70 YEARS 1945—2015
Flying better. Together.

IATA

Loss of Control In-Flight 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 Loss of Control In-Flight Accident Analysis Report
ISBN 978-92-9252-775-4

Montreal—Geneva

Table of Contents

List of Figures

List of Tables

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. This Loss of Control In-Flight (LOC-I) analysis evaluates the risk factors from recent LOC-I accidents and presents information designed to aid industry in the implementation of mitigation strategies. Accidents from 2010 through to 2014 were reviewed for this analysis. The data set includes aircraft over 5,700 kg maximum take-off weight that suffered an operational accident according to the IATA definition (included in this report).

LOC-I refers to accidents in which the flight crew was unable to maintain control of the aircraft in flight, resulting in an unrecoverable deviation from the intended flight path. LOC-I can result from engine failures, icing, stalls or other circumstances that interfere with the ability of the flight crew to control the flight path of the aircraft. It is one of the most complex accident categories, involving numerous contributing factors that act individually or, more often, in combination. These contributing factors include latent conditions in the system, external threats to the flight crew, errors in the handling of those threats, and undesired aircraft states resulting from deficiencies in managing threats or errors. Contributing factors related to accidents presented in this report are based on the information available at the time of classification.

LOC-I accidents are almost always catastrophic; 97 percent of the accidents analyzed involved fatalities to passengers or crew. This category of accident contributed to the most fatalities, (1,242 of 2,541), in the period. Given this severity, LOC-I accidents have been assessed by the IATA Safety Department and the industry to be the highest risk to aviation safety, and deemed to be an area for increased attention.

This report analyzes the 38 LOC-I accidents that occurred during the period, which included 37 fatal accidents and caused 1,242 fatalities.

Section 2–Data Source

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

Section 3–Exclusions

This report specifically excludes 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

This report is intended to provide a detailed understanding of Loss of Control In-Flight (LOC-I) accident statistics. It provides accident breakdown by aircraft propulsion, by scheduled/unscheduled and cargo/passenger operations, rates of occurrence for accidents involving jet and turboprop aircraft, a comparison between IOSA and non-IOSA registered operators and regional accident statistics.

[1] Such as post maintenance functional check flights

Section 5—Global Accident Data

This report was 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 during this period, of which 38 were classified as LOC-I and form the primary focus for this report. Figure 1 illustrates the global breakdown of accidents across all categories. It should be noted that 409 (99 percent) of the accidents could be assigned an accident category or End State[2], while the remaining six (6) accidents lacked sufficient information for classification.

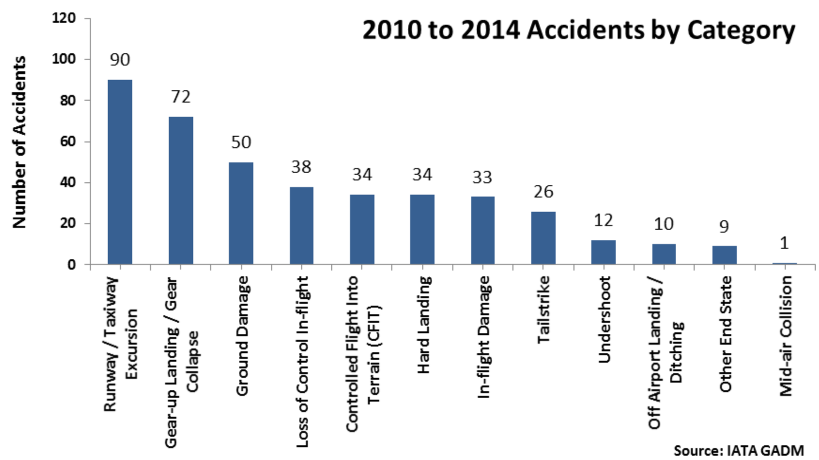

Figure 1: Global Accident Categories Breakdown

Of the total 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 2. Note that 86 of the fatal accidents were assigned an End State.

LOC-I was the most frequent category of fatal accident representing 37 fatal accidents or 43 percent of total fatal accidents with sufficient information for classification. These LOC-I accidents resulted in 1,242 fatalities among passengers and crew.

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

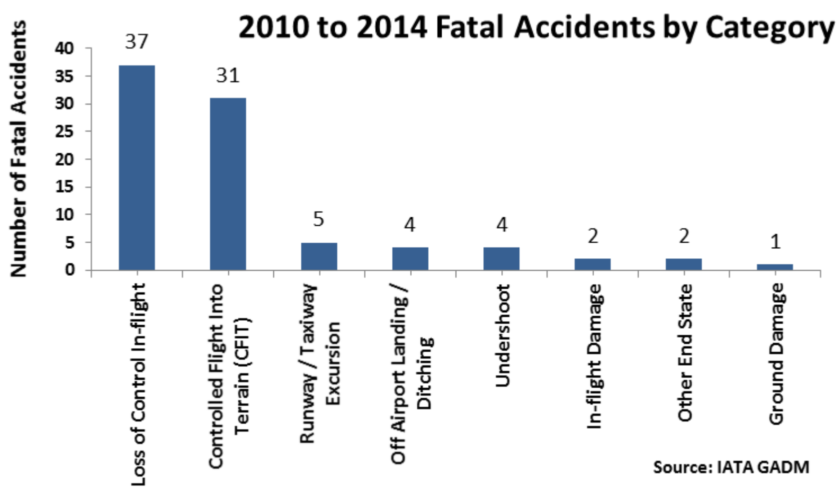

Figure 2: Number of Fatal Accidents per Accident Category

The representation of the percentage of commercial accident categories worldwide in relation to the total accidents is shown in figure 3.

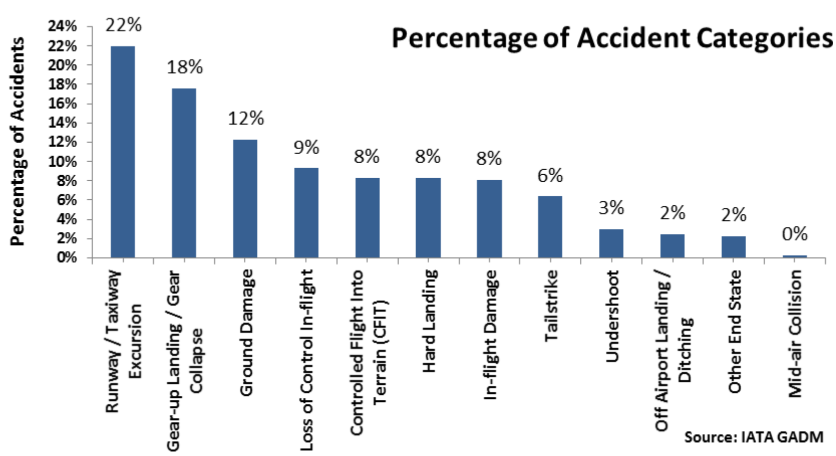

Figure 3: Percentage of Commercial Accident Cateorgies in Relation to Total Accidents

Over the period, IATA Operational Safety Audit (IOSA) program demonstrated positive results for the 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 4 presents the frequency of IOSA registry accidents versus non-IOSA Registry in relation to the total accidents per year.

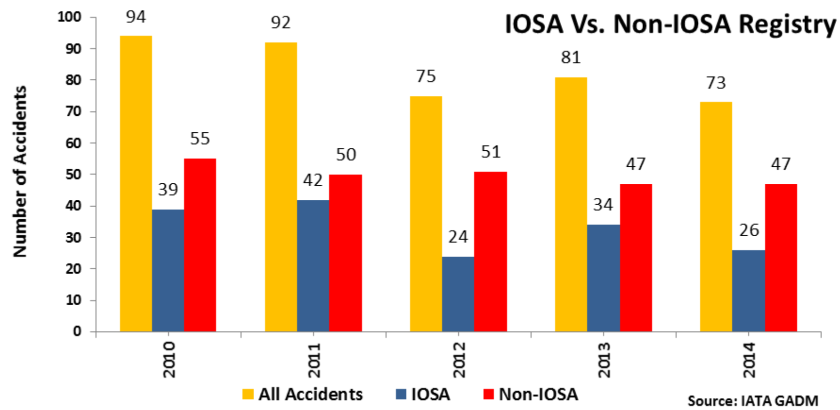

Figure 4: Distribution of IOSA Registry Accidents Versus Non-IOSA Registry in Relation to Total Accidents per Year

The positive results of IOSA are demonstrated when the 'all accident' rate is broken down to show the rate for IOSA registered airlines compared to the rate for operators not on the IOSA registry. The overall accident rate for IOSA registered airlines is just over a third of that for non-IOSA registered airlines for the period between 2010 and 2014. Figure 5 shows the IOSA versus the Non-IOSA registered accident rates in relation to the total accident rates.

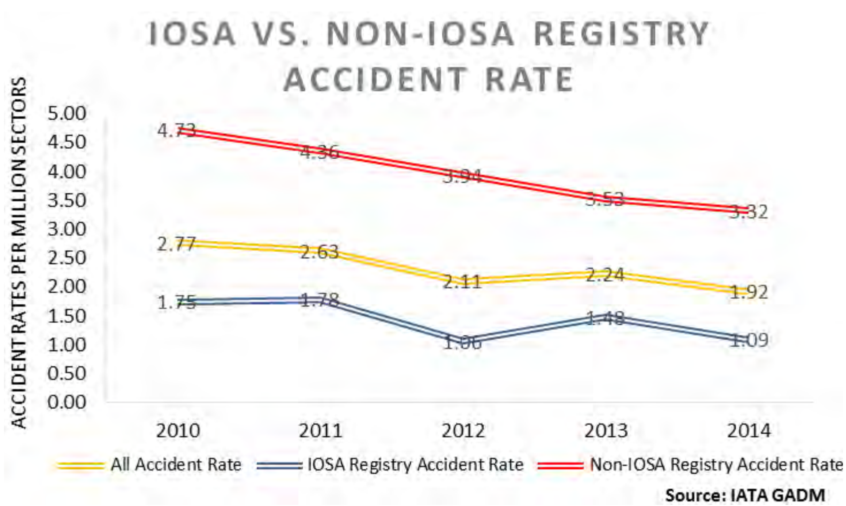

Figure 5: Distribution of IOSA Registry Accident Rates Versus Non-IOSA Registry Accident Rates in Relation to Total Accident Rates per Year

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 6. Note that 86 were assigned an End State.

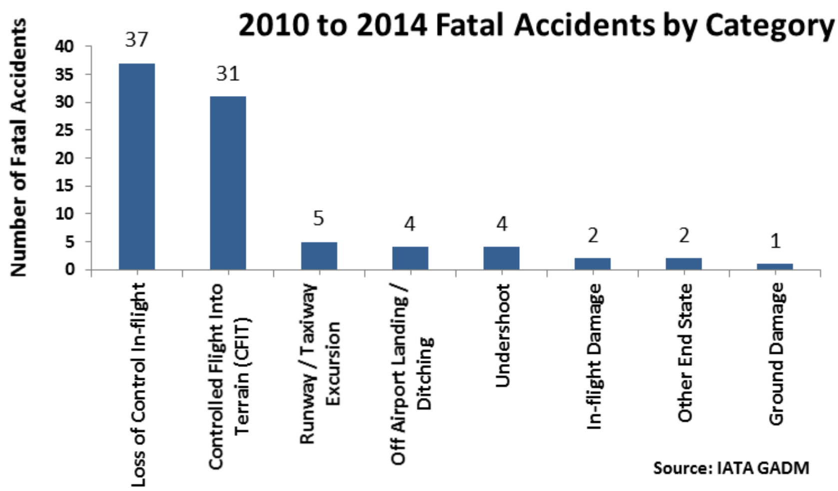

Figure 6: Number of Fatal Accidents per Accident Category

The relative percentage of fatal accidents remained fairly constant from 2010 through 2014, at 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 that occurred annually between 2010 and 2014 declined overall from 23 to 12. Figure 7 presents the frequency of fatal accidents per year.

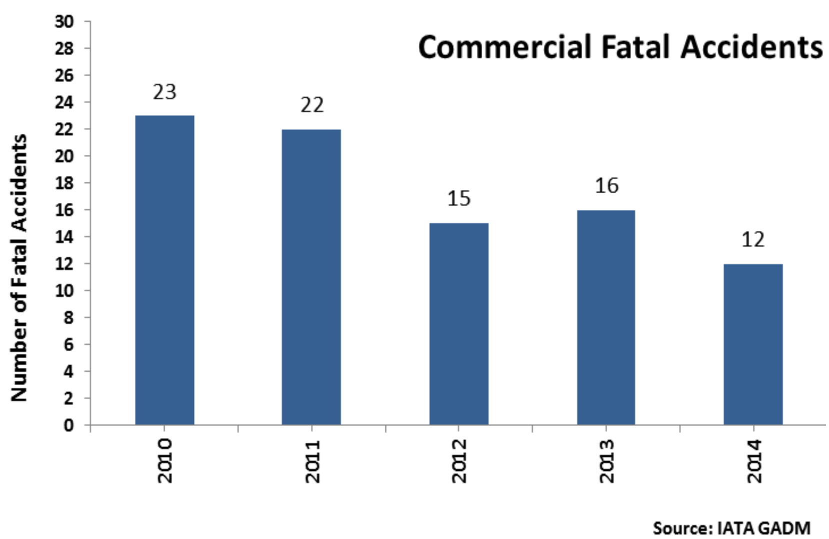

Figure 7: Frequency of Fatal Accidents per Year

LOC-I accidents are almost always catastrophic; 97 percent of LOC-I accidents between 2010 and 2014 involved fatalities to passengers and/or flight crew. Over this period, 9.3 percent of all accidents were categorized as LOC-I and LOC-I accidents contributed to 49 percent of fatalities (1,242 out of 2,541).

Figure 8 presents the concept of high-risk accident categories. This was designed to expand beyond the traditional method using frequency of accidents as the single metric for prioritization of mitigation efforts and to introduce a metric for accident outcome related to survivability.

In figure 8, 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 the accident category. From this analysis Loss of Control In-Flight, Controlled Flight Into Terrain (CFIT) and Runway Excursions were identified as the top three high risk categories to be addressed by IATA.

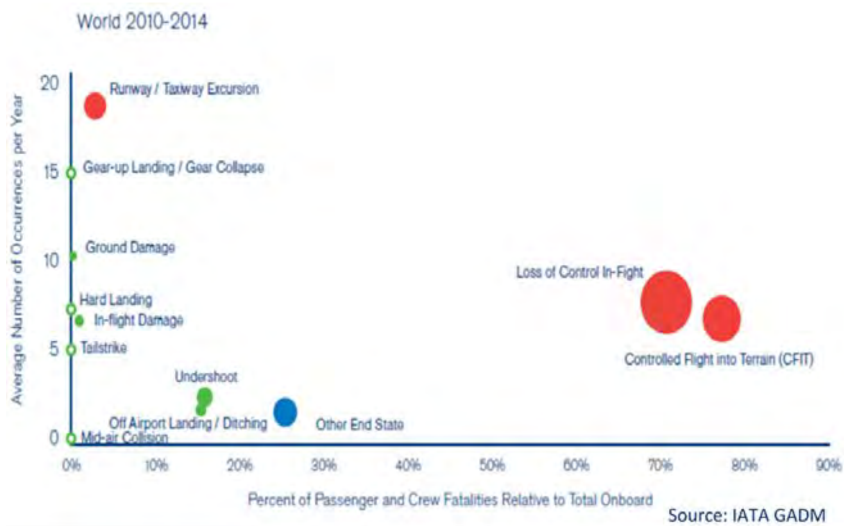

Figure 8: High Risk Accident Category

Furthermore, as shown in Table 1 below, LOC-I was the primary cause of commercial aviation fatalities between 2010 and 2014, followed by CFIT[3]. The improving trends in the other accident categories have resulted in LOC-I becoming the leading cause of fatal accidents in commercial air transportation worldwide and it is only in recent years that LOC-I accidents have overtaken CFIT as the leading fatal accident category. The fact that LOC-I is receiving substantial industry attention despite the relatively low number of accidents is on account of the disturbing number of fatalities they have caused. The remainder of this paper focuses on LOC-I accidents.

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

[3] See Appendix D for additional information on taxonomy-issues.

Section 6—Loss of Control In-Flight (LOC-I) Definition

The definition of LOC-I as stated in the IATA Safety Report is “Loss of Aircraft Control While In-Flight”. This includes events such as aerodynamic stalls and upsets following failures of aircraft systems.

Section 7—Loss of Control In-Flight (LOC-I) Accident Data

In the five (5) years 2010 – 2014, there were 38 LOC-I accidents reported, with an average of 7.6 accidents per year. Although, the number of commercial aircraft accidents fluctuated year to year, the number of LOC-I accidents between 2010 and 2014 declined from ten (10) accidents to six (6). Figure 9 shows the frequency of LOC-I accidents by year for the period. The lowest number occurred in 2012 and in 2014 when there were six (6) LOC-I accidents each. The six (6) accidents were below the five-year average.

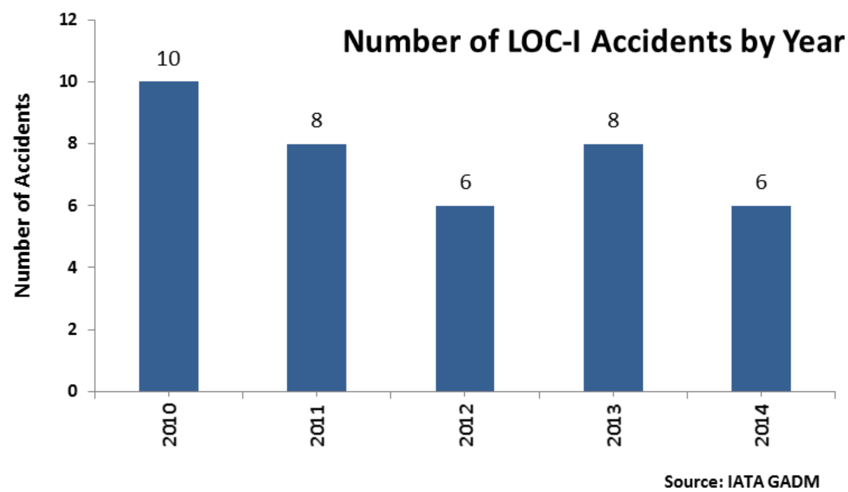

Figure 9: Number of LOC-I Accidents per Year

Absolute numbers of accidents are not necessarily a good indication of safety performance and are of limited comparative value unless they are normalized by the number of sectors[4] flown per year to create an accident rate. Figure 10 shows the accident rates per million sectors flown per year. Although there is an improving trend in this category, LOC-I accidents continue to outpace other categories as the leading cause of fatal accidents.

[4] IATA defines 'sector' as the operation of an aircraft between takeoff at one location and landing at another location (other than a diversion).

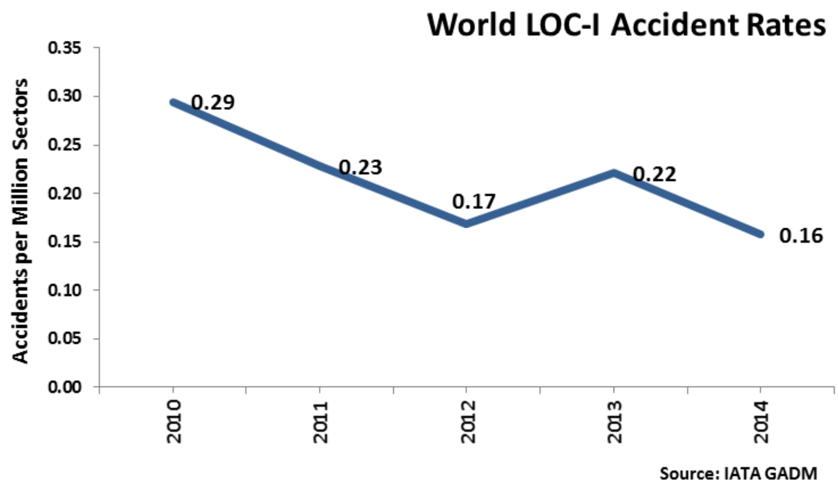

Figure 10: LOC-I Accident Rates per Million Sectors

7.1 Loss of Control In-Flight (LOC-I) by Aircraft Propulsion

This section breaks down the LOC-I accidents by aircraft propulsion and accident rates per million sectors flown by each aircraft propulsion. Over the five (5) years covered in this report, jet aircraft were involved in 13 accidents or 34 percent of the total LOC-I accidents, while turboprop aircraft were involved in 25 accidents or 66 percent. Figure 11 illustrates the distribution of LOC-I accident count per aircraft propulsion per year.

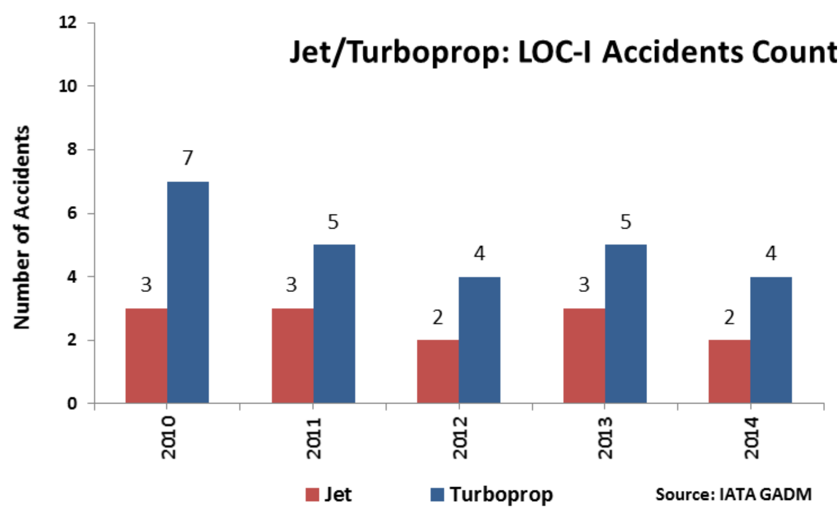

Figure 11: Distribution of Jet and Turboprop Aircraft LOC-I Accident Count

When analyzed by aircraft propulsion, turboprop aircraft had a significantly higher average rate of LOC-I accidents than jet aircraft (0.68 accidents per million flights as opposed to 0.09). Figure 12 illustrates the distribution of accident rates per year broken down by turboprop and jet propulsion.

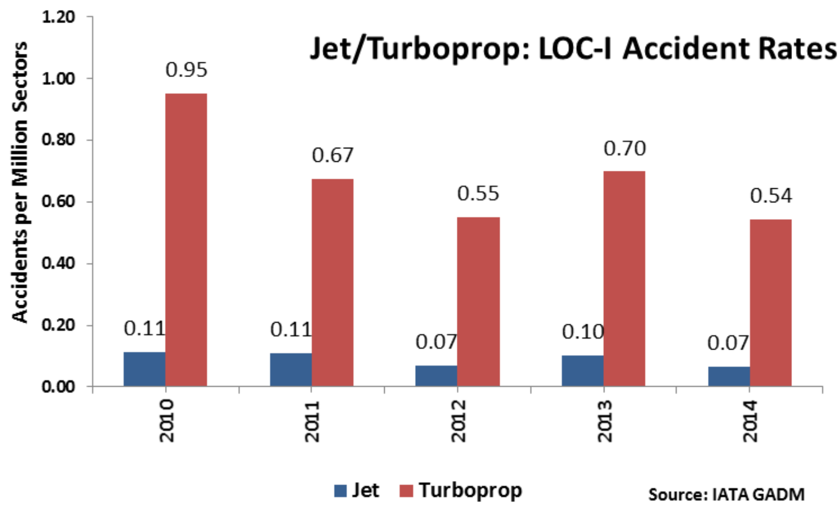

Figure 12: Distribution of Jet and Turboprop Aircraft LOC-I Accident Rates

7.2 Loss of Control In-Flight (LOC-I) Severity

LOC-I accidents tend to be severe in terms of number of fatalities and damage to the airframe. Of the 38 total LOC-I accidents from 2010-2014, 37 (97 percent) resulted in a hull loss with one or more fatalities among the passengers or crew. Figure 13 illustrates LOC-I hull loss and substantial damage accidents for all aircraft between 2010 and 2014.

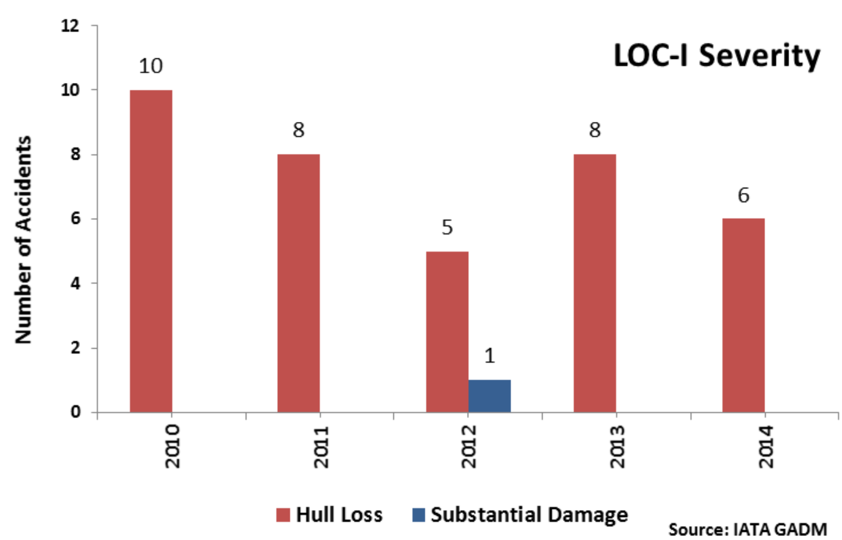

Figure 13: Hull Loss Versus Substantial Damage LOC-I Accidents

The data revealed that over the reporting period, LOC-I was the biggest single cause of commercial transport aircraft fatal accidents and hull losses. Figure 14 illustrates the distribution of fatal LOC-I accidents per year. The average number of fatal LOC-I accidents was 7.4 accidents per year, the years 2012 and 2014 recorded lower fatal accidents than the average.

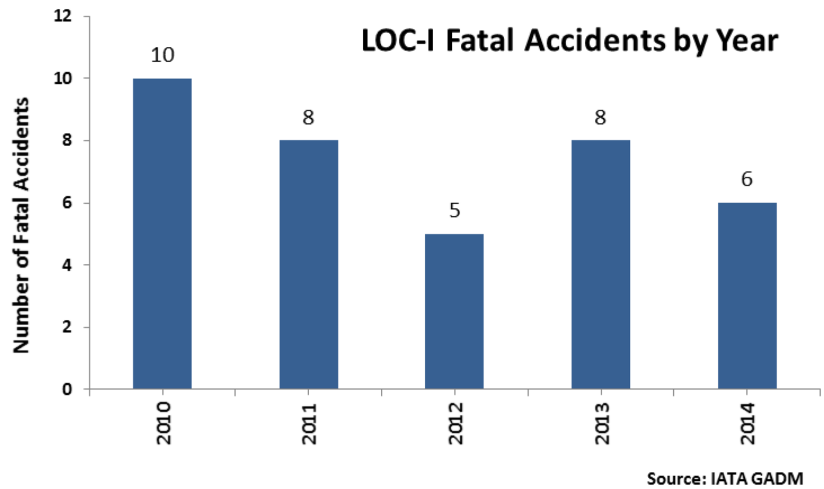

Figure 14: Distribution of Fatal Accidents per Year

Figure 15 illustrates the comparison of all LOC-I accidents with the 37 that resulted in fatalities. It was noted that all LOC-I accidents during the reporting period were fatal except in 2012 which recorded the only non-fatal LOC-I accident in the period.

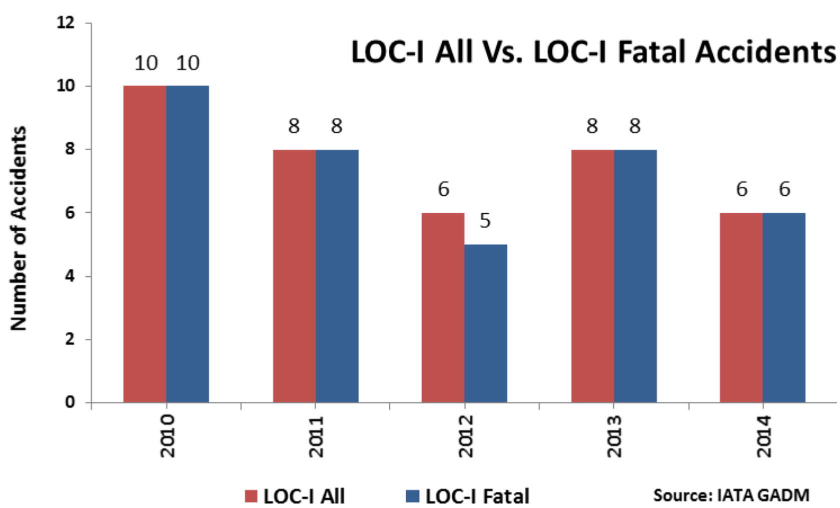

Figure 15: Total LOC-I Accidents Versus Fatal LOC-I Accidents

Of the 37 LOC-I hull loss fatal accidents, 13 accidents involved jet hull losses accidents, as opposed to 24 accidents involving turboprop hull losses. Table 2 summarizes the count and the rate of jet and turboprop hull loss accidents by year.

	Jet hull loss accident count	Jet hull loss accident rate	Turboprop hull loss accident count	Turboprop hull loss accident rate
2010	3	0.11	7	0.95
2011	3	0.11	5	0. 67
2012	2	0.07	3	0.41
2013	3	0.10	5	0.70
2014	2	0.07	4	0.54

Table 2: Jet Versus Turboprop Hull Loss LOC-I Accident Count Versus Rate

As shown in table 2 above, when the 37 LOC-I fatal accidents were broken down by aircraft propulsion and turboprop aircraft had a significant higher average rate of fatal accidents (0.66 Versus 0.09 for jet); figure 16 illustrates the breakdown of the accident rates of fatal accidents by aircraft propulsion per year.

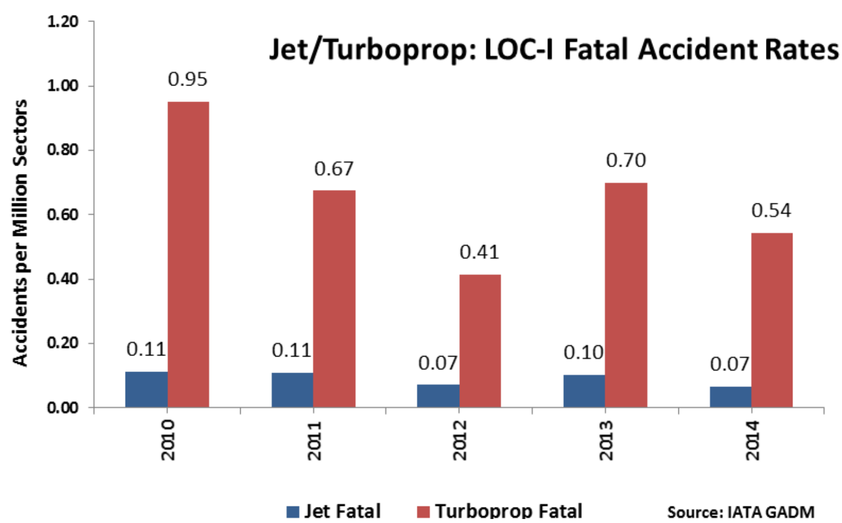

Figure 16: LOC-I Fatal Accidents by Aircraft Propulsion per Year

Although turboprop aircraft had a higher number of fatal accidents, jet aircraft had a higher number of fatalities (875 versus 367 for turboprop); this reflects the capacity difference of jet versus turboprop aircraft. Table 3 presents the LOC-I fatal accidents, rates and the number of fatalities per aircraft propulsion.

	Jet fatal accidents	Jet fatal accident rates	Jet fatalities	Turboprop fatal accidents	Turboprop fatal accident rates	Turboprop fatalities
2010	3	0.11	103	7	0.95	138
2011	3	0.11	154	5	0.67	59
2012	2	0.07	280	3	0.41	37
2013	3	0.10	60	5	0.70	76
2014	2	0.07	278	4	0.54	57

Table 3: LOC-I Fatal and Fatalities per Aircraft Propulsion

It can be useful to understand how many people onboard survived a fatal accident. The survivability percentage, comparing the number of people who survived with the total number of people onboard, can help to understand the relative severity of different groups of fatal accidents. Table 4 presents the LOC-I fatal accident count and rate by aircraft class.

Class	Fatal Accident Count	Fatal LOC-I Accident Rate	Fatalities	Survivability
Jets	13	0.09	875	10%
Turboprops	24	0.66	367	16%

Table 4: LOC-I Fatal Accident Counts and Survibility by Aircraft Propulsion

The following section provides insight into the IOSA registered and non-IOSA registered accident rates (2010-2014).

7.3 IOSA Registered Carriers Versus Non-IOSA Registered Accident Rates

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 positive results of IOSA were illustrated when all accidents were broken down to show the rate for IOSA registered airlines compared to the rate for operators not on the IOSA registry. The overall accident rate for IOSA registered airlines was almost three (3) times lower than that for non-IOSA registered airlines for the period between 2010 and 2014. Table 5 shows the IOSA versus the Non-IOSA registered accident rates.

Category	2010	2011	2012	2013	2014	Average 2010-2014
All Accident	2.77	2.63	2.11	2.24	1.92	2.33
IOSA	1.75	1.78	1.06	1.48	1.09	1.43
Non-IOSA	4.73	4.36	3.94	3.53	3.32	3.98

Table 5: IOSA Versus Non-IOSA Registered Accident Rates

The positive results were also demonstrated when the LOC-I fatal accident rate was broken down to show the rate for IOSA registered airlines compared to the rate for operators not on the IOSA registry. The LOC-I accident rate for IOSA registered airlines was almost eight (8) times lower than that for non-IOSA registered airlines for the period between 2010 and 2014. Figure 17 shows the all fatal LOC-I accident rates in comparison to IOSA versus the Non-IOSA registered LOC-I fatal accident rates.

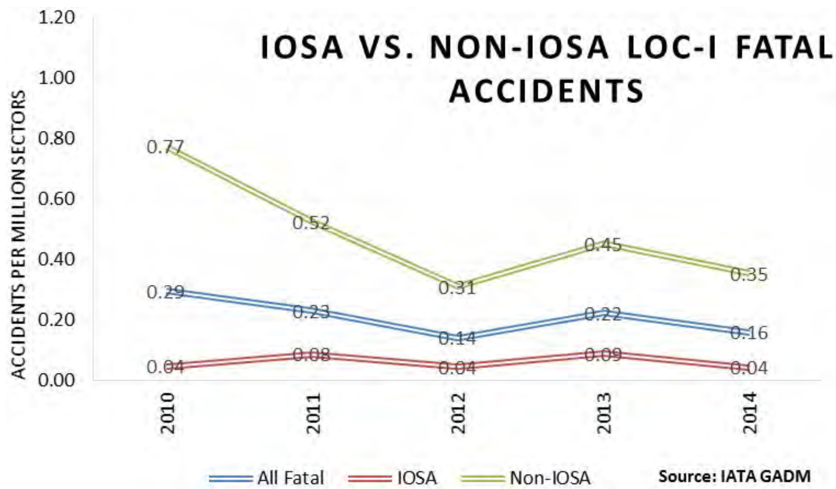

Figure 17: IOSA Versus Non-IOSA LOC-I Fatal Accidents

IOSA also demonstrated a positive impact on aviation safety, when comparing jet and turboprop safety performance. The LOC-I fatal accident rate was broken down to show the LOC-I fatal accident rates of the different types of aircraft propulsion in relation to IOSA versus non-IOSA registered jet and turboprop aircraft operators. Table 6 shows the LOC-I fatal accident rates for operators of turboprop and jet aircraft on the IOSA registry Versus Non-IOSA registry.

Category	2010	2011	2012	2013	2014	Average 2010-2014
Fatal Accidents – Jet	0.11	0.11	0.07	0.10	0.07	0.09
IOSA- Jet	0.05	0.09	0.00	0.10	0.05	0.06
Non-IOSA-Jet	0.30	0.16	0.25	0.12	0.11	0.19
Fatal Accidents – Turboprop	0.95	0.67	0.41	0.7	0.54	0.66
IOSA – Turboprop	0.00	0.00	0.43	0.00	0.00	0.09
Non-IOSA – Turboprop	1.38	0.99	0.41	0.99	0.76	0.91

Table 6: LOC-I Fatal Accident Rates for Operators of Turboprop and Jet Aircraft on the IOSA Registry Versus Non-IOSA Registry

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

7.4 Impact of Types of Service

Different operational service types and/or the familiarity of the operating environment can influence the potential for a LOC-I accident. This section presents the type of operational service, in terms of cargo or passenger operations and scheduled or unscheduled operations. The majority with 68 percent of LOC-I accidents involved passenger flights, while cargo represented 32 percent.

Of the 26 LOC-I accidents to passenger services, 25 accidents were fatal, resulting in 1,190 fatalities with 23 percent survivability. 12 accidents involved cargo flights, resulting in 52 fatalities with three (3) percent survivability.

Of the 25 fatal LOC-I accidents to passenger services, 19 accidents or 76 percent of those were operating domestic flights and six (6) accidents or 24 percent were engaged in international operations. Of the 12 fatal accidents to cargo flights, six (6) accidents, or 50 percent were operating domestic flights and six (6) or 50 percent were engaged in international operations. Table 7 presents the summary of fatal accidents by type of operational service.

Service	Total fatal accidents	Domestic flights	International flights
Passenger	25	19	6
Cargo	12	6	6

Table 7: LOC-I Fatal Accidents by Type of Service[5]

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 4) compared to non-scheduled passenger operations, while scheduled cargo operations had an accident factor of two (2) times lower than non-scheduled cargo operations. Table 8 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 sectors flown in the period.

[5] The higher number of passenger LOC-I accidents reflects the high volume of flights in this category

Service	All	Fatal	Fatalities	Survivability
Passenger				
Scheduled	21	20	1073	22%
Non-scheduled	5	5	117	24%
Cargo				
Scheduled	4	4	11	0%
Non-scheduled	8	8	41	4%

Table 8: LOC-I Accidents by Scheduled Versus Non-Scheduled[6]

Table 9 breaks down the fatal accidents by phase of flight and type of operational service. Note, the percentage shown summarizes the proportion of fatal accidents for the phase of flight compared to the total number of fatal accidents for each of the different types of operational service.

Phase of Flight	Passenger count	Passenger percentage	Cargo count	Cargo percentage
TOF	2	8%	1	8%
ICL	6	24%	4	33%
ECL	0	0%	1	8%
CRZ	5	20%	2	17%
DST	0	0%	1	8%
APR	7	28%	1	8%
GOA	4	16%	0	0%
LND	1	4%	2	17%

Table 9: Distribution of Flight Phases by Service Type for Fatal LOC-I Accidents

Figure 18 illustrates the percentage of the phase of flight associated with the total number of fatal LOC-I accidents involved with each of the different types of operational service.

[6] The higher number of scheduled passenger LOC-I accidents reflects the high volume of flights in this category

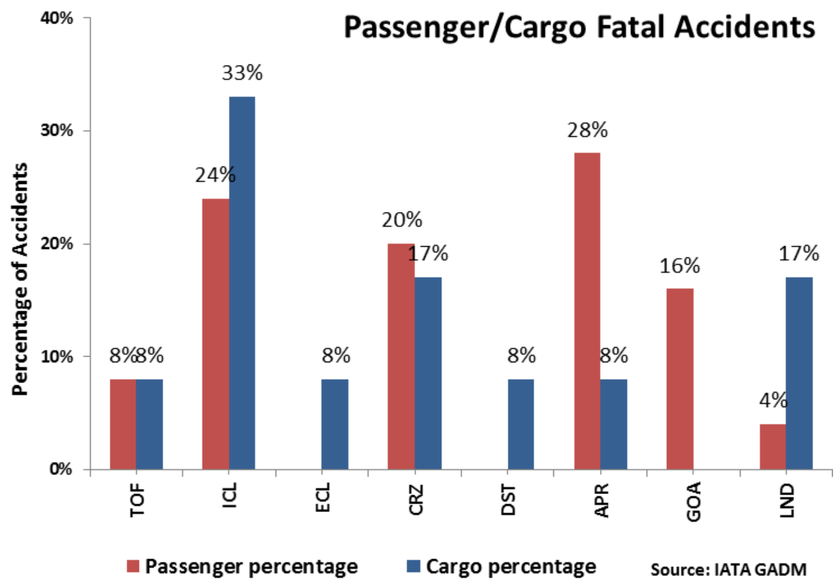

Figure 18: Percentage of LOC-I Fatal Accidents in Each Flight Phase by Type of Service

7.5 Loss of Control In-Flight (LOC-I) Accidents by Flight Phase

Loss of Control In-Flight accidents have the potential to occur during any airborne flight phase. The definitions for each phase used in this report are presented in Appendix A.

Figure 19 illustrates that eight (8), or 21 percent, of LOC-I accidents occurred during the approach phase of flight as opposed to 12 percent for all accidents in the same time period. Ten (10), or 26 percent of LOC-I accidents occurred during the initial climb phase as opposed to five (5) percent for all accidents and seven (7), or 18 percent, during the cruise phase as opposed to five (5) percent for all accidents. The majority of LOC-I accidents during the period 2010-2014 occurred at low altitudes, such as during the initial climb, from which recovery is clearly more difficult.

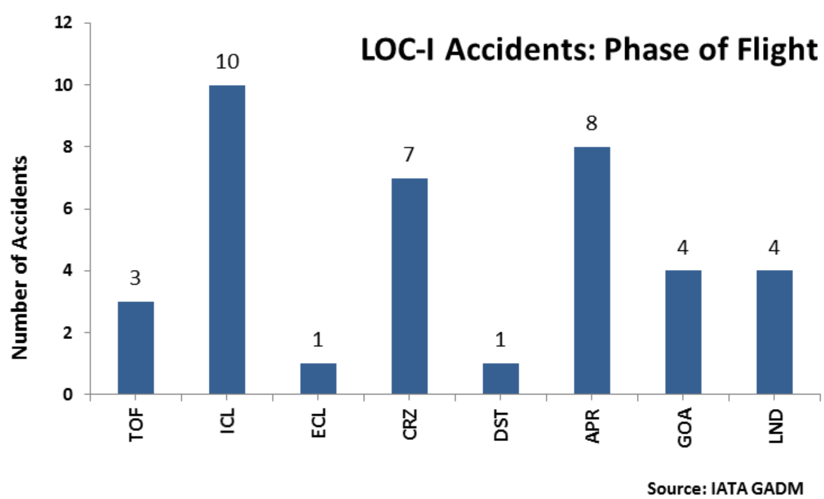

Figure 19: LOC-I Accidents by Phases of Flight

Figure 20 presents the LOC-I accidents versus all accidents during the period 2010-2014 per phase of flight.

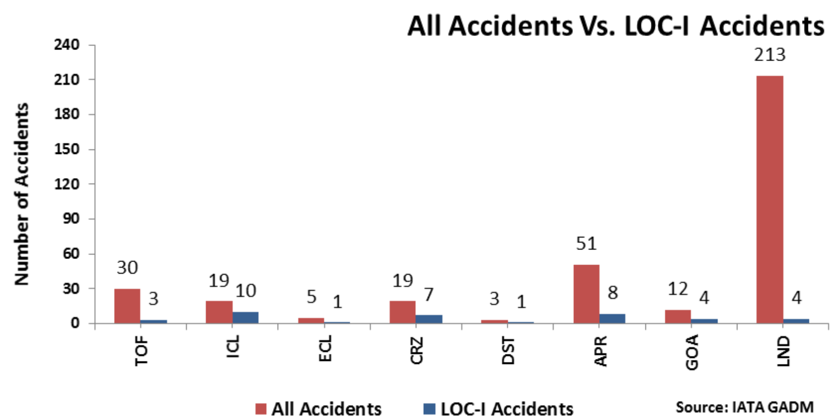

Figure 20: LOC-I Accidents Versus All Accidents per Phases of Flight

To understand the impact of aircraft propulsion on LOC-I accidents at various phases of flight, the occurrences were broken down into jet or turboprop propulsion. This distribution is illustrated in Figure 21. The primary differences were noted in the initial climb (ICL), en-route climb (ECL), cruise (CRZ), Descent (DST), and approach (APR) phases of flight where turboprop aircraft had a higher frequency of occurrence.

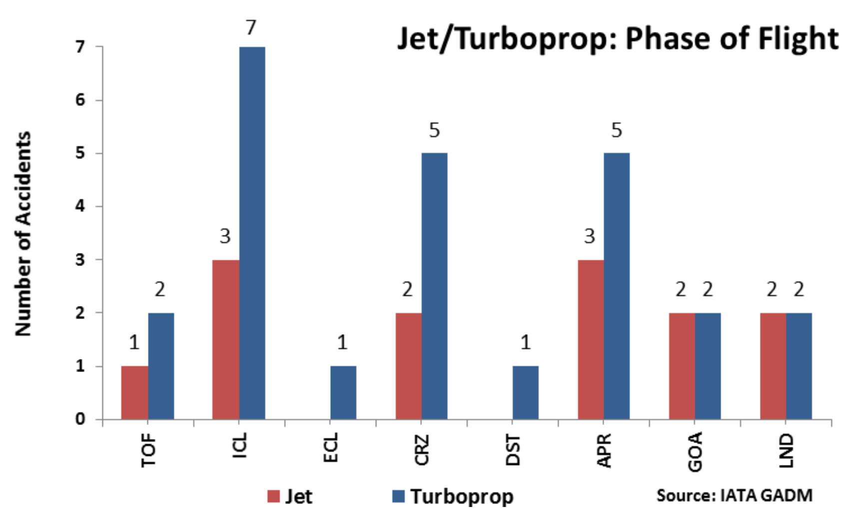

Figure 21: Distribution of Jet Versus Turboprop Accidents by Phases of Flight

When analyzing the 37 LOC-I fatal accidents by phases of flight per aircraft propulsion as illustrated in Figure 22, it was apparent that there were non-fatal jet accidents during the ECL and DST phases of flight.

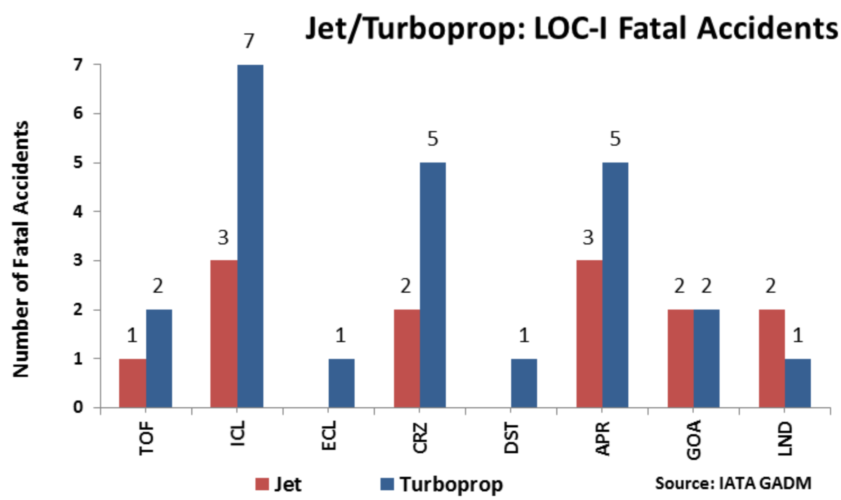

Figure 22: Fatal LOC-I Accidents by Phase and Propulsion

7.6 Loss of Control In-Flight (LOC-I) Regional Analysis

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

Figure 23 presents the overall distribution of LOC-I occurrences as well as the percentage of the total LOC-I accidents by region of operator. Operators from Africa (AFI) suffered the greatest number of occurrences with ten (10) accidents, or 26 percent, of the total, followed by operators from Latin America & the Caribbean (LATAM/CAR) with seven (7) accidents, or 18 percent, of the total. Operators from Commonwealth of Independent States (CIS) also were involved in seven (7) accidents, or 18 percent of the total LOC-I accidents. Operators from Asia Pacific (ASPAC) were involved in five (5) accidents, or 13 percent of the total. North American (NAM) operators were involved in four (4) accidents or 11 percent of the total, European (EUR) operators had three (3) accidents or eight (8) percent of the total, and Middle East and North Africa (MENA) had the lowest number of occurrences with two (2) accidents, or five (5) percent, of the total. None of the North Asian (NASIA) operators had a LOC-I accident in the time period studied.

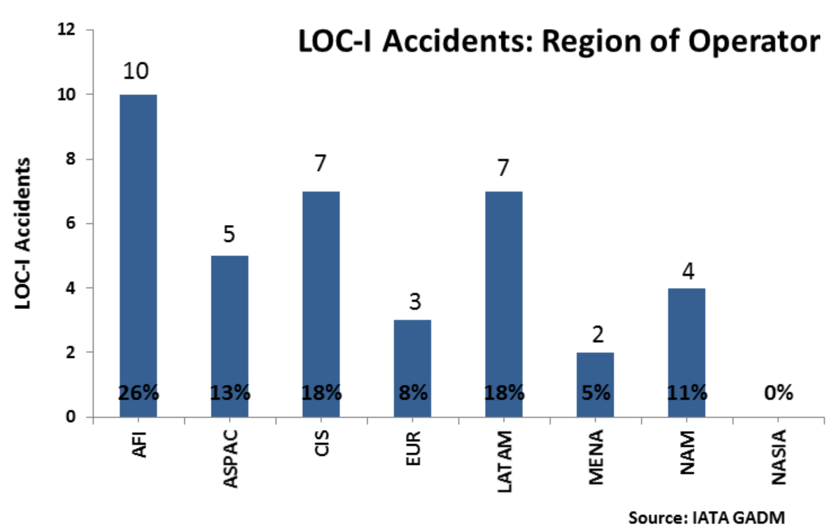

Figure 23: LOC-I Accidents by Region of Operator

Figure 24 illustrates the accident rates per million sectors flown based on region of operator. Operators from AFI had the highest rate of LOC-I accidents, with a 2.01 accident rate per million sectors flown. Operators from NAM and EUR had the second lowest rate, with a 0.07 accident rate per million sectors flown, and operators from NASIA had the lowest rate with zero (0) LOC-I accidents.

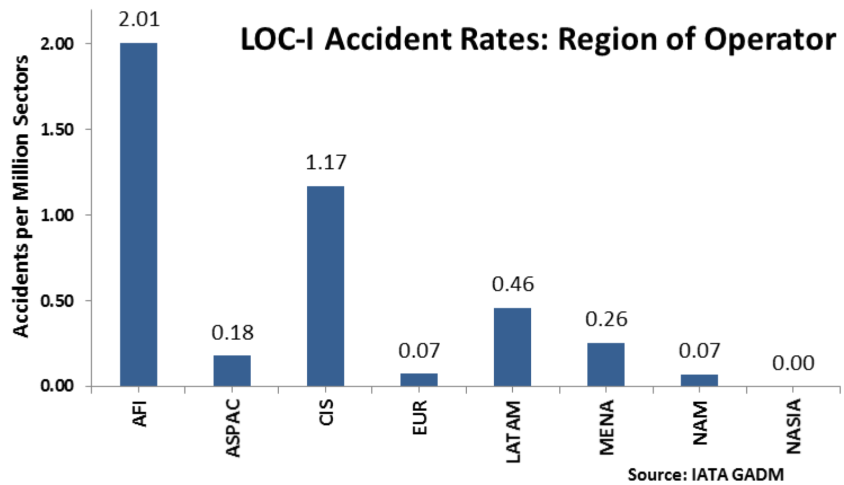

Figure 24: LOC-I Accident Rates by IATA Operator Region

This report includes a worldwide comparison of the total LOC-I accidents versus fatal accidents by region; this shows all accidents involving operators from AFI, ASPAC, CIS, LATAM, MENA and NAM were fatal. As indicated in figure 23, European based operators had a total of three (3) accidents, two (2) of which were fatal accidents[7]. Figure 25 illustrates the distribution of fatal accidents per region of operator.

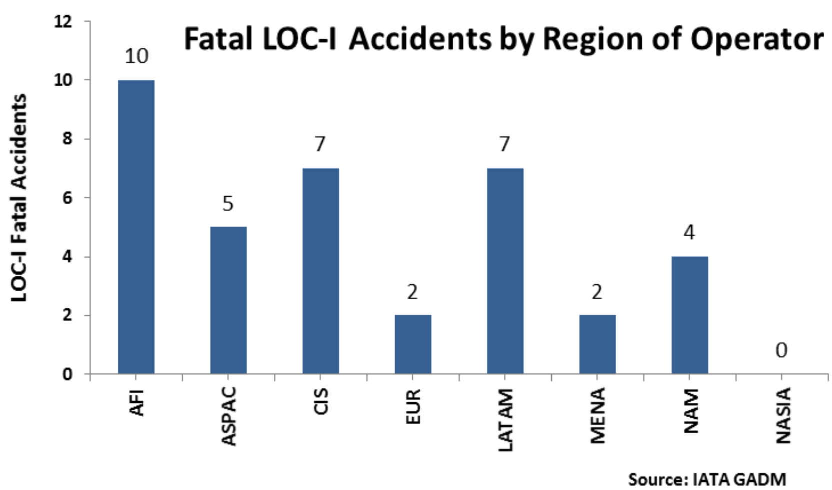

Figure 25: Fatal LOC-I Accidents by Region of Operator

[7] The one (1) non-fatal LOC-I accident occurred in Europe in 2012. The flight experienced smoke in the cabin and the crew decided to return to the departure airport. The left engine was shut-down after a fire warning. While on approach, the crew reported that the rudder pedals were 'stuck' and 'very difficult to move'. The aircraft became misaligned with the runway but the crew decided to continue on the approach due to the smoke in the cabin and the apparent flight control issues. The aircraft was brought back onto the runway heading using the ailerons, but it reportedly touched down crabbed to one side. Directional control was not regained and the aircraft veered left off the runway coming to rest approximately 80 meters from the side of the runway.

Analysis showed that the highest fatal accident rate was for operators from Africa, with a fatal accident rate of 2.01 per million sectors followed by operators from CIS with a fatal accident rate of 1.17. Operators from North Asia had the lowest rate of fatal accidents, with a zero accident rate per million sectors due to the absence of any LOC-I accidents in the period. Figure 26 depicts fatal accident rates per million sectors flown based on region of operator.

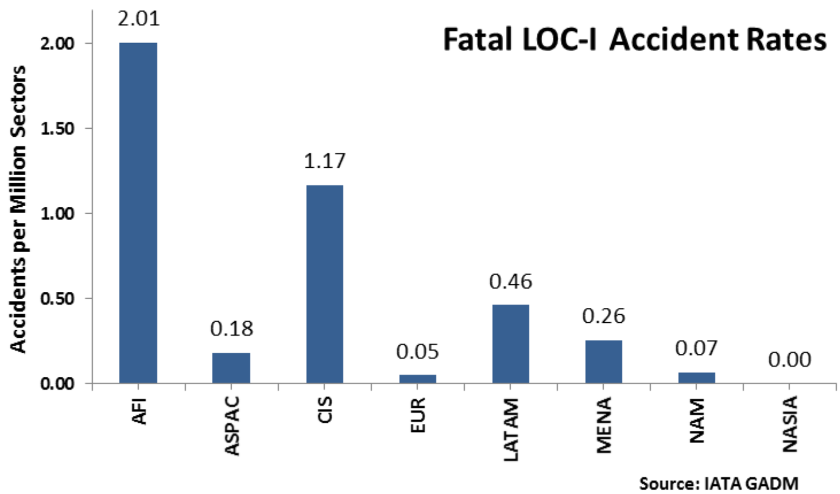

Figure 26: Fatal LOC-I Accident Rates by Operator Region

Figure 27 presents the number of fatal LOC-I accidents in each region broken down by type of operational service; passenger or cargo. The largest discrepancy in service type was for NAM operators where cargo operations represented the highest number of fatal LOC-I accidents.

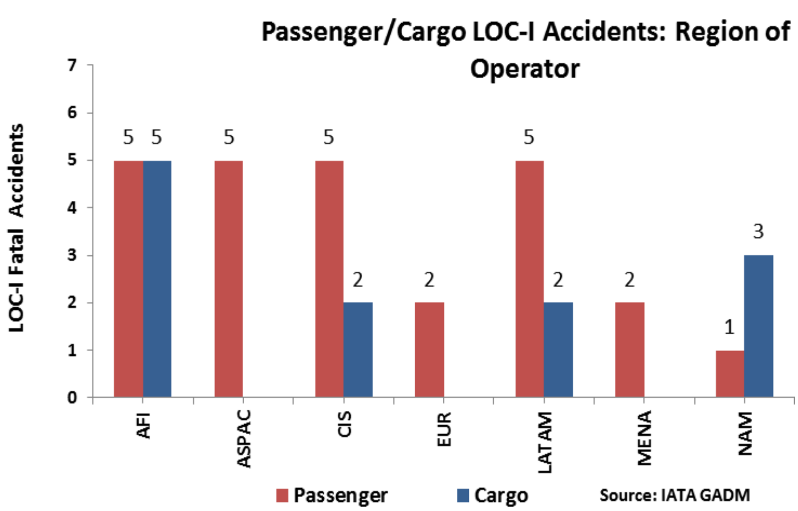

Figure 27: Distribution of LOC-I Accidents by Service Type and Operator Region

A detailed sector breakdown by passenger or cargo operations was not available for this analysis. Without sector information, the configuration of the world fleet can be used to make some estimates of the exposure. At the end of 2014, 25,494 aircraft were configured for passenger operations while 3,474 were configured for cargo operations (this includes: all cargo, mixed passenger/cargo or quick change configurations). Based on this, we can calculate an accident rate per 1,000 aircraft. Cargo configured aircraft had a higher incidence of LOC-I accident per 1000 aircraft (5.18 per 1,000 aircraft compared to 2.12 for passenger). Figure 28 illustrates the distribution of Cargo versus Passenger LOC-I accidents per 1000 aircraft.

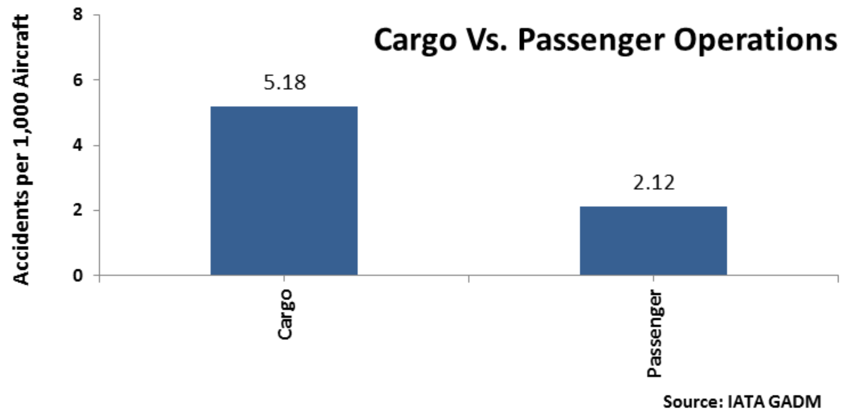

Figure 28: Distribution of Cargo Versus Passenger LOC-I Accidents per 1000 Aircraft

7.7 Loss of Control In-Flight (LOC-I) Accidents by Regional Aviation Safety Group (RASG) Regions

A further regional analysis is provided using the ICAO Regional Aviation Safety Group regions. A full breakdown of the five (5) RASG regions are at Appendix C. The number of accidents and the normalized accident rate per million sectors by RASG region are shown in this section.

Figure 29 illustrates the distribution of LOC-I accidents by RASG region of operator.

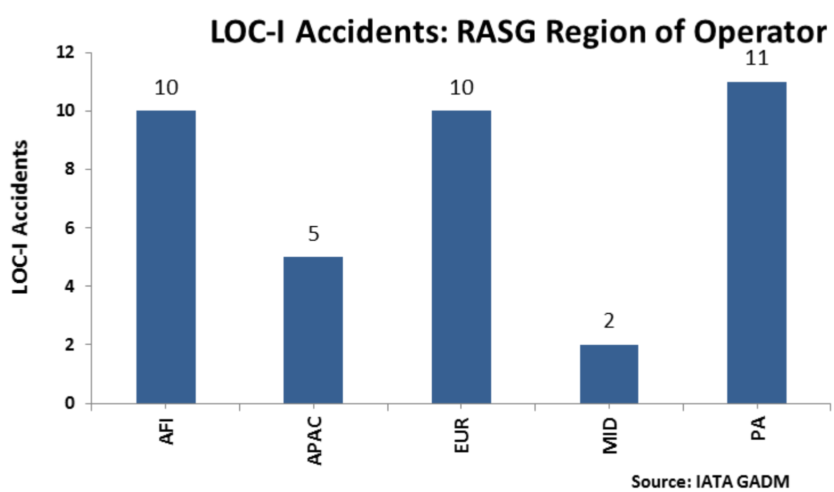

Figure 29: LOC-I Accidents by RASG Region of Operator

Figure 30 illustrates the distribution of Loss of Control In-Flight accidents rate per million sectors flown per RASG region of operator.

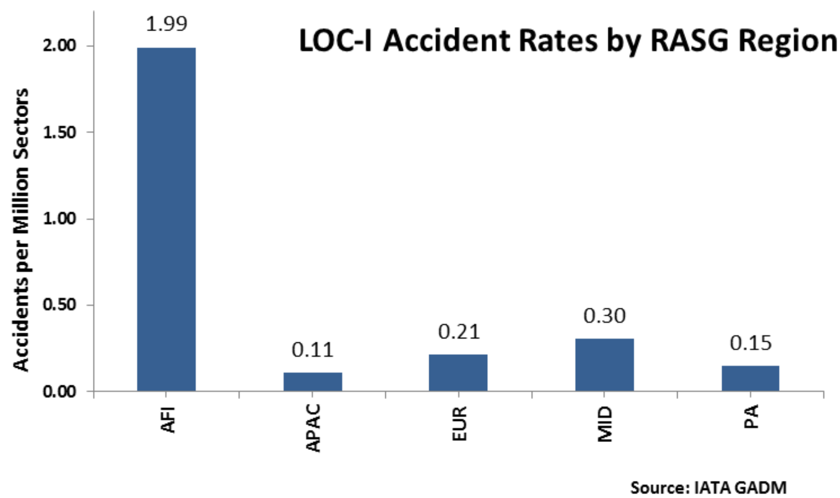

Figure 30: LOC-I Accident Rates by RASG Operator Region

Figure 31 illustrates the RASG regional LOC-I accidents by aircraft propulsion.

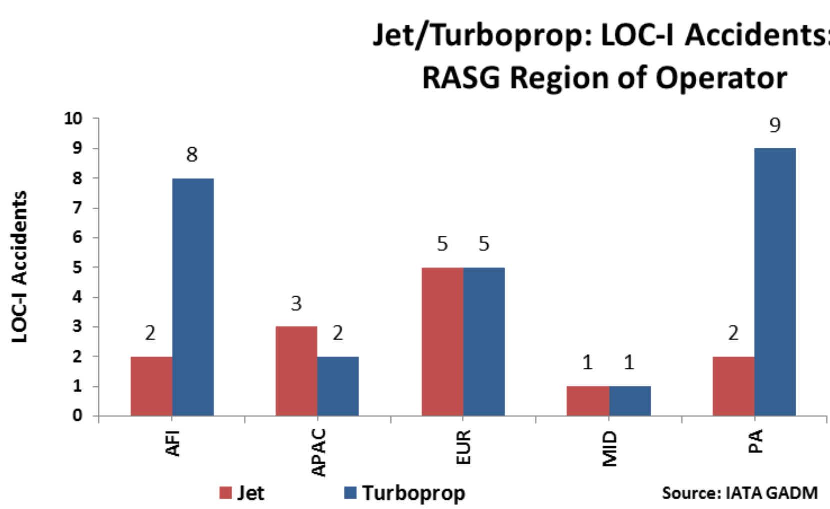

Figure 31: RASG Regional LOC-I Accidents by Aircraft Propulsion

In any aircraft accident, there are different causal factors and influential parameters such as the non-availability of precision approach aids, airport infrastructure, type of aircraft involved, air traffic control, meteorological conditions, as well as the socio-cultural environment that may differ from one region to another. It is, therefore, important to also breakdown by region of occurrences. The highest number of LOC-I accidents occurred in Pan America RASG Region (PA) region with 11 accidents, followed by Africa-Indian Ocean RASG Region (AFI) with ten (10) accidents in total. Figure 32 provides the distribution of LOC-I accidents by RASG Region of Operator versus RASG Region of Occurrence.

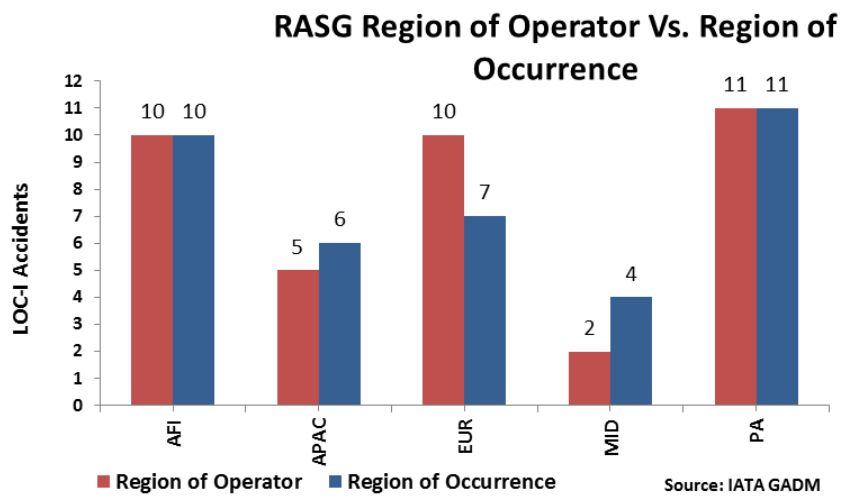

Figure 32: Distribution of LOC-I accidents by RASG Region of Operator versus RASG Region of Occurrence

7.8 Loss of Control In-Flight (LOC-I) Contributing Factors

IATA, through the Accident Classification Task Force, assigns contributing factors to accidents to better understand the correlations. There were five (5) LOC-I accidents that could not be classified due to insufficient data, the rest of data was classified and the most frequent contributing factors are shown in figure 33.

Latent Conditions (deficiencies in...)	
Flight Operations	24%
Flight Ops: Training Systems	18%
Flight Ops: SOPs & Checking	13%
Safety Management	24%
Regulatory Oversight	18%
Environmental Threats	
Meteorology	37%
Icing Conditions	13%
Poor visibility / IMC	13%
Thunderstorms	13%
Lack of Visual Reference	11%
Airline Threats	
Aircraft Malfunction	37%
Contained Engine Failure/Powerplant Malfunction	24%
Operational Pressure	8%
Fire / Smoke (Cockpit/Cabin/Cargo)	5%

Flight Crew Errors (related to…)	
Manual Handling / Flight Controls	29%
SOP Adherence / SOP Cross-verification	26%
Intentional	16%
Unintentional	11%
Callouts	8%
Undesired Aircraft States	
Vertical / Lateral / Speed Deviation	21%
Operation Outside Aircraft Limitations	16%
Unnecessary Weather Penetration	16%
Unstable Approach	11%
Abrupt Aircraft Control	5%
Countermeasures	
Overall Crew Performance	32%
Contingency Management	16%
Captain should show leadership	11%
Leadership	11%
Monitor / Cross-check	11%

Source: IATA GADM

Figure 33: LOC-I Top Contributing Factors

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 maintain margins of safety
- Flight Crew Errors: errors in the management of threats
- Undesired Aircraft States: flight-crew induced aircraft state(s) that reduce safety margins. An undesired aircraft state is recoverable.

In some cases there are sub-categories of contributing factors and 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 may equal more than the total for the category.

Latent conditions are typically difficult to derive unless very detailed information is available. The 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 34, were deficiencies in the implementation of Safety Management Systems at the operator, insufficient regulatory oversight, and weak training standards in flight operations.

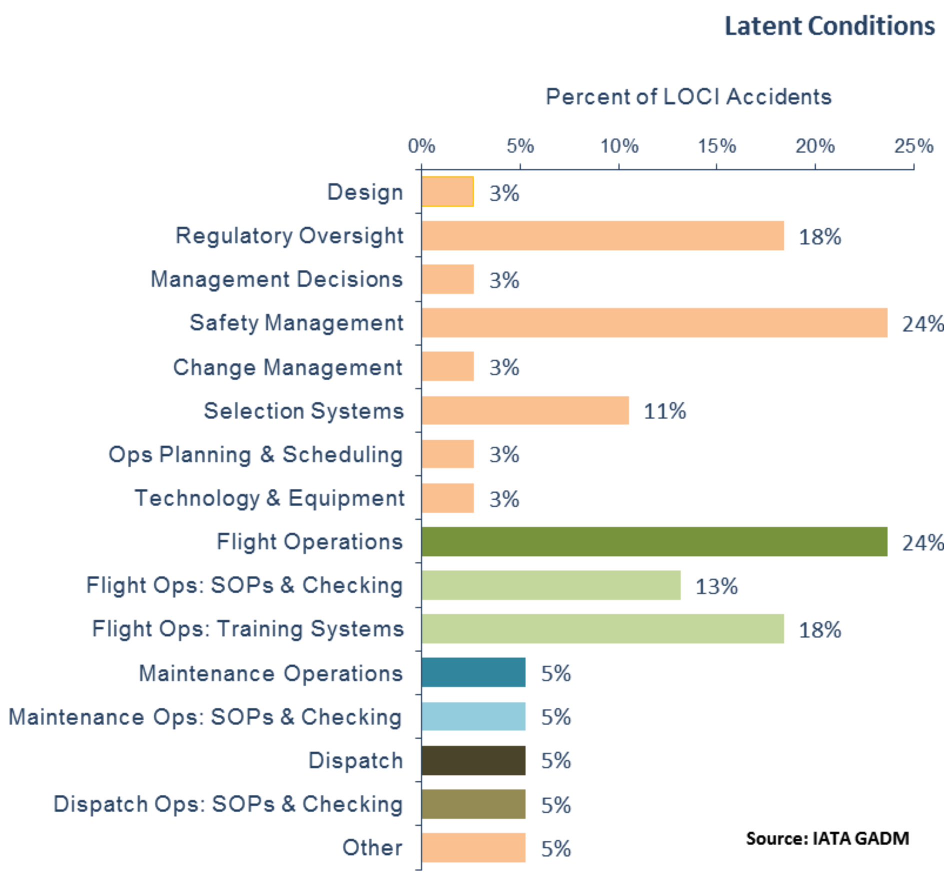

Figure 34: Latent Conditions Contributing to LOC-I Accidents

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

In the Environmental and Airline Threats contributing factors, meteorology and aircraft malfunction were cited as common factors. Evidence showed that aircraft systems failure, which interfered with normal flight management and/or directly with aircraft control, were a primary threat potentially leading to LOC-I accidents. This includes engine failures, loss of correct function or control of a significant element of the flying controls, major electrical failure and loss or malfunction of critical flight instrument displays. Figure 35 indicates the most common environmental and airline-related threats associated with LOC-I accidents.

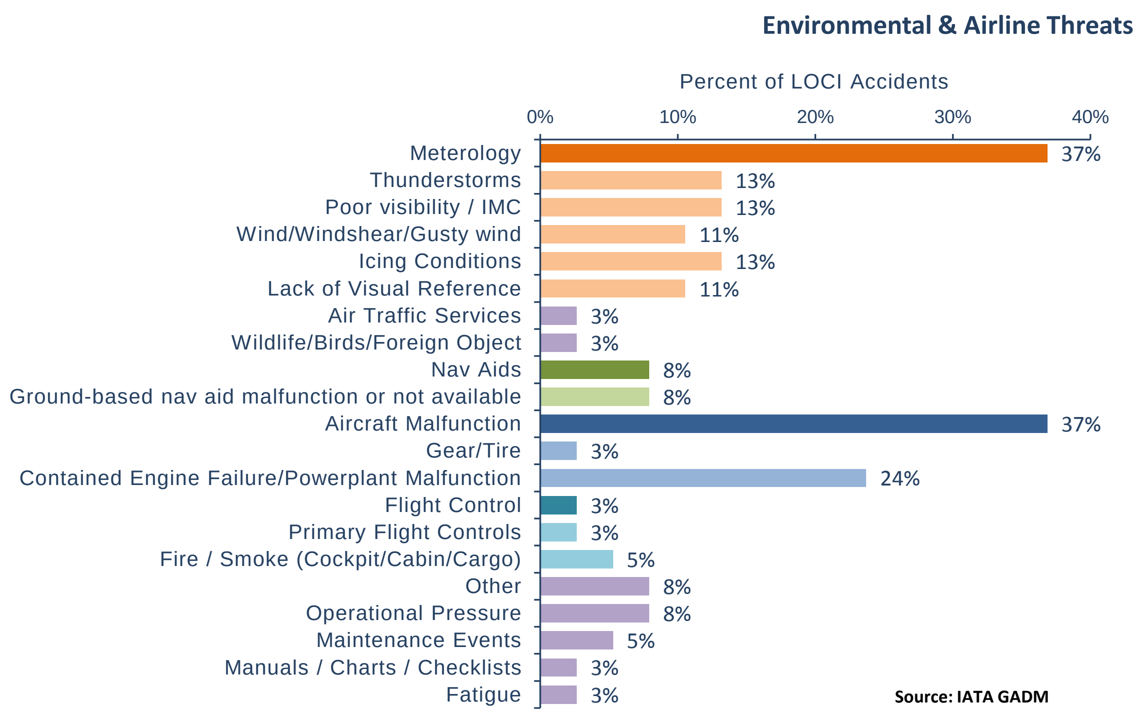

Figure 35: Environmental and Airline Threats Contributing to LOC-I Accidents

If a threat is not managed correctly it can lead to an error, defined as flight crew deviations from organizational expectations or crew intentions. Figure 36 illustrates the contributing factors related to the Flight Crew Errors category.

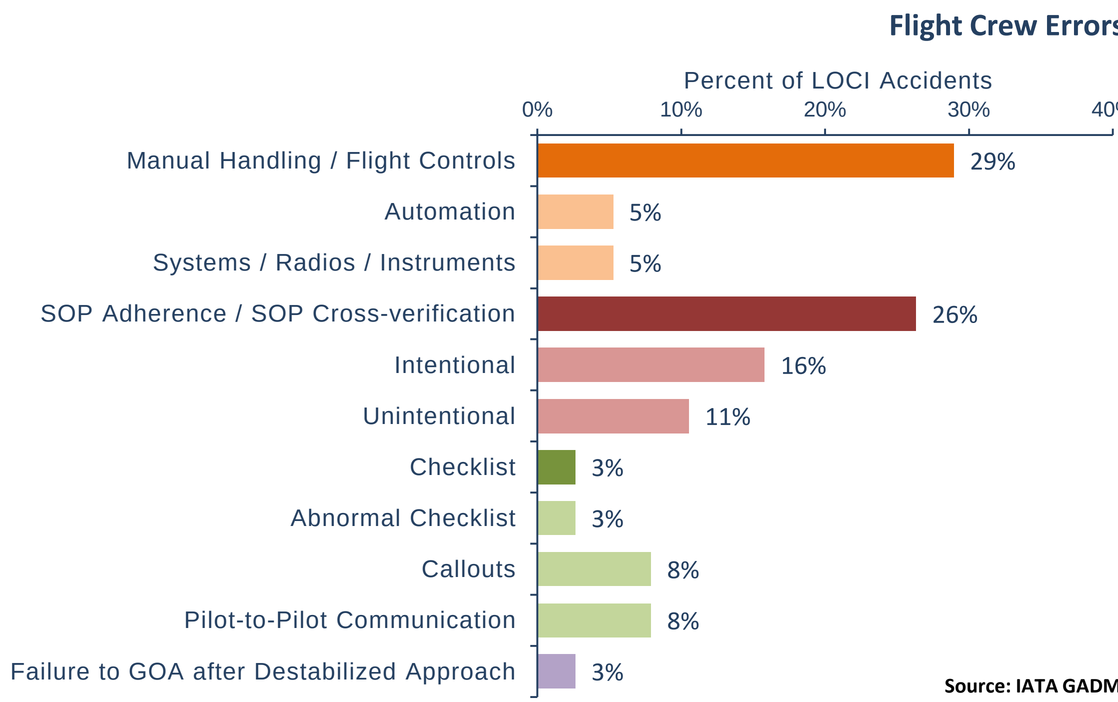

Figure 36: Flight Crew Errors Contributing to LOC-I Accidents

Mis-managed threats or errors can lead to additional errors and/or to undesired aircraft states. These are flight crew-induced states that clearly reduce safety margins but undesired aircraft states are still recoverable. Figure 37 illustrates the undesired aircraft states that are associated with the LOC-I accidents analyzed in this report.

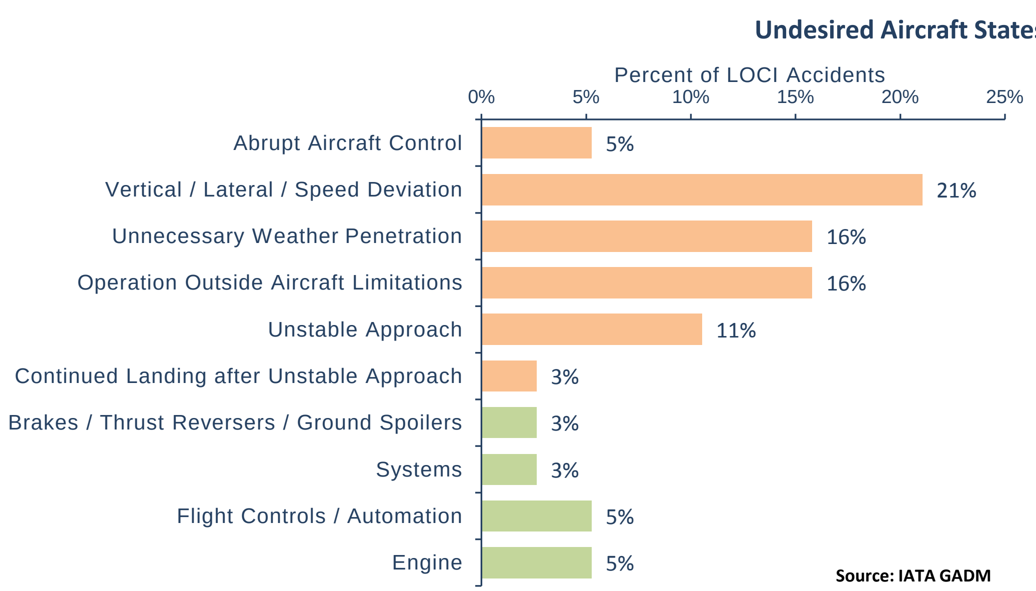

Figure 37: Undesired Aircraft States Contributing to LOC-I Accidents

7.9 Accident Scenarios of Interest

Some likely scenarios leading to Loss of Control In-Flight accidents are:

SCENARIO 1:

The operator has deficiencies with regards to safety management and operates in an area of weak regulatory oversight. The flight crew faces operational pressure from their airline. They commit Standard Operating Procedures (SOP) adherence and cross verification errors leading to the aircraft operating outside its limitations or in an incorrect configuration. The flight crew loses control and the aircraft is destroyed.

SCENARIO 2:

The flight crew intentionally deviates from SOPs or does not properly cross-check while conducting an approach in marginal weather conditions. Subsequently, the approach becomes unstable; the crew commits a decision making error, fails to go-around and loses control of the aircraft while attempting to land.

SCENARIO 3:

There are noted deficiencies in the regulatory oversight of the region. The airlines has an issue with maintenance SOPs. The flight crew encounters an aircraft malfunction during the flight, losing control of their aircraft which crashes subsequently.

SCENARIO 4:

While operating in poor visibility the flight crew commits errors relating to use of automation. The aircraft subsequently deviates from the flight path and crashes.

SCENARIO 5:

The operator has deficiencies with regards to its flight training activities. The flight crew unintentionally deviates from SOPs and does not properly cross-check. They commit manual handling errors and lose control of the aircraft.

Section 8—Conclusion

This Loss of Control In-Flight (LOC-I) analysis used data from 38 LOC-I accidents that resulted in 1,242 fatalities during the five-year period of 2010 – 2014. LOC-I was the most frequent fatal accident category in that period, resulting in the highest number of fatalities and representing the highest risk for fatal aircraft accidents and hull losses.

In LOC-I accidents, as with most accident categories, the investigation usually reveals a multitude of factors leading up to a loss of control. Very often the trigger that initiates a LOC-I accident sequence is an external environmental factor, predominantly meteorological but potentially traffic related in the form of wake turbulence. Human performance deficiencies, including improper, inadequate or absent training, automation and flight mode confusion, distraction the ‘startle’ factor and loss of situational awareness frequently compounded the initial upset and precluded an effective recovery until it was too late.

The analysis found that pilots often missed or ignored readily available indications that could have alerted them to an impending upset or LOC-I event. These included icing conditions, flight control system malfunctions and turbulence. Ultimately, the failure to recognize these precursors to loss of control led to inadvertent or in some cases even deliberate pilot-induced upsets and LOC-I accidents.

Current training methodologies and regulatory requirements have as yet had little success in mitigating this most frequent aviation fatal accident category. A focus on effective upset prevention, recognition and recovery training is required to mitigate the risk of LOC-I accidents and reduce the unacceptably high number of fatalities. Pilot training programs must also ensure that pilots have sufficient aircraft system and environmental knowledge to be able to recognize when they are exposed to enhanced risk of LOC-I and to respond effectively to the threats.

IATA through its Pilot Training Task Force has developed detailed guidance material in support of the implementation of the ICAO provisions by its airline members. The manual for upset prevention and recovery training (UPRT) aims to better train pilots, in order to face unexpected events, potentially leading to a loss of control.

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.

Initial Climb (ICL): This phase begins at 35 ft above the runway elevation; it ends after the speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise.

It may also end by the crew initiating an "Approach" phase.

Note: Maneuvering altitude is based upon such an altitude to safely maneuver the aircraft after an engine failure occurs, or pre-defined as an obstacle clearance altitude. Initial Climb includes such procedures applied to meet the requirements of noise abatement climb, or best angle/rate of climb.

En Route Climb (ECL): This phase begins when the crew establishes the aircraft at a defined speed and configuration enabling the aircraft to increase altitude for the purpose of cruising; it ends with the aircraft established at a predetermined constant initial cruise altitude at a defined speed or by the crew initiating a "Descent" phase.

Cruise (CRZ): The cruise phase begins when the crew establishes the aircraft at a defined speed and predetermined constant initial cruise altitude and proceeds in the direction of a destination; it ends with the beginning of Descent for the purpose of an approach or by the crew initiating an "En Route Climb" phase.

Descent (DST): This phase begins when the crew departs the cruise altitude for the purpose of an approach at a particular destination; it ends when the crew initiates changes in aircraft configuration and/or speeds to facilitate a landing on a particular runway. It may also end by the crew initiating an "En Route Climb" or "Cruise" phase.

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

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.)

Appendix D – Challenges with Applying Taxonomies

For the team members of the task force who apply the taxonomy is not always clear-cut whether the accident falls into the LOC-I category or perhaps in some other category (mainly CFIT).

In some cases it is unclear whether an aircrew first lost control of the aircraft and the flight subsequently ended as CFIT or whether a flight crew encountered a controlled flight towards terrain, realized the situation in last second and subsequently stalled the aircraft in an attempt to avoid terrain.

An answer can be derived once the official accident investigation report is available and the sequence of events is determined (e.g. FDA time pattern).