Carriers	14	1	7	92%
Scheduled	9			
Non-scheduled	0			
Domestic	3			
International	6			

Table 14: Distrubution of IOSA Registered Carriers Involved in Runway Safety Accidents by Operational Service

[5] The higher number of scheduled passenger runway safety accidents reflects the high volume of flights in this category

7.6 Accidents Regional Analysis

The following section presents an analysis of the regional differences in runway safety accidents. Regions are defined by IATA and the breakdown of regions and countries is listed in Appendix B.

Figure 31 presents the overall distribution of runway safety occurrences by region of the operator. Operators from Asia Pacific (ASPAC) witnessed the greatest number of occurrences with 36 accidents, or 23 percent, of the total, followed by European (EUR) operators with 35 accidents or 22 percent of the total. Operators from Africa (AFI) were involved in 22 accidents or 14 percent, and North American (NAM) operators were involved in 20 accidents. Operators from Latin America & the Caribbean (LATAM/CAR) had 18 accidents, or 11 percent, of the total. Operators from Commonwealth of Independent States (CIS) also were involved in 11 accidents, or seven (7) percent of the total runway safety accidents. North Asian (NASIA) operators had the lowest number of occurrences with seven (7) accidents or four (4) percent.

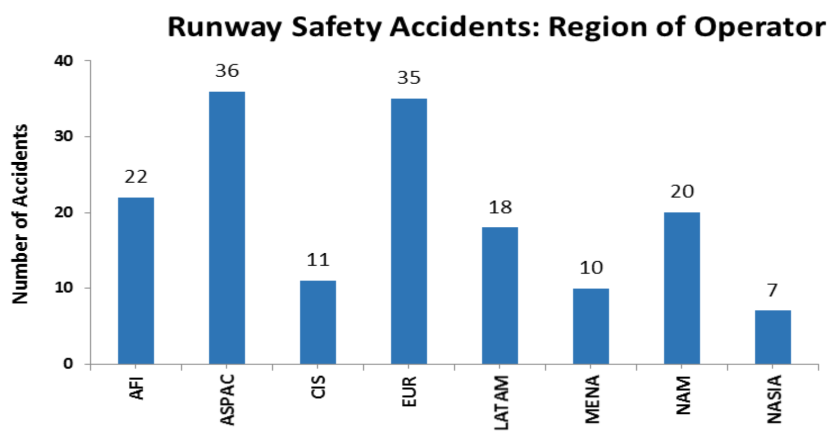

Figure 31: Distribution of Runway Safety Accidents by Region of Operator

Figure 32 illustrates the runway accident rates per million sectors flown based on region of operator. Operators from AFI had the highest rate of runway safety accidents, with a rate of 4.41 accidents per million sectors flown. Operators from CIS had the second highest rate at 1.84 accidents per million sectors flown, and operators from NAM had the lowest rate with 0.34 runway safety accidents per million sectors.

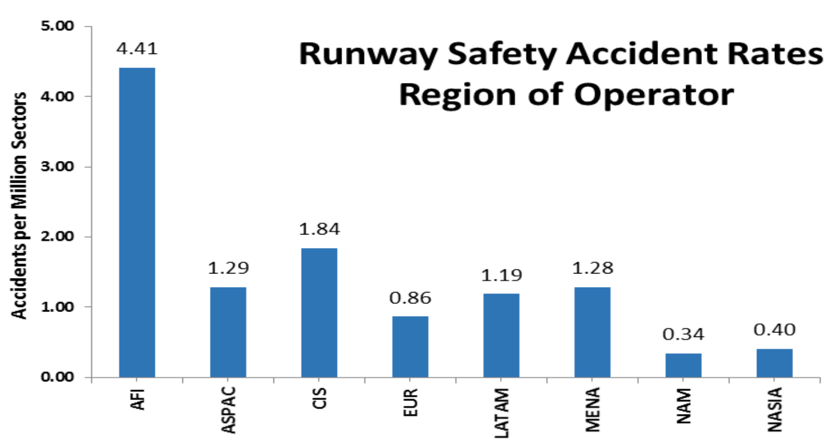

Figure 32: Runway Safety Accident Rates by IATA Region of Operator

A worldwide comparison of non-fatal versus fatal runway safety accidents by region of operator shows that operators from AFI, ASPAC, CIS, LATAM, and NAM had fatal accidents whereas those from EUR, MENA and NASIA had none. Figure 33 illustrates the distribution of fatal versus non-fatal accidents per region of operator.

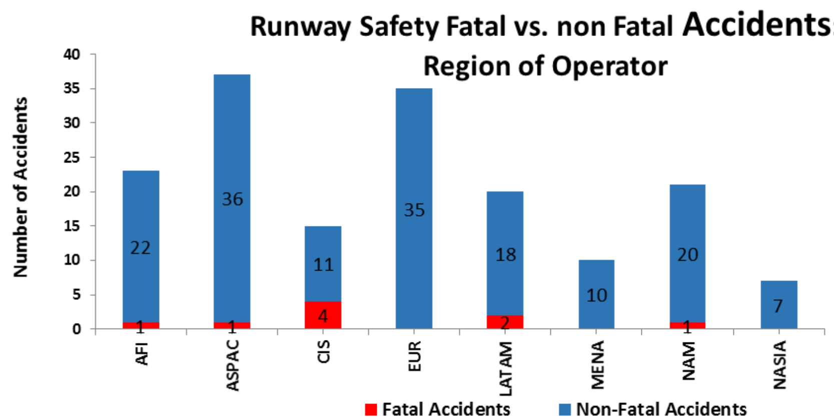

Figure 33: Non-Fatal Versus Fatal Runway Safety Accidents by Region of Operator

Analysis revealed that the highest fatal runway safety accident rate was for operators from CIS, with a rate of 0.67 per million sectors, followed by operators from AFI with a fatal accident rate of 0.2. Operators from NAM had the lowest rate, with 0.02 accidents per million sectors and as mentioned above those from EUR, MENA and NASIA had no fatal accidents in the category. Figure 34 depicts fatal versus non-fatal accident rates per million sectors flown based on region of operator.

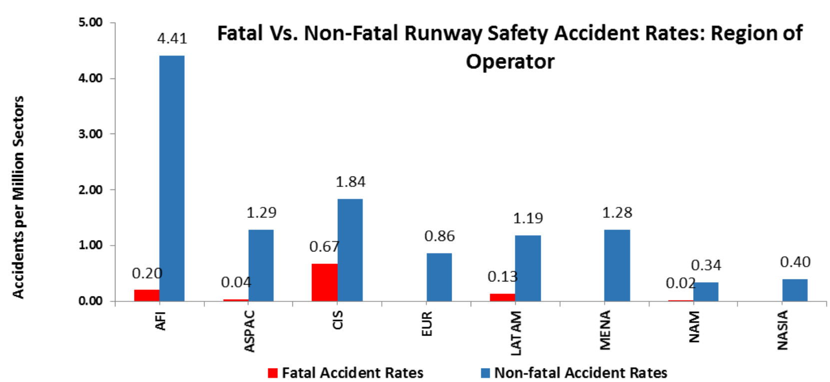

Figure 34: Fatal Versus Non-Fatal Runway Safety Accident Rates by Region of Operator

Figure 35 illustrates a worldwide comparison of the IATA regional operators involved in runway safety accidents by aircraft propulsion.

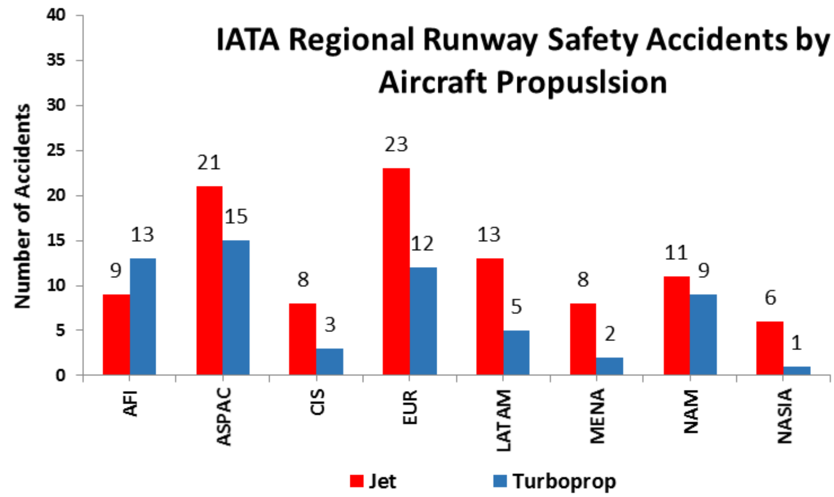

Figure 35: IATA Regional Operators Involved in Runway Safety Accidents by Aircraft Propulsion

Figure 37 illustrates a worldwide comparison of the aircraft propulsion runway safety accident rates by region of operator.

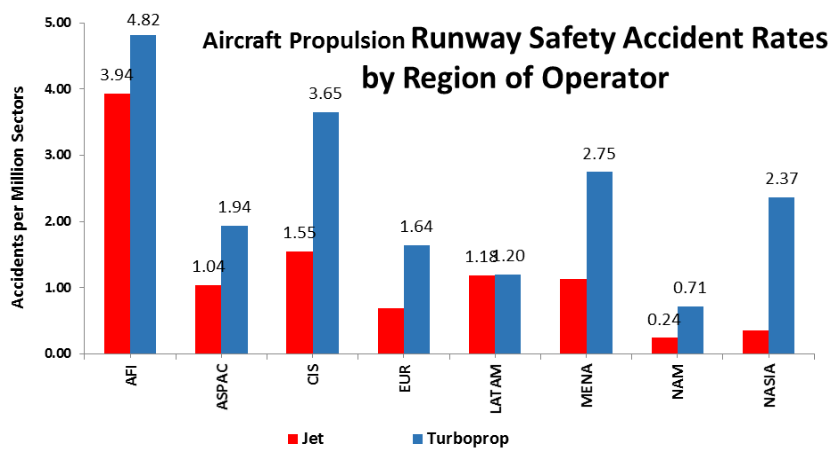

Figure 36: A Comparison of the Aircraft Propulsion Runway Safety Accident Rates by Region of Operator

The IATA Operational Safety Audit (IOSA) program is an internationally recognized and accepted evaluation system designed to assess the operational management and control systems of an airline. All IATA members are IOSA registered and must remain registered to maintain IATA membership. Increasingly, non-IATA members are applying for registration.

The regional breakdown of runway safety figures is shown in figure 37 and shows that the total runway safety accident rates for IOSA carriers is lower than the overall industry rate and lower than that of non-IOSA operators. Over the reporting period, IOSA registered operators suffered zero fatal runway safety accidents.

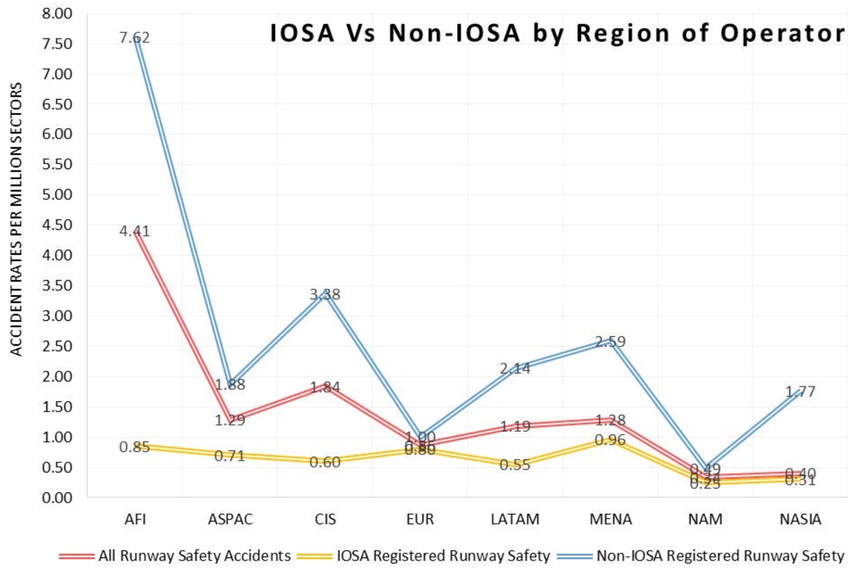

Figure 37: Regional Breakdown of Runway Safety Performance for IOSA Registered Airlines Versus Non-IOSA Registered Airlines

Figure 38 presents the number of runway safety accidents in each region broken-down by type of service; passenger or cargo.

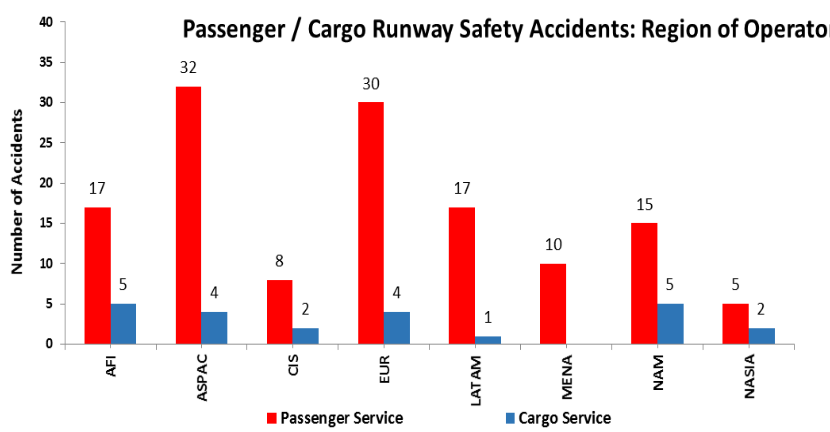

Figure 38: Distribution of Runway Safety Accidents by Service Type and Operator Region

Figure 39 shows the percentage of runway excursion accidents by region of operator. The greatest number of excursions occurred in ASPAC with 23 percent of total runway excursion accidents, then Africa with 21 percent and LATAM with 13 percent. In total these three regions accounted for about 56 percent of all runway excursion accidents between 2010 -2014.

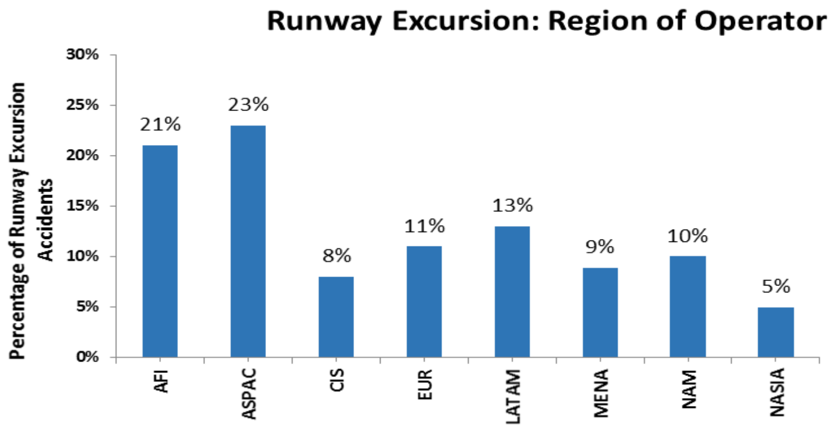

Figure 39: Percentage of Runway Excursion by Region of Operator

Absolute numbers of accidents alone are not necessarily a good indication of safety performance and are of limited comparative value unless they are normalized by the number of sectors flown per year for each region, in order to create an accident rate. Figure 40 illustrates the distribution of runway excursion accident rates by region of operator.

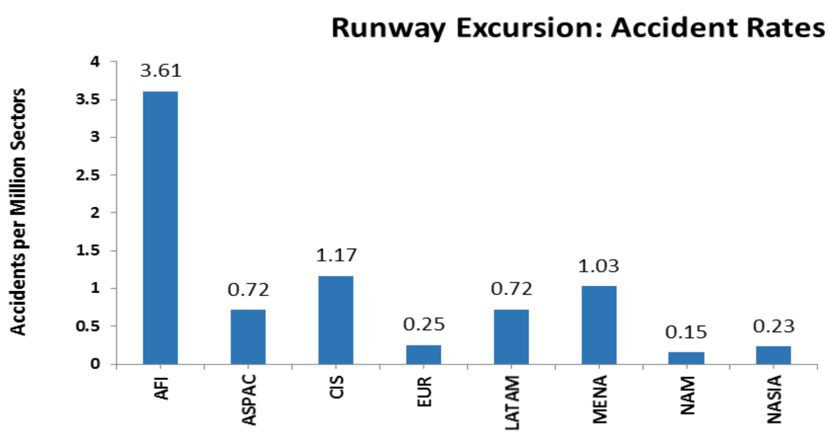

Figure 40: Runway Excursion Accident Rates by Region of Operator

7.7 Runway Safety Accidents by Regional Aviation Safety Group (RASG) Regions

A further regional analysis is provided using the International Civil Aviation Organization (ICAO) Regional Aviation Safety Group (RASG) regions. The full breakdown of the five (5) RASG regions is at Appendix C. The number of accidents and normalized accident rates by RASG region are shown in this section. Figure 41 illustrates the distribution of runway safety accidents per RASG Region.

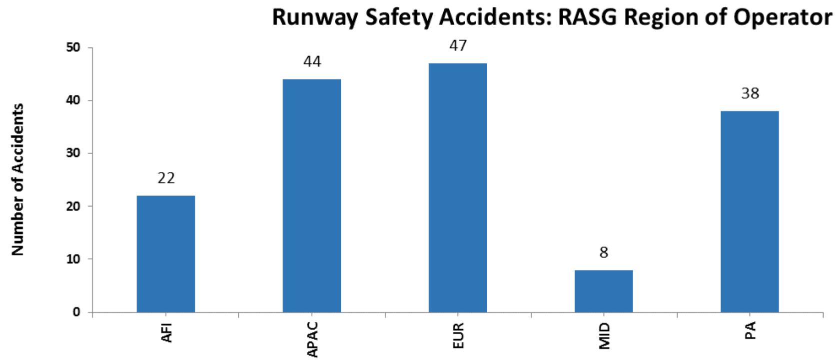

Figure 41: Runway Safety Accidents by RASG Region of Operator

Figure 42 illustrates the distribution of runway safety accident rates per million sectors flown per RASG Region.

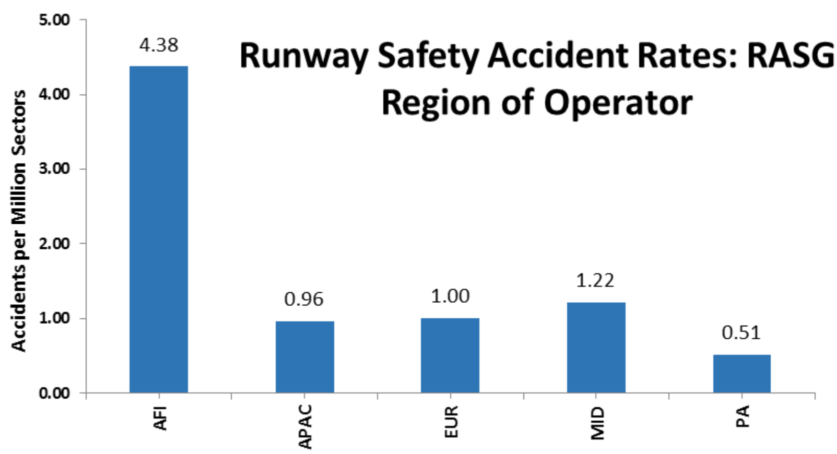

Figure 42: Runway Safety Accident Rates by RASG Region of Operator

The data shows from both figures 41 and 42 above that Operators from Europe (EUR) suffered the greatest number of occurrences with 47 accidents, however, when calculating the accident rates per million sectors, they had an accident rate of one (1) per million sectors; followed by operators from Asia and Pacific (APAC) with 44 accidents or 0.96 accidents per million sectors. Operators from Pan America (PA) were involved in 38 accidents or 0.51 accidents per million sectors. Operators from Africa-Indian Ocean (AFI) were involved in 22 accidents, or 14.38 accidents per million sectors. Operators from Middle East (MID) had the lowest number of occurrences with eight (8) accidents, or 1.22 accidents per million sectors in the time period studied.

Figure 43 illustrates a worldwide comparison of RASG region of operator involved in runway safety accidents by aircraft propulsion.

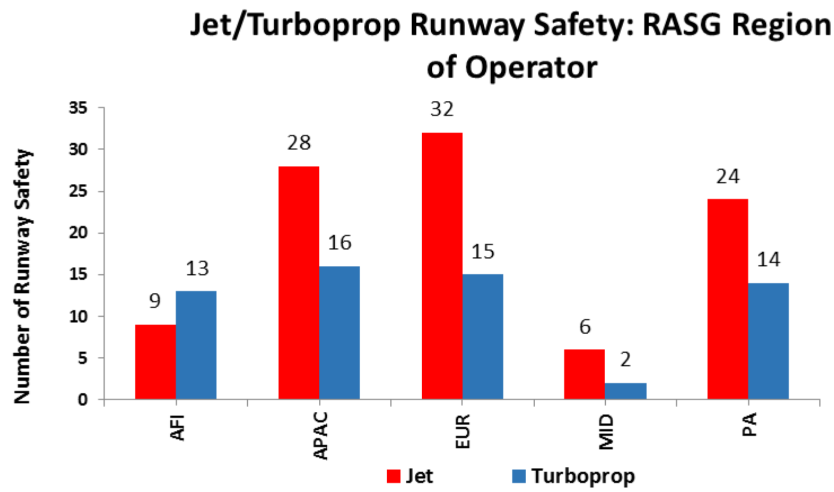

Figure 43: Runway Safety Accident Count by RASG Region of Operator and Aircraft Propulsion

Figure 44 illustrates the RASG regional runway safety accident rates broken-down by the different types of aircraft propulsion.

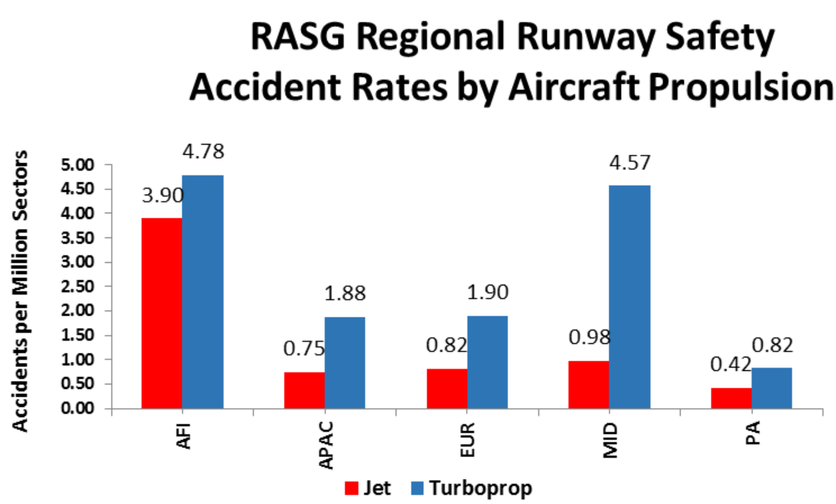

Figure 44: RASG Regional Runway Safety Accident Rates by Aircraft Propulsion

The difference between jet and turboprop operations involved in Runway Safety accidents is noteworthy in all regions, but most remarkable in MID RASG Region.

Figure 45 illustrates runway excursion accidents based on the RASG regions of operator. Operators from AFI region had the highest number of turboprop runway excursion accidents, while APAC had the highest number of jet runway excursion accidents.

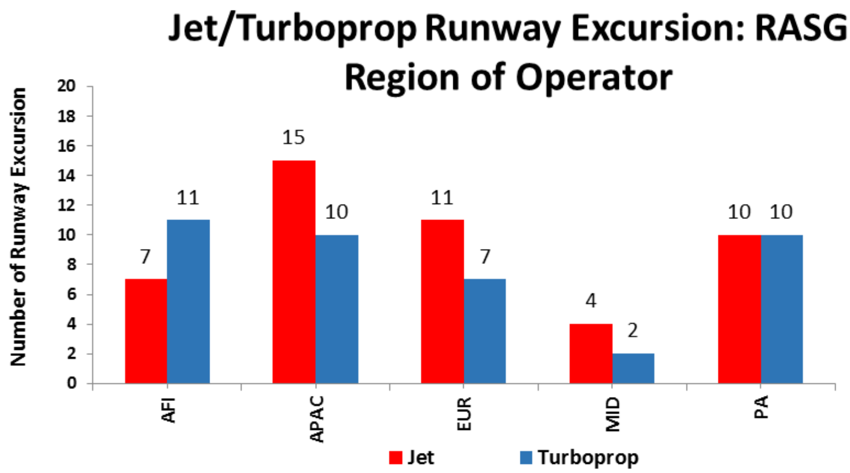

Figure 45: Runway Excursion Accident Count by RASG Region of Operator and Aircraft Propulsion

In the genesis of any aircraft accident there are different causal and contributory factors such as the non-availability of precision approach aids, airport infrastructure, type of aircraft involved, airport facilities, meteorological conditions, as well as the socio-cultural environment that may differ from one region to another. It is, therefore, important to break down accidents by the geographical region of occurrence. Figure 46 provides the distribution of runway safety accidents by RASG region of operator versus region of occurrence.

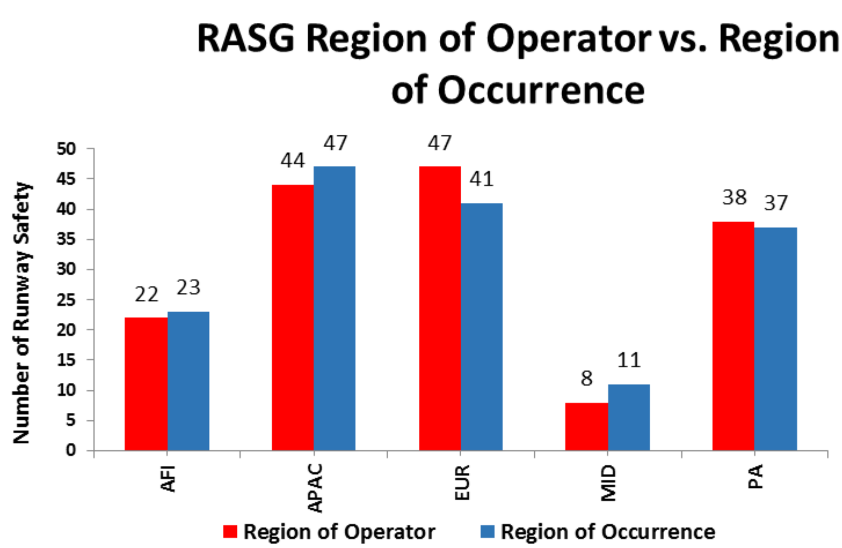

Figure 46: Distribution of Runway Safety Accidents by RASG Region of Operator Versus Region of Occurrence

7.8 Runway Safety Contributing Factors

IATA, through the Accident Classification Task Force, assigns contributing factors to accidents to better understand the correlations. The most frequent contributing factors are shown in figure 47.

Latent Conditions (deficiencies in...)	
Regulatory Oversight	25%
Safety Management	21%
Flight Operations	19%
Flight Ops: Training Systems	18%
Flight Ops: SOPs & Checking	7%
Environmental Threats	
Meteorology	36%
Wind/Windshear/Gusty wind	23%
Airport Facilities	18%
Ground-Based Nav Aid Malfunction or not available	13%
Nav Aids	13%
Airline Threats	
Aircraft Malfunction	10%
Brakes	3%
Contained Engine Failure/Powerplant Malfunction	3%
Gear / Tire	3%
Other	2%

Errors (related to…)	
Manual Handling / Flight Controls	42%
SOP Adherence / SOP Cross-verification	23%
Intentional	16%
Failure to GOA After Destabilized Approach	15%
Unintentional	7%
Undesired Aircraft States	
Long/floated/bounced/firm/off-center/crabbed land	42%
Vertical / Lateral / Speed Deviation	19%
Unstable Approach	15%
Continued Landing after Unstable Approach	14%
Operation Outside Aircraft Limitations	9%
Countermeasures	
Overall Crew Performance	26%
Monitor / Cross-check	18%
Contingency Management	12%
Leadership	8%
Taxiway / Runway Management	6%

Figure 47: Contributing Factors to Runway Safety Accidents

The contributing factors follow a Threat and Error Management structure and are divided into the following four areas:

- Latent Conditions: underling issues in the system before an accident,
- Environmental and Airline Threats: events outside the control of the flight crew that must be managed to ensure safety,
- Flight Crew Errors: errors in the management of threats,
- Undesired Aircraft States: flight-crew induced aircraft state(s) that reduces safety margins. The undesired aircraft state is recoverable.

In some cases there are sub-categories of contributing factors, these are displayed as darker colors in the chart for the category and a lighter hue of the same color for the sub-category. It is possible for one event to have more than one sub-category, in this case the total percentage of the sub categories will equal more than the total for the category.

Latent conditions are typically difficult to derive unless very detailed information is available. Accident Classification Task Force (ACTF) derives Latent Conditions by looking at IOSA-results and any earlier safety issues that might have been identified. Classification also explores what risk mitigation strategies would likely have prevented the accident.

The main contributing factors in Latent Conditions, as shown in figure 48, were deficiencies in the implementation of Safety Management Systems (SMS) at the operator, insufficient regulatory oversight, and weak training standards in flight operations.

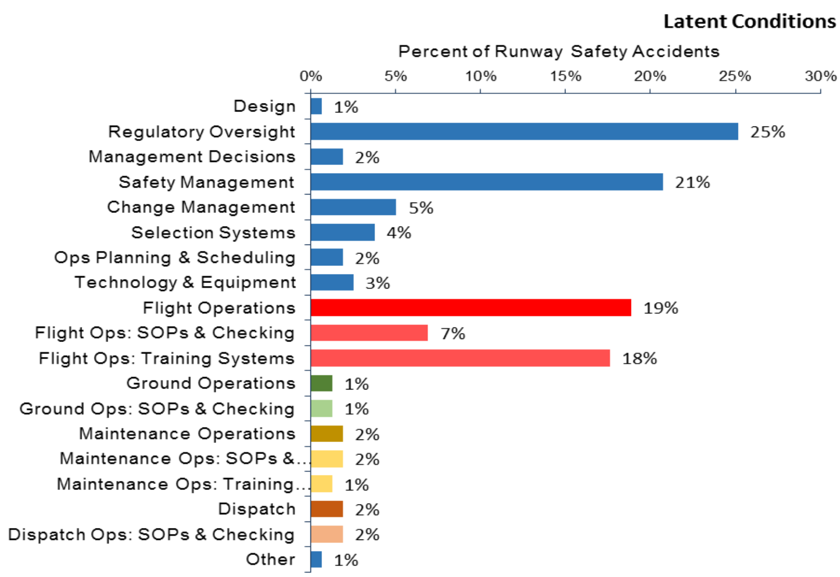

Figure 48: Latent Conditions Contributing to Runway Safety Accidents

Events outside of the influence of the flight crew that have the potential to reduce the safety margins of a flight are considered to be threats. These require crew attention and management to ensure that margins of safety are maintained.

In the Environmental and Airline Threats category, meteorology, wind factor, airport facility, contaminated runway and poor braking action, ground based nav-aid malfunction, and aircraft malfunction were identified as common contributing factors. Figure 49 indicates the most common environmental and airline-related threats associated with runway safety accidents.

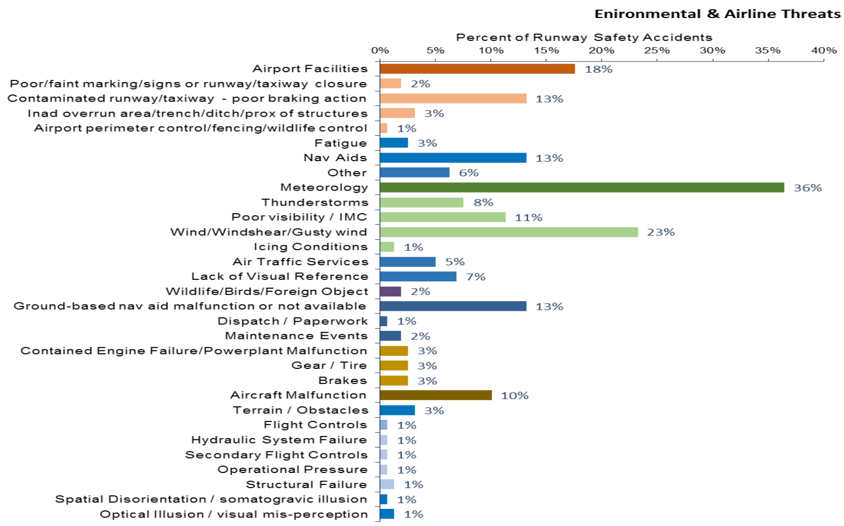

Figure 49: Environmental and Airline Threats Contributing to Runway Safety Accidents

If a threat is not managed correctly it can lead to an error. These are flight crew deviations from organizational expectations or crew intentions. Failure to adhere to SOP by flight crew, general manual handling of the aircraft and failure to go around after an unstable approach were identified as common contributing factors. Figure 50 illustrates the contributing factors related to the Flight Crew Errors category.

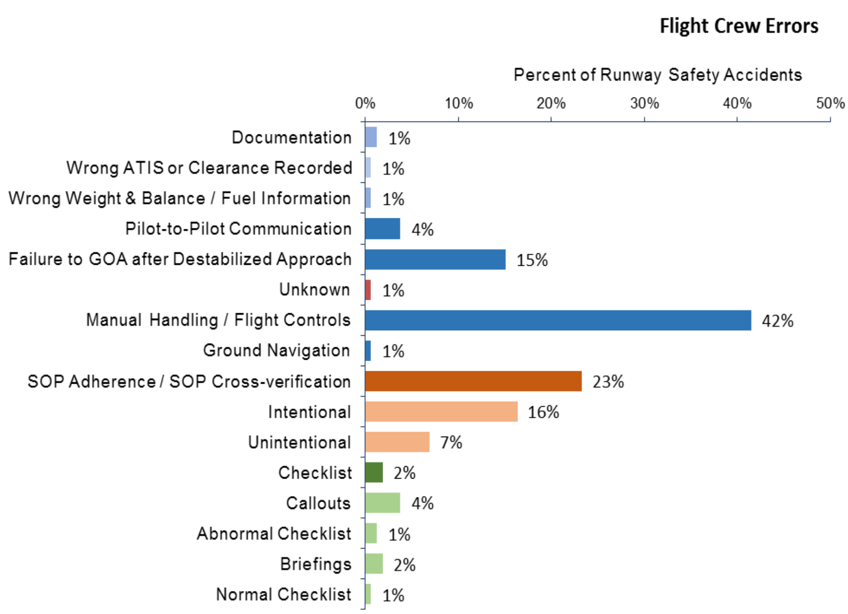

Figure 50: Flight Crew Errors Contributing to Runway Safety Accidents

Mis-managed errors can lead to additional errors and/or undesired aircraft states; flight crew-induced states that clearly reduce safety margins. Note that undesired aircraft states are still recoverable. Figure 51 illustrates the undesired aircraft states that were associated with runway safety accidents analyzed in this report.

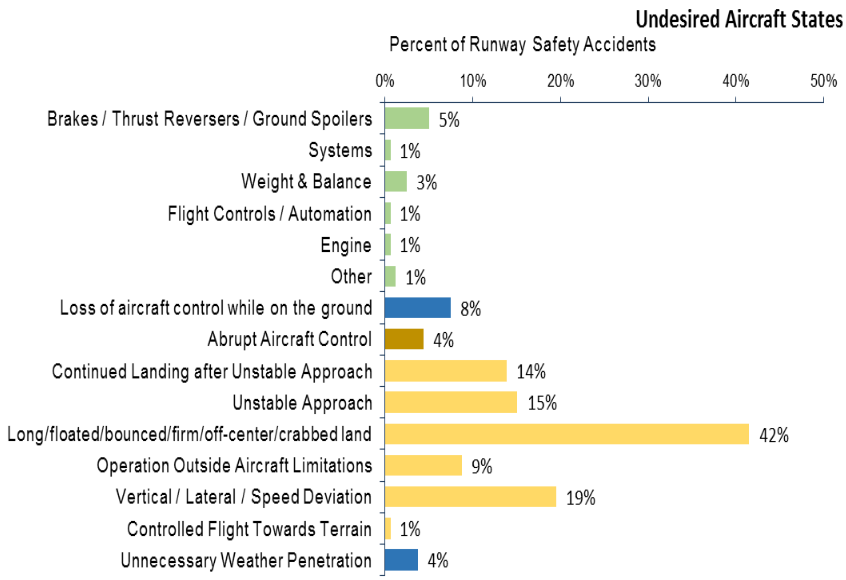

Figure 51: Undesired Aircraft States Contributing to Runway Safety Accidents

Many factors may contribute to a runway safety occurrence including runway contamination, adverse weather conditions, mechanical failure, pilot error and unstable approaches. The next section will focus briefly on unstable approaches but because this condition has been addressed in other IATA safety documentation and guidance materials it is not examined in detail.

Section 8—Unstabilized Approaches

An unstabilized approach is a serious Undesired Aircraft State (UAS) that places additional pressure on the flight crew during one of the most critical phases of flight, and may reduce the time available to complete checklists and prepare for the landing.

As seen earlier in this report unstable approaches are a frequent precursor to runway excursions due to the influence of higher aircraft energy on touchdown point and stopping performance.

A stable approach is one in which the final few hundred feet are flown at a constant speed and rate of descent, with the aircraft in the planned landing configuration such that the pilot flying need only make small inputs to the flight controls and thrust to account for environmental influences on the flight path. This affords the greatest chance for the aircraft to touch down at the right point on the runway, in the correct attitude and at the optimal speed to allow it to be stopped safely.

If this stable condition cannot be achieved by the altitude specified in the operator's SOP, or if the approach subsequently deviates from the stable condition below this altitude, the pilot must initiate a go around and follow the published missed approach procedure.

Only by requiring rigorous adherence to this policy can operators be sure to minimize the risk of runway excursion due to unstable approaches. It should be noted that one recent study concluded that as many as 97% of unstable approaches recorded worldwide did not result in a go around. Operators are encouraged to review their approach procedures and to ensure that they have a robust stable approach policy in place.

In another study conducted by IATA on unstable approaches, fatigue, company policy, peer and company pressure, and a desire to get on the ground, combined with unanticipated instructions from Air Traffic Control were some of the major factors influencing flight crew decisions to continue to land from unstable approaches.

Section 9—Mitigations

The most robust operational mitigation against runway excursions, which constitute the majority of runway safety accidents, is effective recognition and decision making in respect to unstable approaches. If an aircraft arrives at touchdown too fast or with too little runway remaining the chances of completing the landing safely are much reduced. If the approach cannot be stabilized a go around must be flown, followed by a second stable approach or diversion to a more suitable runway. A fundamental understanding of the exponential effect of additional speed on total aircraft energy at landing, whether due to excess airspeed or to tailwind, is vital to this process and training programs must ensure pilots are well aware of this relationship (momentum = ½ mass x velocity^2). Operators should ensure that they promulgate, monitor (using flight data programs – see below) and enforce a rigorous stabilized approach policy, supported by clear procedures and effective training. There are an increasing number of technological solutions available to assist pilots in the decision making process and these are discussed in a separate IATA guidance document. Air traffic service providers can facilitate stabilized approaches by ensuring that the approach paths offered are 'compliant' in terms of final approach interception angle and altitude.

Pilots must also recognize the importance of the timely deployment of retardation devices to the aircraft's runway stopping performance. Many accidents have been exacerbated by the absence of ground spoiler deployment, late selection of reverse thrust or late/inadequate application of braking.

Contaminated runways frequently contribute to runway safety accidents and pilots must ensure that the landing performance has been calculated correctly in respect to the runway condition. Air traffic service providers and airport managements can greatly assist in this by ensuring accurate and timely runway condition reports are provided to pilots, both for arrivals and departures.

Airports and their regulators can also help mitigate the severity of runway excursions by requiring and providing runway end safety areas (RESA) in accordance with ICAO standards and recommended practices (Annex 14). Where local topography does not permit the standard RESA, consideration may be given to the installation of engineered materials arresting systems, which use frangible concrete paving to absorb aircraft energy in the runway overrun area. Neither of these measures will prevent runway excursions but they may reduce damage, fatalities and injuries by ensuring aircraft do not impact obstacles prior to stopping.

FDM Guidance for Monitoring Runway Safety Indicators

The European Action Plan for the Prevention of Runway Excursions – Released Edition 1.0 – January 2013 states that European regulation requires aircraft operators to establish and maintain an accident and flight safety program which includes a flight data monitoring (FDM) program for aircraft in excess of 27.000kg.

The flight path parameters monitored by this system should include parameters closely related to the risk of runway excursion such as:

Landing:

- Deep landing Short landing
- Long flare
- Spoiler deployment during landing
- Late landing flaps selection
- Late landing gear selection
- Tail and/or crosswind
- Stabilized approach criteria met at the specified gates
- Threshold crossing height
- Excess speed over the threshold
- Use of reverse thrust
- Use of brakes
- High speed exits from runways
- Landing performance analysis

Takeoff:

- Use of reverse on rejected takeoff
- Use of brakes on rejected takeoff
- Nose wheel steering used at high speeds
- Runway distance remaining after rejected takeoff
- Crosswind and/or tailwind

The European Authorities Coordination Group on Flight Data Monitoring developed standardized FDM-based indicators for Runway Excursion as follows:

- RE1 – High speed rejected takeoff
- RE2 – Takeoff with abnormal configuration
- RE3 – Insufficient take-off performance
- RE4 – Unstable shortly before landing
- RE5 – Abnormal altitude or bounce at landing
- RE6 – Hard or heavy landing
- RE7 – Aircraft lateral deviations at high speed on the ground
- RE8 – Low remaining runway length when braking

Section 10—Accident Scenarios of Interest

Some likely scenarios leading to runway safety accidents are:

SCENARIO 1:

The flight crew are flying a stable approach to an airfield but in gusty wind conditions or the presence of wind shear. After touchdown they lose control of the aircraft on the ground and subsequently overrun or veer-off the runway resulting in substantial damage or a hull loss.

SCENARIO 2:

The flight crew commits manual handling errors / flight control errors, leading to an unstable approach. The aircraft lands long, bounces, or touches down off the runway centerline. The flight departs the runway surface and is substantially damaged or destroyed.

SCENARIO 3:

The airport has weak regulatory oversight and suffers contaminated runways with poor braking action. The aircraft departs the runway surface and is substantially damaged or destroyed.

SCENARIO 4:

The operator has deficiencies in their flight crew training program. The flight crew commits errors relating to manual handling resulting in a long, floated, bounced, hard, off-center or crabbed landing resulting in substantial damage.

Section 11—Conclusion

The runway safety analysis used data from 159 accidents (including runway excursions, hard landings, tailstrikes and undershoots) that resulted in 278 fatalities during the five-year period of 2010 – 2014. Runway excursions, including overruns and veer-offs, were the most frequent with an average of 18 annually worldwide, accounting for 54.7 percent of all runway safety accidents and 22 percent of total aircraft accidents in the period.

A separate analysis of runway excursions used 87 accidents that resulted in 178 fatalities. 5.8 percent of runway/taxiway excursion accidents caused fatalities, and the category was the third largest source of fatal accidents, whereas runway excursions accounted for 23 percent of total hull losses, the largest single accident category. From this it can be concluded that runway excursions, while relatively frequent, are often survivable.

As with most accidents analysis revealed a number of factors contributing to each runway safety accident. The most common precursors were ineffective braking due to contaminated runways, gear malfunctions, unstable approaches, wet and contaminated runways in combination with gusts/strong/cross- or tailwinds, and late or ineffective deployment of retardation devices.

Airlines, air traffic service providers, airport operators and regulators can all contribute to a reduction in the frequency and severity of runway safety accidents in general and runway excursions in particular.

Appendix A—Phase of Flight Definitions

Phase of flight: the phase of flight definitions applied by IATA for the purpose of accident analysis was developed by the Air Transport Association (ATA). They are presented in the following table.

Take-off (TOF): This phase begins when the crew increases the thrust for the purpose of lift-off; it ends when an Initial Climb is established or the crew initiates a “Rejected Take-off” phase.

Rejected Take-off (RTO): This phase begins when the crew reduces thrust for the purpose of stopping the aircraft prior to the end of the Take-off phase; it ends when the aircraft is taxied off the runway for a “Taxi-in” phase or when the aircraft is stopped and engines shutdown.

Approach (APR): This phase begins when the crew initiates changes in aircraft configuration and /or speeds enabling the aircraft to maneuver for the purpose of landing on a particular runway; it ends when the aircraft is in the landing configuration and the crew is dedicated to land on a specific runway. It may also end by the crew initiating an “Initial Climb” or “Go-around” phase.

Go-around (GOA): This phase begins when the crew aborts the descent to the planned landing runway during the Approach phase, it ends after speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise (same as end of “Initial Climb”).

Landing (LND): This phase begins when the aircraft is in the landing configuration and the crew is dedicated to touch down on a specific runway; it ends when the speed permits the aircraft to be maneuvered by means of taxiing for the purpose of arriving at a parking area. It may also end by the crew initiating a “Go-around” phase.

Appendix B—IATA Regions

Region	Country
AFI	Angola
	Benin
	Botswana
	Burkina Faso
	Burundi
	Cameroon
	Cape Verde
	Central African Republic
	Chad
	Comoros
	Congo, Democratic Republic of
	Congo, Republic of
	Côte d'Ivoire
	Djibouti
	Equatorial Guinea
	Eritrea
	Ethiopia
	Gabon
	Gambia
	Ghana
	Guinea
	Guinea-Bissau
	Kenya
	Lesotho
	Liberia
	Madagascar
	Malawi
	Mali
	Mauritania
	Mauritius
	Mozambique
	Namibia
	Niger
	Nigeria
	Rwanda
	São Tomé and Príncipe
	Senegal
	Seychelles

Region	Country
	Sierra Leone
	Somalia
	South Africa
	South Sudan
	Swaziland
	Tanzania
	Togo
	Uganda
	Zambia
	Zimbabwe
ASPAC	Australia[1]
	Bangladesh
	Bhutan
	Brunei Darussalam
	Burma
	Cambodia
	East Timor
	Fiji Islands
	India
	Indonesia
	Japan
	Kiribati
	Laos
	Malaysia
	Maldives
	Marshall Islands
	Micronesia
	Nauru
	Nepal
	New Zealand[2]
	Pakistan
	Palau
	Papua New Guinea
	Philippines
	Samoa
	Singapore
	Solomon Islands
	South Korea
	Sri Lanka

Region	Country
	Thailand
	Tonga
	Tuvalu, Ellice Islands
	Vanuatu
	Vietnam
CIS	Armenia
	Azerbaijan
	Belarus
	Georgia
	Kazakhstan
	Kyrgyzstan
	Moldova
	Russia
	Tajikistan
	Turkmenistan
	Ukraine
	Uzbekistan
EUR	Albania
	Andorra
	Austria
	Belgium
	Bosnia and Herzegovina
	Bulgaria
	Croatia
	Cyprus
	Czech Republic
	Denmark[3]
	Estonia
	Finland
	France[4]
	Germany
	Greece
	Hungary
	Iceland
	Ireland
	Italy
	Israel
	Kosovo
	Latvia

Region	Country
	Liechtenstein
	Lithuania
	Luxembourg
	Macedonia
	Malta
	Monaco
	Montenegro
	Netherlands[5]
	Norway
	Poland
	Portugal
	Romania
	San Marino
	Serbia
	Slovakia
	Slovenia
	Spain
	Sweden
	Switzerland
	Turkey
	United Kingdom[6]
	Vatican City
LATAM	Antigua and Barbuda
	Argentina
	Bahamas
	Barbados
	Belize
	Bolivia
	Brazil
	Chile
	Colombia
	Costa Rica
	Cuba
	Dominica
	Dominican Republic
	Ecuador
	El Salvador
	Grenada

Region	Country
	Guatemala
	Guyana
	Haiti
	Honduras
	Jamaica
	Mexico
	Nicaragua
	Panama
	Paraguay
	Peru
	Saint Kitts and Nevis
	Saint Lucia
	Saint Vincent and the Grenadines
	Suriname
	Trinidad and Tobago
	Uruguay
	Venezuela
MENA	Afghanistan
	Algeria
	Bahrain
	Egypt
	Iran
	Iraq
	Jordan
	Kuwait
	Lebanon
	Libya
	Morocco
	Oman
	Qatar
	Saudi Arabia
	Sudan
	Syria
	Tunisia
	United Arab Emirates
	Yemen

Region	Country
NAM	Canada
	United States of America[7]
NASIA	China[8]
	Mongolia
	North Korea

[1]Australia includes:
Christmas Island Cocos (Keeling) Islands Norfolk Island Ashmore and Cartier Islands Coral Sea Islands Heard Island and McDonald Islands

[2]New Zealand includes:
Cook Islands Niue Tokelau

[3]Denmark includes:
Faroe Islands Greenland

[4]France includes:
French Polynesia New Caledonia Saint-Barthélemy Saint Martin Saint Pierre and Miquelon Wallis and Futuna French Southern and Antarctic Lands

[5]Netherlands include:
Aruba

[6]United Kingdom includes:
England Scotland Wales Northern Ireland Akrotiri and Dhekelia Anguilla Bermuda British Indian Ocean Territory British Virgin Islands Cayman Islands Falkland Islands Gibraltar Montserrat Pitcairn Islands Saint Helena South Georgia and the South Sandwich Islands Turks and Caicos Islands British Antarctic Territory Guernsey Isle of Man Jersey

[7]United States of America include:
American Samoa Guam Northern Mariana Islands Puerto Rico United States Virgin Islands

[8]China includes:
Hong Kong Macau Chinese Taipei

Appendix C—RASG Regions

RASG Region	List of Countries
Africa-Indian Ocean (AFI)	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ívoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Île De La Réunion (Fr.), Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte (Fr.), Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
Asia and Pacific (APAC)	Afghanistan, American Samoa (U.S.A.), Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Cook Islands, Democratic People's Republic of Korea, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, French Polynesia (Fr.), Guam (U.S.A.), India, Indonesia, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Maldives, Marshall Islands, Mongolia, Myanmar, Nauru, Nepal, New Caledonia (Fr.), New Zealand, Niue (NZ.), Norfolk Island (Austr.), Northern Mariana Islands (U.S.A.), Pakistan, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Tuvalu, Vanuatu, Viet Nam, Wallis Is.(Fr.)
Europe (EUR)	Albania, Algeria, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands (Den.), Finland, France, Georgia, Germany, Gibraltar (U.K.), Greece, Greenland (Den.), Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Tunisia, turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan
Middle East (MID)	Bahrain, Egypt, Iraq, Islamic Republic of Iran, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, United Arab Emirates, Yemen
Pan-America (PA)	Anguilla (U.K.), Antigua and Barbuda, Argentina, Aruba (Neth.), Bahamas, Barbados, Belize, Bermuda (U.K.), Bolivia, "Bonaire, Saint Eustatius and Saba", Brazil, Canada, Cayman Islands (U.K.), Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic, Ecuador, El Salvador, Falklan Islands (Malvinas), French Guiana (Fr.), Grenada, Guadeloupe (Fr.), Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique (Fr.), Mexico, Montserrat (U.K.), Nicaragua, Panama, Paraguay, Peru, Puerto Rico (U.S.A.), Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sint Maarten (Dutch part), Suriname, Trinidad and Tobago, Turks and Caicos Islands (U.K.), United States, Uruguay, Venezuela, Virgin Islands (U.S.A.)