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Differences in Characteristics of Aviation Accidents during 1993-2012 Based on Aircraft Type

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Introduction

Usually aviation accidents are categorized and analyzed within flight conduct rules (Part 121, Part 135, Part 91) because differences in accident rates between flight rules have been demonstrated. Several different aircraft types operate within each flight conduct category. For many people, Part 121 flights are synonymous with large jet transports, and indeed this is the largest group of aircraft operating within Part 121. But there are also regional jets, turbo-props and even a few piston-engine aircraft experiencing accidents while flying under the rules of Part 121. The primary purpose of the analysis reported here is to examine the differences in aviation accidents based on the type of aircraft. Some of the factors examined are the accident severity, pilot characteristics and accident occurrence categories. Twenty consecutive years of data were available and utilized to complete this analysis.

Data Source

The National Transportation Safety Board is an independent Federal agency that investigates every civil aviation accident in the United States and significant accidents in the other modes of transportation, conducts special investigations and safety studies, and issues safety recommendations to prevent future accidents. The information collected by the NTSB investigators during their investigations of these aviation events resides in the NTSB Aviation Accident and Incident Data System. A copy of this database in Microsoft Access format was obtained from the Aviation Safety Information Analysis and Sharing (ASIAS) department of the FAA Office of Aviation Safety[1] in September 2014. At that point in time, the NTSB investigation was not complete for a substantial number of 2013 accidents, particularly those which occurred toward the end of the year. For this reason, all work on the database was restricted to the period 1986-2012, which resulted in an update of two years beyond the previous working version of the data. The update process requires several months of cross-checking various data elements and attempting to fill in any missing data, followed by the assignment of occurrence categories to each accident.

The NTSB database includes events involving a wide variety of aircraft (airplanes, helicopters, hot air balloons, gliders, ultra-lights, etc.) with operations conducted under various Federal Aviation Regulations (Part 91: General Aviation, Part 121: Commercial Air Carriers, Part 129: Foreign Air Carriers, Part 135: Commuters and On-Demand Air Taxis, Part 137: Agricultural Operations, etc.). In March 1997 a change was made in the Federal Aviation Regulations defining the requirements for Part 121 versus Part 135 operations. As a result, Part 121 regulations were applied to commuter operations with 10 or more passengers[2].

The NTSB considers each event to be either an accident or an incident, under the following definitions:[3]

Accident - an occurrence associated with the operation of an aircraft, which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage

Incident - an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations

Any injury or aircraft damage which occurs when there was no intent for flight (high speed taxi tests, movement of the aircraft around the airfield, maintenance run-ups, etc.) is, by definition, an incident.

All recorded accidents involving commercially built fixed-wing airplanes operating under FAR Part 121, Part 135 or Part 91 were included in this working dataset, regardless of whether the

[1] http://www.asias.faa.gov/portal/page/portal/asias_pages/asias_home/

[2] National Transportation Safety Board. *Annual Review of Aircraft Accident Data US Air Carrier Operations, Calendar Year 1999, NTSB/ARC-02/03, PB2002-109241,* November 13, 2002, page 1.

[3] National Transportation Safety Board, "Government Information Locator Service (GILS): Aviation Accident Synopses"' http://ntsb.gov/Info/gils/gilssyn.htm

investigation is in a preliminary stage or finalized, and whether or not the event occurred within the United States. Amateur built or experimental aircraft were excluded, as were helicopters, ultra light aircraft, gliders and balloons.

Aircraft Type

In order to describe the types of aircraft which were involved in these accidents, the specific aircraft make and model (and in many cases, aircraft series) was determined for each accident. For the vast majority of events, this information could be easily found in the data record. For some events it was necessary to consult the FAA's aircraft registry database, and to assume that the correct aircraft registration number was recorded in the data system.

All aircraft in the data system for the chosen time period (1993-2012) were divided into thirteen groups based on some combination of engine type, aircraft use, aircraft size and aircraft complexity. The aircraft categories are as follows, and a list of the particular aircraft models (sometimes including series information) within each category can be found in Appendix A.

- Wide Body Jet Airliners
- Narrow Body Jet Airliners
- Regional Jets
- Medium Sized Business Jets
- Small Business Jets (maximum takeoff weight <= 12,500 lb)

- Large Turbo-props (maximum takeoff weight >= 32,000 lb and more than 30 seats)
- Medium Turbo-props (12,500<= maximum takeoff weight <32,000 lb or 15-30 seats)
- Small Turbo-props (maximum takeoff weight <12,500 lb and less than 15 seats)

- Heavier multiple reciprocating engines (maximum takeoff weight >=15,000 lb)
- Lighter multiple reciprocating engines (maximum takeoff weight < 15,000 lb)

- Single reciprocating engine, retractable landing gear
- Single reciprocating engine, fixed landing gear

- Light Sport Aircraft (maximum takeoff weight <= 1320 lb)

Other Derived Variables

Accident Occurrence Category

All of the accidents included in this report have been assigned occurrence categories based on the taxonomy developed by the Commercial Aviation Safety Team/International Civil Aviation

Organization (CAST/ICAO) Common Taxonomy Team (CICTT)[4]. A few categories were added to this taxonomy for non-transport accidents, and details of all categories can be found in Appendix B. The assignment of categories was performed by means of a computer program, based on the occurrence codes and causal factor codes in the NTSB database. During the assignment process, many of the more complicated accidents were reviewed by the author, and all of the fatal accidents for Part 121 and scheduled Part 135 were reviewed by other systems analysis staff within the Aviation Research Mission Directorate. Note that a particular accident might have been assigned multiple occurrence categories.

One CICTT specification was not followed; this was regarding loss of control when a system/component failure/malfunction rendered the aircraft uncontrollable. The CICTT taxonomy states that the loss of control should not be considered as a separate category in these cases. However, this analysis retained the loss of control category in all circumstances, regardless of malfunctions, in order to capture all of the loss of control including those that followed system/component failure/malfunction or other circumstances (e.g., incapacitation, weather, etc.) that might have rendered the aircraft uncontrollable.

Accident Severity

In 1997 the NTSB developed a classification system in order to combine injury and aircraft damage into one rating of accident severity. The classification was developed for Part 121 aircraft only, but has been expanded in this report to apply to all aircraft. When multiple aircraft were involved in the accident, the most severe injury and damage was used to classify the accident. The definitions for these classifications are as follows:

Major: the aircraft was destroyed
OR there were multiple fatalities
OR there was one fatality and the aircraft was substantially damaged

Serious: there was one fatality without substantial aircraft damage
OR there was at least one serious injury and the aircraft was substantially damaged

Injury: no fatalities but at least one serious injury
(with less than substantial damage to the aircraft)

Damage: no fatalities or serious injuries, but the aircraft was substantially damaged

[4] CAST/ICAO Common Taxonomy Team, "Aviation Occurrence Categories Definitions and Usage Notes, April 2011 (4.1.5) http://www.intlaviationstandards.org/Documents/CICTTOccurrenceCategoryDefinitions.pdf.

Results and Discussion

Table 1 shows the distribution of aircraft types among flight operation categories. Eighty-two percent of Part 121 accidents were in jet aircraft, and 17% involved turbo-prop aircraft. Turbo-props were involved with thirty-six percent of Scheduled Part 135 accidents, and piston-engine aircraft comprised seventy-five percent of Non-Scheduled Part 135 accidents. More than two-thirds of Part 91 accidents were in single engine aircraft with fixed landing gear. Sixty-four percent of jet aircraft accidents occurred while flying under Part 121 rules. Sixty-three percent of turbo-prop accidents and ninety-six percent of accidents in piston-engine aircraft were operating under Part 91.

Table 1. Summary of Accidents by Flight Operation (1993-2012)

Aircraft Type	Part 121	Scheduled Part 135	Non-Scheduled Part 135	Part 91	Total
Wide Body Jet Airliner	172	0	0	2	174
Narrow Body Jet Airliner	364	0	0	9	373
Regional Jet	99	0	0	9	108
Business Jet	0	0	67	276	343
Large Turbo-Prop	60	0	0	7	67
Medium Turbo-Prop	75	37	83	178	373
Small Turbo-Prop	0	26	124	496	646
Multiple Piston Engine	4	46	342	2314	2706
Single Engine (piston) Retractable Landing Gear	0	3	89	4838	4930
Single Engine (piston) Fixed Landing Gear	0	64	382	17239	17685
Light Sport Aircraft	0	0	0	187	187
Total	774	176	1087	25555	27592

Table 2 summarizes the number of accidents and fatal accidents, and also the number of total injuries out of all persons on board during these accidents, for each of the eleven aircraft types. The percentage of accidents including a fatality was lowest in wide-body, narrow-body and regional jet aircraft (6% in the three types combined). The highest percentages were in small turbo-props (34%) and twin-engine (piston) aircraft (33%). Between ten and twenty-seven percent of accidents in the other six aircraft types were fatal. Overall, 19% of accidents included at least one fatality.

In very general terms, the larger the aircraft, the smaller the percentage of those on board who were injured, although the lowest percentage was in regional jets (3.7%). The highest percentages were in single-engine, retractable gear aircraft (48%), twin-engine aircraft (48%) and small turbo-props (44%). Overall, 20% of all persons on board accident flights were injured.

Table 2. Summary of Accidents and Injuries (1993-2012)

Aircraft Type	Total Accidents	Fatal Accidents	Total Persons on Board	Total Injuries
Wide Body Jet Airliner	174	10 (5.7%)	27221	1485 (5.5%)
Narrow Body Jet Airliner	373	25 (6.7%)	35988	1637 (4.5%)
Regional Jet	108	5 (4.6%)	4649	170 (3.7%)
Business Jet	343	64 (18.7%)	1422	358 (25.2%)
Large Turbo-Prop	67	7 (10.4%)	1776	180 (10.1%)
Medium Turbo-Prop	373	102 (27.3%)	2752	554 (20.1%)
Small Turbo-Prop	646	222 (34.4%)	1871	827 (44.2%)
Multiple Piston Engine	2706	895 (33.1%)	6634	3176 (47.9%)
Single Engine (piston) Retractable Landing Gear	4930	1275 (25.9%)	10013	4810 (48.0%)
Single Engine (piston) Fixed Landing Gear	17685	2533 (14.3%)	31148	11591 (37.2%)
Light Sport Aircraft	187	26 (13.9%)	266	102 (38.3%)
All	27592	5164 (18.7%)	123740	24890 (20.1%)

Table 3. Summary of Injuries and Fatal Injuries (1993-2012)

Aircraft Type	Total Injuries	Injuries per Accident	Fatal Injuries	Fatal Injuries per Accident	Fatal Injuries per Fatal Accident
Wide Body Jet Airliner	1485	8.53	653	3.75	65.30
Narrow Body Jet Airliner	1637	4.39	675	1.81	27.00
Regional Jet	170	1.57	78	0.72	15.60
Business Jet	358	1.04	209	0.61	3.27
Large Turbo-Prop	180	2.69	121	1.81	17.29
Medium Turbo-Prop	554	1.49	377	1.01	3.70
Small Turbo-Prop	827	1.28	570	0.88	2.57
Multiple Piston Engine	3176	1.17	1949	0.72	2.18
Single Engine (piston) Retractable Landing Gear	4810	0.98	2430	0.49	1.91
Single Engine (piston) Fixed Landing Gear	11591	0.66	4285	0.24	1.69
Light Sport Aircraft	102	0.55	34	0.18	1.31
All	24890	0.90	11381	0.41	2.20

Table 3 displays several summary statistics related to injuries and fatal injuries. Piston-engine aircraft flights resulted in the most injuries and fatalities, as well as the most accidents. However, due to the greater number of persons on board larger aircraft, the largest number of injuries per accident, fatal injuries per accident, and fatal injuries per fatal accident were seen on flights in wide-body jet aircraft, followed by narrow-body jets, large turbo-props and regional jets. The lowest number of injuries and fatal injuries per accident were in light sport aircraft and those with a single piston engine, but this is due more to the limited number of persons on board the aircraft than to any safety advantages.

Table 4 shows the four levels of aircraft damage associated with each aircraft type. Overall, eighty percent of accidents result in substantial damage to the aircraft. In general, the larger aircraft were less likely to be substantially damaged. In fact, at least 30% of large turbo-props, regional jets and both wide- and narrow-body jet airliners had no damage at all. Conversely, at least 98% of accidents in small turbo-props or piston engine aircraft (including light sport aircraft) resulted in either aircraft destruction or substantial damage.

Table 4. Summary of Aircraft Damage (1993-2012)

Aircraft Type	No Damage	Minor Damage	Substantial Damage	Aircraft Destruction
Wide Body Jet Airliner	68 (39.1%)	24 (13.8%)	68 (39.1%)	14 (8.0%)
Narrow Body Jet Airliner	159 (42.6%)	31 (8.3%)	163 (43.7%)	20 (5.4%)
Regional Jet	33 (30.6%)	5 (4.6%)	67 (62.0%)	3 (2.8%)
Business Jet	9 (2.6%)	5 (1.5%)	255 (74.3%)	74 (21.6%)
Large Turbo-Prop	20 (29.9%)	4 (6.0%)	38 (56.7%)	5 (7.5%)
Medium Turbo-Prop	23 (6.2%)	9 (2.4%)	253 (67.8%)	88 (23.6%)
Small Turbo-Prop	4 (0.6%)	6 (0.9%)	426 (65.9%)	210 (32.5%)
Multiple Piston Engine	8 (0.3%)	17 (0.6%)	1810 (66.9%)	871 (32.2%)
Single Engine (piston) Retractable Landing Gear	11 (0.2%)	22 (0.4%)	3725 (75.6%)	1172 (23.8%)
Single Engine (piston) Fixed Landing Gear	56 (0.3%)	96 (0.5%)	15099 (85.4%)	2434 (13.8%)
Light Sport Aircraft	0 (0.0%)	0 (0.0%)	182 (97.3%)	5 (2.7%)
All	391 (1.4%)	219 (0.8%)	22086 (80.0%)	4896 (17.7%)

Table 5 shows the four levels of aircraft severity (according to the NTSB severity classification system) associated with each aircraft type. Nearly 70% of all accidents in this time period were considered “damage” accidents, the lowest severity classification; only 23% were major accidents. “Damage” accidents were the largest category for every aircraft type except wide-body and narrow-body jet airliners, where there were slightly more “injury” accidents than “damage” accidents. More than 30% of regional jet and large turbo-prop accidents were “injury”

accidents; for all other aircraft types, five percent or less of the accidents were “injury” and at least 15% were “major” accidents.

Table 5. Summary of Accident Severity (1993-2012)

Aircraft Type	Damage	Injury	Serious	Major
Wide Body Jet Airliner	73 (42.0%)	81 (46.6%)	6 (3.5%)	14 (8.1%)
Narrow Body Jet Airliner	160 (42.9%)	173 (46.4%)	17 (4.6%)	23 (6.2%)
Regional Jet	63 (58.3%)	35 (32.4%)	6 (5.6%)	4 (3.7%)
Business Jet	240 (70.0%)	10 (2.9%)	15 (4.4%)	78 (22.7%)
Large Turbo-Prop	36 (53.7%)	21 (31.3%)	5 (7.5%)	5 (7.5%)
Medium Turbo-Prop	222 (59.5%)	19 (5.1%)	23 (6.2%)	109 (29.2%)
Small Turbo-Prop	361 (55.9%)	5 (0.8%)	28 (4.3%)	252 (39.0%)
Multiple Piston Engine	1455 (53.8%)	9 (0.3%)	170 (6.3%)	1072 (39.6%)
Single Engine (piston) Retractable Landing Gear	3013 (61.1%)	7 (0.1%)	399 (8.1%)	1511 (30.7%)
Single Engine (piston) Fixed Landing Gear	13103 (74.1%)	54 (0.3%)	1218 (6.9%)	3310 (18.7%)
Light Sport Aircraft	141 (75.4%)	0 (0.0%)	17 (9.1%)	29 (15.5%)
All	18867 (68.4%)	414 (1.5%)	1904 (6.9%)	6407 (23.2%)

Table 6. Summary of Pilot Age (1993-2012)

Aircraft Type	Mean	Median	Range	Number Missing
Wide Body Jet Airliner	52.9	54	39-64	47 (27.0%)
Narrow Body Jet Airliner	48.8	49	31-62	31 (8.3%)
Regional Jet	41.3	42	23-62	13 (12.0%)
Business Jet	49.0	50	24-80	38 (11.1%)
Large Turbo-Prop	39.7	38.5	25-61	7 (10.4%)
Medium Turbo-Prop	42.1	41	20-74	16 (4.3%)
Small Turbo-Prop	48.3	49	18-82	27 (4.2%)
Multiple Piston Engine	47.6	48	19-89	119 (4.4%)
Single Engine (piston) Retractable Landing Gear	51.2	51	17-91	87 (1.8%)
Single Engine (piston) Fixed Landing Gear	46.7	47	14-94	269 (1.5%)
Light Sport Aircraft	57.9	60	18-89	0 (0.0%)
All	47.7	48	14-94	654 (2.4%)

Table 6 presents various summary statistics related to the age of the primary pilot. In general, the pilots in large and medium turbo-props and regional jets were somewhat younger than other pilots, while those in light sport aircraft, wide-body jet airliners and single-engine retractable gear aircraft were somewhat older. It might be disturbing that for 27% of wide-body jet airliner accidents the investigation did not record the age of the primary pilot. These 47 accidents were reviewed: 46 of the accidents were international flights, for which less information generally is recorded, and one accident investigation is in the preliminary stage, so not all information was available.

Table 7 shows the distribution of certification for the primary pilot. In general, the smaller the aircraft, the less likely it is that the pilot has an air transport license, so the results in this table are not surprising.

Table 7. Summary of Pilot Certification (1993-2012)

Aircraft Type	Air Transport	CFI or Commercial	Private	Student or Recreation	Other or Unknown
Wide Body Jet Airliner	138 (79.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	36 (20.7%)
Narrow Body Jet Airliner	353 (94.6%)	1 (0.3%)	0 (0.0%)	0 (0.0%)	19 (5.1%)
Regional Jet	98 (90.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (9.3%)
Business Jet	277 (80.8%)	33 (9.6%)	15 (4.4%)	0 (0.0%)	18 (5.3%)
Large Turbo-Prop	62 (92.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (7.5%)
Medium Turbo-Prop	282 (75.6%)	70 (18.8%)	10 (2.7%)	0 (0.0%)	11 (3.0%)
Small Turbo-Prop	278 (43.0%)	229 (35.5%)	127 (19.7%)	1 (0.2%)	11 (1.7%)
Multiple Piston Engine	784 (29.0%)	1141 (42.2%)	726 (26.8%)	7 (0.3%)	48 (1.8%)
Single Engine (piston) Retractable Landing Gear	466 (9.5%)	1394 (28.3%)	2980 (60.5%)	51 (1.0%)	39 (0.8%)
Single Engine (piston) Fixed Landing Gear	1595 (9.0%)	4967 (28.1%)	8741 (49.4%)	2209 (12.5%)	173 (1.0%)
Light Sport Aircraft	9 (4.8%)	50 (26.7%)	67 (35.8%)	57 (30.5%)	4 (2.1%)
All	4342 (16%)	7885 (29%)	12666 (46%)	2325 (8.4%)	374 (1.3%)

Tables 8, 9 and 10 show the number of accidents assigned to each CICTT occurrence category within each aircraft type. All of the percentages are based on the total number of accidents in each type. The reader is reminded that a particular accident might be assigned multiple occurrence categories. The additional categories that are not part of the official CICTT taxonomy are denoted with an asterisk (*). These data are presented but not discussed below. (Note: In the three reciprocating engine aircraft types with a high percentage of accidents that include fuel-related loss of engine power, many of the accident sequences also include collision with an object or terrain during the precautionary landing.)

Roughly one-third of wide-body jet airliner accidents were turbulence encounters. Three other categories represent at least ten percent of the accidents: abnormal runway contact (13%), ground handling (11%) and non-powerplant system/component failures (10%). Collectively, these four categories accounted for 64% of accidents in this type.

More than half of narrow-body jet airliner accidents were either turbulence encounters (32%) or ground handling (26%). The next most frequent occurrence category was non-powerplant system/component failure (8%).

Thirty percent of regional jet accidents were ground handling accidents, and nineteen percent were turbulence encounters. Three other categories represent more than five percent of the accidents: ground collision (12%), non-powerplant system/component failures (10%) and runway excursion (9%). Collectively, these five categories accounted for 79% of accidents in this type.

Thirty-eight percent of business jet accidents were runway excursions. Four other categories represent at least thirteen percent of the accidents: non-powerplant system/component failures (19%), post-impact fire (18%), abnormal runway contact (14%) and loss of control – in flight (13%). Collectively, these five categories accounted for 72% of accidents in this type.

Twenty-five percent of large turbo-prop accidents were turbulence encounters, and twenty-one percent were ground handling accidents. Two other categories represent more than ten percent of the accidents: abnormal runway contact (11%) and non-powerplant system/component failures (11%). Collectively, these four categories accounted for 66% of accidents in this type.

The occurrence categories for medium and small turbo-prop accidents are very similar, except for ground handling events (medium:15%; small:5%). Otherwise, the top five categories are loss of control – in flight (medium:16%; small:28%), runway excursion (medium:19%; small:15%), post-impact fire (medium:15%; small:20%), abnormal runway contact (medium:13%; small:14%) and non-powerplant system/component failures (11% for both). Collectively, these five (STP) and six (MTP) categories accounted for 65% (STP) and 67% (MTP) of accidents.

Six occurrence categories each accounted for at least ten percent of accidents among flights in aircraft with twin (piston) engines: loss of control – in flight (27%), post-impact fire (21%), runway excursion (16%), abnormal runway contact (16%), non-powerplant system/component failure (14%), and fuel related loss of engine power (13%). Collectively, these six categories accounted for 70% of accidents in this type.

Table 8. Accidents by CICTT Occurrence Category (1993-2012)

CICTT Occurrence Category	Wide-Body Jet Airliner	Narrow-Body Jet Airliner	Regional Jets	Business Jets
Total Events	174	373	108	343
Abrupt Maneuver	8 (4.6%)	9 (2.4%)	3 (2.8%)	5 (1.5%)
Abnormal Runway Contact	22 (12.6%)	30 (8.0%)	5 (4.6%)	48 (14.0%)
Aerodrome	2 (1.2%)	4 (1.1%)	2 (1.9%)	17 (5.0%)
Air Traffic Management	3 (1.7%)	10 (2.7%)	4 (3.7%)	6 (1.8%)
Bird Strikes	1 (0.6%)	6 (1.6%)	6 (5.6%)	10 (2.9%)
Cabin Safety or Pilot Incapacitation	3 (1.7%)	10 (2.7%)	3 (2.8%)	5 (1.5%)
Controlled Flight Into Terrain	0 (0.0%)	3 (0.8%)	0 (0.0%)	13 (3.8%)
Collision with Object – Takeoff or Landing	1 (0.6%)	2 (0.5%)	1 (0.9%)	4 (1.2%)
Collision with Object – Prec Landing *	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (0.6%)
Collision with Terrain – Prec Landing *	1 (0.6%)	0 (0.0%)	1 (0.9%)	3 (0.9%)
Encounter with Terrain – Prec Landing *	0 (0.0%)	1 (0.3%)	0 (0.0%)	0 (0.0%)
Evacuation	14 (8.1%)	26 (7.0%)	5 (4.6%)	0 (0.0%)
Fire – Non-Impact	12 (6.9%)	11 (3.0%)	2 (1.9%)	7 (2.0%)
Fire – Post Impact	5 (2.9%)	13 (3.5%)	2 (1.9%)	60 (17.5%)
Ground Collision	13 (7.5%)	30 (8.0%)	13 (12.0%)	13 (3.8%)
Ground Handling or Inadequate Pre-Flight	19 (10.9%)	97 (26.0%)	33 (30.6%)	21 (6.1%)
Icing	0 (0.0%)	2 (0.5%)	1 (0.9%)	9 (2.6%)
Low Altitude Operations	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (1.8%)
Loss of Control – In Flight	6 (3.4%)	12 (3.2%)	2 (1.9%)	45 (13.1%)
Loss of Control – On Ground	0 (0.0%)	2 (0.5%)	1 (0.9%)	7 (2.0%)
Mid Air Collision	0 (0.0%)	3 (0.8%)	1 (0.9%)	4 (1.2%)
Power Loss – Fuel	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (1.2%)
Power Loss – Other Reasons *	0 (0.0%)	2 (0.5%)	1 (0.9%)	3 (0.9%)
Power Loss – Unknown Reason *	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.3%)
Runway Excursion	13 (7.5%)	18 (4.8%)	10 (9.3%)	130 (37.9%)
Runway Incursion (Vehicle, Aircraft or Person)	0 (0.0%)	1 (0.3%)	0 (0.0%)	2 (0.6%)
SCF – Powerplant	10 (5.8%)	8 (2.1%)	1 (0.9%)	7 (2.0%)
SCF – Non Powerplant	18 (10.3%)	31 (8.3%)	11 (10.2%)	66 (19.2%)
SCF – Stress Limits Exceeded *	3 (1.7%)	1 (0.3%)	0 (0.0%)	1 (0.3%)
Security Related	3 (1.7%)	2 (0.5%)	0 (0.0%)	0 (0.0%)
Turbulence Encounter	59 (33.9%)	120 (32.2%)	21 (19.4%)	10 (2.9%)
Thunderstorm or Windshear	2 (1.2%)	6 (1.6%)	1 (0.9%)	8 (2.3%)
Undershoot or Overshoot	1 (0.6%)	2 (0.5%)	0 (0.0%)	13 (3.8%)
Unintended Flight in IMC	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.3%)
Wildlife	0 (0.0%)	0 (0.0%)	0 (0.0%)	9 (2.6%)
Other	2 (1.2%)	5 (1.3%)	1 (0.9%)	7 (2.0%)
Unknown or Undetermined	4 (2.3%)	3 (0.8%)	0 (0.0%)	12 (3.5%)

* Denotes occurrence categories not in the official CAST/ICAO taxonomy

Table 9. Accidents by CICTT Occurrence Category (1993-2012)

CICTT Occurrence Category	Large Turbo-Prop	Medium Turbo-Prop	Small Turbo-Prop
Total Events	67	373	646
Abrupt Maneuver	1 (1.5%)	1 (0.3%)	0 (0.0%)
Abnormal Runway Contact	7 (10.5%)	48 (12.9%)	92 (14.2%)
Aerodrome	1 (1.5%)	16 (4.3%)	10 (1.6%)
Air Traffic Management	0 (0.0%)	3 (0.8%)	16 (2.5%)
Bird Strikes	5 (7.5%)	7 (1.9%)	4 (0.6%)
Cabin Safety or Pilot Incapacitation	0 (0.0%)	4 (1.1%)	13 (2.0%)
Controlled Flight Into Terrain	0 (0.0%)	33 (8.9%)	53 (8.2%)
Collision with Object – Takeoff or Landing	1 (1.5%)	8 (2.1%)	8 (1.2%)
Collision with Object – Prec Landing *	0 (0.0%)	7 (1.9%)	37 (5.7%)
Collision with Terrain – Prec Landing *	3 (4.5%)	7 (1.9%)	25 (3.9%)
Encounter with Terrain – Prec Landing *	0 (0.0%)	2 (0.5%)	14 (2.2%)
Evacuation	1 (1.5%)	1 (0.3%)	1 (0.2%)
Fire – Non-Impact	3 (4.5%)	7 (1.9%)	4 (0.6%)
Fire – Post Impact	4 (6.0%)	57 (15.3%)	130 (20.1%)
Ground Collision	3 (4.5%)	20 (5.4%)	21 (3.3%)
Ground Handling or Inadequate Pre-Flight	14 (20.9%)	55 (14.8%)	34 (5.3%)
Icing	3 (4.5%)	12 (3.2%)	47 (7.3%)
Low Altitude Operations	0 (0.0%)	13 (3.5%)	26 (4.0%)
Loss of Control – In Flight	3 (4.5%)	58 (15.6%)	181 (28.0%)
Loss of Control – On Ground	1 (1.5%)	6 (1.6%)	33 (5.1%)
Mid Air Collision	0 (0.0%)	7 (1.9%)	10 (1.6%)
Power Loss – Fuel	2 (3.0%)	15 (4.0%)	35 (5.4%)
Power Loss – Other Reasons *	0 (0.0%)	7 (1.9%)	4 (0.6%)
Power Loss – Unknown Reason *	0 (0.0%)	6 (1.6%)	29 (4.5%)
Runway Excursion	4 (6.0%)	69 (18.5%)	97 (15.0%)
Runway Incursion (Vehicle, Aircraft or Person)	0 (0.0%)	1 (0.3%)	8 (1.2%)
SCF – Powerplant	2 (3.0%)	16 (4.3%)	41 (6.4%)
SCF – Non Powerplant	7 (10.5%)	41 (11.0%)	71 (11.0%)
SCF – Stress Limits Exceeded *	0 (0.0%)	1 (0.3%)	20 (3.1%)
Security Related	0 (0.0%)	3 (0.8%)	1 (0.2%)
Turbulence Encounter	17 (25.4%)	8 (2.1%)	20 (3.1%)
Thunderstorm or Windshear	1 (1.5%)	9 (2.4%)	15 (2.3%)
Undershoot or Overshoot	0 (0.0%)	10 (2.7%)	17 (2.6%)
Unintended Flight in IMC	0 (0.0%)	8 (2.1%)	15 (2.3%)
Wildlife	0 (0.0%)	6 (1.6%)	4 (0.6%)
Other	1 (1.5%)	4 (1.1%)	14 (2.2%)
Unknown or Undetermined	0 (0.0%)	7 (1.9%)	9 (1.4%)

* Denotes occurrence categories not in the official CAST/ICAO taxonomy.

Table 10. Accidents by CICTT Occurrence Category (1993-2012)

CICTT Occurrence Category	Multiple Piston Engines	Single Engine, Retractable Gear	Single Engine, Fixed Gear	Light Sport Aircraft
Total Events	2706	4930	17685	187
Abrupt Maneuver	12 (0.4%)	27 (0.6%)	95 (0.5%)	0 (0.0%)
Abnormal Runway Contact	425 (15.7%)	666 (13.5%)	2129 (12.0%)	54 (28.9%)
Aerodrome	46 (1.7%)	48 (1.0%)	224 (1.3%)	1 (0.5%)
Air Traffic Management	26 (1.0%)	32 (0.7%)	75 (0.4%)	0 (0.0%)
Bird Strikes	17 (0.6%)	10 (0.2%)	50 (0.3%)	0 (0.0%)
Cabin Safety or Pilot Incapacitation	53 (2.0%)	77 (1.6%)	231 (1.3%)	0 (0.0%)
Controlled Flight Into Terrain	184 (6.8%)	238 (4.8%)	460 (2.6%)	0 (0.0%)
Collision with Object – Takeoff or Landing	43 (1.6%)	151 (3.1%)	738 (4.2%)	4 (2.1%)
Collision with Object – Prec Landing *	170 (6.3%)	679 (13.8%)	1642 (9.3%)	7 (3.7%)
Collision with Terrain – Prec Landing *	158 (5.8%)	289 (5.9%)	573 (3.2%)	2 (1.1%)
Encounter with Terrain – Prec Landing*	140 (5.2%)	498 (10.1%)	1034 (5.9%)	6 (3.2%)
Evacuation	2 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Fire – Non-Impact	92 (3.4%)	76 (1.5%)	122 (0.7%)	0 (0.0%)
Fire – Post Impact	561 (20.7%)	612 (12.4%)	1014 (5.7%)	5 (2.7%)
Ground Collision	49 (1.8%)	76 (1.5%)	382 (2.2%)	2 (1.1%)
Ground Handling or Inadequate Pre-Flight	99 (3.7%)	127 (2.6%)	415 (2.4%)	13 (7.0%)
Icing	106 (3.9%)	92 (1.9%)	126 (0.7%)	1 (0.5%)
Low Altitude Operations	80 (3.0%)	184 (3.7%)	1183 (6.7%)	11 (5.9%)
Loss of Control – In Flight	735 (27.2%)	1007 (20.4%)	3207 (18.1%)	64 (34.2%)
Loss of Control – On Ground	76 (2.8%)	244 (5.0%)	3836 (21.7%)	29 (15.5%)
Mid Air Collision	26 (1.0%)	54 (1.1%)	232 (1.3%)	0 (0.0%)
Power Loss – Fuel	357 (13.2%)	736 (14.9%)	2174 (12.3%)	11 (5.9%)
Power Loss – Other Reasons *	35 (1.3%)	44 (0.9%)	143 (0.8%)	0 (0.0%)
Power Loss – Unknown Reason *	197 (7.3%)	377 (7.7%)	951 (5.4%)	9 (4.8%)
Runway Excursion	445 (16.4%)	767 (15.6%)	3768 (21.3%)	51 (27.3%)
Runway Incursion (Vehicle, Aircraft or Person)	5 (0.2%)	13 (0.3%)	95 (0.5%)	0 (0.0%)
SCF – Powerplant	156 (5.8%)	558 (11.3%)	939 (5.3%)	4 (2.1%)
SCF – Non Powerplant	366 (13.5%)	529 (10.7%)	821 (4.6%)	15 (8.0%)
SCF – Stress Limits Exceeded *	44 (1.6%)	119 (2.4%)	55 (0.3%)	0 (0.0%)
Security Related	10 (0.4%)	12 (0.2%)	52 (0.3%)	0 (0.0%)
Turbulence Encounter	29 (1.1%)	60 (1.2%)	100 (0.6%)	1 (0.5%)
Thunderstorm or Windshear	53 (2.0%)	95 (1.9%)	135 (0.8%)	0 (0.0%)
Undershoot or Overshoot	59 (2.2%)	119 (2.4%)	353 (2.0%)	4 (2.1%)
Unintended Flight in IMC	75 (2.8%)	181 (3.7%)	486 (2.8%)	2 (1.1%)
Wildlife	11 (0.4%)	36 (0.7%)	91 (0.5%)	0 (0.0%)
Other	9 (0.3%)	17 (0.3%)	170 (1.0%)	2 (1.1%)
Unknown or Undetermined	53 (2.0%)	49 (1.0%)	139 (0.8%)	0 (0.0%)

* Denotes occurrence categories not in the official CAST/ICAO taxonomy

Those same categories are among the seven most frequently seen in single-engine retractable landing gear accidents: loss of control – in flight (20%), runway excursion (16%), fuel related loss of engine power (15%), abnormal runway contact (14%), post-impact fire (12%), powerplant system/component failure (11%), and non-powerplant system/component failure (11%). Collectively, these seven categories account for 66% of single-engine retractable landing gear accidents.

Five accident categories each represent at least ten percent of single-engine, fixed gear accidents: loss of control – on ground (22%), runway excursion (21%), loss of control – in flight (18%), fuel related loss of engine power (12%) and abnormal runway contact (12%). Collectively, these five categories account for 63% of single-engine fixed landing gear accidents.

Four categories represent 83% of accidents in light sport aircraft: loss of control – in flight (34%), abnormal runway contact (29%), runway excursion (27%), and loss of control – on ground (16%).

Eleven accident categories were among the most frequently observed in at least one of the aircraft types. Figure 1 shows the percentage of each aircraft type that was assigned to each of these eleven accident categories. The bubbles are proportional to the percentage, and a ring circles each category that was among the most frequent for that particular aircraft type.

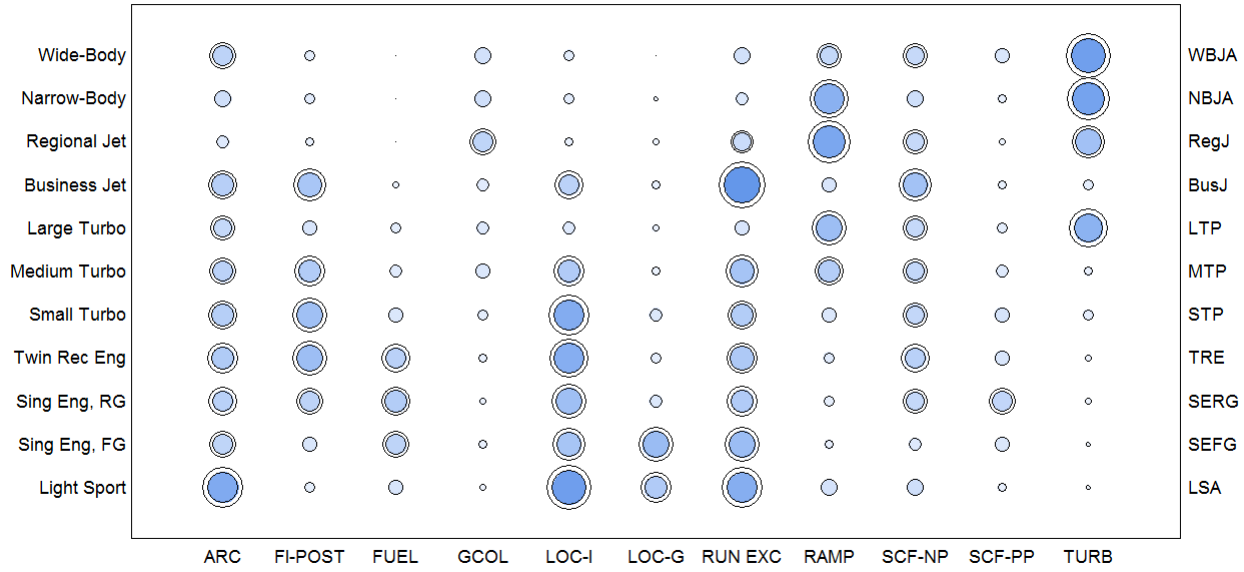

Figure 1. Most Frequent Accident Categories in any Aircraft Type.

In order to summarize the risk associated with each aircraft type, seven measures of adverse outcome were selected, and scores were assigned to ranges of those outcomes. The score definitions (with abbreviations used in Table 12) are in Table 11, and the actual scores, as well as an average score, are presented in Table 12.

Table 11. Adverse Outcome Scoring

Adverse Outcome	1	2	3	4	5
Total Number of Accidents (TA)	<1000	1000-2000	2000-4000	4000-6000	>6000
Percentage of Accidents with a Fatality (FAP)	<10%	10-20%	20-30%	30-40%	>40%
Total Number of Injuries (TI)	<500	500-1000	1000-2000	2000-3000	>3000
Percentage Injured out of All Persons On Board (TIP)	<10%	10-20%	20-30%	30-40%	>40%
Injuries per Accident (I/A)	<0.5	0.5-1	1-1.5	1.5-2	>2
Percentage of Aircraft Destruction (PD)	<5%	5-10%	10-20%	20-30%	>30%
Percentage of Major Accidents (MA)	<10%	10-20%	20-25%	25-30%	>30%

Table 12. Summary of Adverse Outcomes (1993-2012)

Aircraft Type	TA	FAP	TI	TIP	I/A	PD	MA	Avg
Wide Body Jet Airliner	1	1	3	1	5	2	1	2
Narrow Body Jet Airliner	1	1	3	1	5	2	1	2
Regional Jet	1	1	1	1	4	1	1	1.43
Business Jet	1	2	1	3	3	4	3	2.43
Large Turbo-Prop	1	2	1	2	5	2	1	2
Medium Turbo-Prop	1	3	2	3	3	4	4	2.86
Small Turbo-Prop	1	4	2	5	3	5	5	3.57
Multiple Piston Engine	3	4	5	5	3	5	5	4.29
Single Engine (piston) Retractable Landing Gear	4	3	5	5	2	4	5	4
Single Engine (piston) Fixed Landing Gear	5	2	5	4	2	3	2	3.29
Light Sport Aircraft	1	2	1	4	2	1	2	1.86

Table 13 shows the average adverse outcome score along with the percentage of pilots with an air transport license and the percentage of accidents assigned to the seven accident categories

with fairly large percentages in at least four aircraft types (excluding post-impact fire). There appears to be a weak relationship between pilot license and adverse outcome, and a stronger relationship with two of the accidents categories. Except for the light sport aircraft accidents, higher rates of turbulence and lower rates of loss of control – in flight tend to be associated with less severe outcomes.

Table 13. Relation of Adverse Outcome Score to Pilot Air Transport Certification and Top Accident Categories (1993-2012)

Aircraft Type	Avg	ATP	ARC	LOC-I	RE	RAMP	SCF-NP	TURB
Wide Body Jet Airliner	2	79	13	3	8	11	10	34
Narrow Body Jet Airliner	2	94	8	3	5	26	8	32
Regional Jet	1.43	91	5	2	9	31	10	19
Business Jet	2.43	81	14	13	38	6	19	3
Large Turbo-Prop	2	93	11	5	6	21	11	25
Medium Turbo-Prop	2.86	76	13	16	19	15	11	2
Small Turbo-Prop	3.57	43	14	28	15	5	11	3
Multiple Piston Engine	4.29	29	16	27	16	4	14	1
Single Engine (piston) Retractable Landing Gear	4	10	14	20	16	3	11	1
Single Engine (piston) Fixed Landing Gear	3.29	9	12	18	21	2	5	1
Light Sport Aircraft	1.86	5	29	34	27	7	8	1

Summary

Wide-Body Jet Airliner

In 20 years, less than 200 accidents were associated with wide-body jet airliners (US carriers only), with only ten fatal accidents. Less than six percent of wide-body jet airliner accidents were fatal, and 5.5% of all persons on board the aircraft suffered an injury. However, due to the greater number of persons on board these large aircraft, these accidents had by far the largest number of injuries per accident (8.5), fatal injuries per accident (3.8), and fatal injuries per fatal accident (65.3). Only eight percent of the aircraft flown in these accidents were destroyed, and there was no damage to 39% of the aircraft. Forty-two percent of the accidents were considered "damage" accidents, which is the least severe category in the NTSB classification. Another 47% were considered "injury" accidents, and eight percent were major accidents. All of this led to one of the five lowest average scores of the seven adverse outcomes.

At least seventy-nine percent of the primary pilots in these accidents held an air transport license (pilot certification was unknown for 21 percent of the accidents). These pilots are older than in all but one aircraft type (53 years on average). Roughly two-thirds of wide-body jet airliner accidents were either encounters with turbulence, abnormal runway contact, ground handling events, or non-powerplant system/component failures.

Narrow-Body Jet Airliner

Narrow-body jet airliners were the largest subgroup of jet accidents. Less than seven percent of narrow-body jet airliner accidents were fatal, and 4.5% of all persons on board the aircraft suffered an injury. However, due to the greater number of persons on board these large aircraft, these accidents had the second largest number of injuries per accident (4.4), fatal injuries per accident (1.8), and fatal injuries per fatal accident (27.0). Only five percent of the aircraft flown in these accidents were destroyed, and there was no damage to 43% of the aircraft. Forty-three percent of the accidents were considered “damage” accidents, which is the least severe category in the NTSB classification. Another 46% were considered “injury” accidents, and six percent were major accidents. All of this led to one of the five lowest average scores of the seven adverse outcomes, tied with wide-body jets and large turbo-props.

At least ninety-five percent of the primary pilots in these accidents held an air transport license (pilot certification was unknown for 5 percent of the accidents), and their ages were slightly above average (49 years). More than half of narrow-body jet airliner accidents were either encounters with turbulence or ground handling events.

Regional Jets

Only three regional jet accidents occurred between 1992 and 1997, with 105 accidents in the next fifteen years (average of 7 per year). Less than five percent of these accidents were fatal, and less than four percent of persons on board the aircraft were injured. The aircraft was destroyed in less than three percent of accidents, and less than four percent of the accidents were classified as major accidents. As a result, this aircraft type had the lowest average adverse outcomes score. At least 91% of the primary pilots held an air transport license, and these pilots were younger than all but one aircraft type. Five occurrence categories accounted for 79% of the accidents; in addition to turbulence encounters and ground handling events, which comprised nearly half of the accidents, nine to twelve percent of regional jet accidents were ground collisions, non-powerplant system/component failures or runway excursions.

Business Jets

Nineteen percent of business jet accidents were fatal and one quarter of the persons on board were injured in the accident. The aircraft was destroyed in 22% of the accidents, and 23% of accidents were major. The average score of seven adverse outcomes was 2.4, which was the median score among the eleven types. The pilots’ average age was barely higher than the overall

average (49 years), and 90% held either an air transport or commercial license. Five occurrence categories accounted for 72% of the accidents; the most frequent category was runway excursions (38%).

Large Turbo-Props

The fewest accidents among all aircraft types were in large turbo-props (67). Ten percent of the accidents were fatal and ten percent of those on board were injured. Eight percent of the aircraft were destroyed and were considered major accidents. The average adverse outcome score was the same as for wide-body and narrow-body jet airliners. At least 92% of the pilots held an air transport license, and these pilots tended to be the youngest of any aircraft type. The top four accident categories accounted for 66% of large turbo-prop accidents; these are the same categories that were the most frequent in wide-body jet airliners. In general, large turbo-prop outcomes and accident categories were more similar to jet airliners that to medium and small turbo-props.

Medium Turbo-prop

Twenty-seven percent of accidents in medium-sized turbo-prop aircraft were fatal, and twenty percent of all persons on board the aircraft were injured. Nearly one quarter of the aircraft were destroyed and almost 30% of the accidents were considered major. The pilots were older than those flying large turbo-props, but younger than the overall average. Ninety-four percent of the pilots held either an air transport or a commercial license. Six accident categories accounted for 67% of the accidents: runway excursion, loss of control – in flight, ground handling, post-impact fire, abnormal runway contact and non-powerplant system/component failures.

Small Turbo-Prop

Small turbo-prop accidents were the fourth largest group of accidents, but have the highest percentage of fatal accidents (34%) and the third highest percentage of injuries (44%). More of the aircraft were destroyed (33%) than in any other aircraft type and almost 40% of the accidents were classified as major. As a result, this aircraft type had the third highest average adverse outcome score. Twenty percent of the pilots held only a private license. Five accident categories accounted for 65% of the accidents: loss of control – in flight, post-impact fire, runway excursion, abnormal runway contact and non-powerplant system/component failures.

Twin Piston Engines

The third largest group of accidents was in aircraft with two piston engines; 33% of the accidents were fatal and 48% of those on board were injured. Thirty-two percent of the aircraft were destroyed and forty percent of the accidents were considered major, giving this type of aircraft the highest average score of seven adverse outcome. In terms of age, the pilots of these accidents

were representative of pilots in all accidents, although they held more advanced licenses than accident pilots overall. Six accident categories accounted for 70% of the accidents: loss of control – in flight, post-impact fire, runway excursion, abnormal runway contact, non-powerplant system/component failures and fuel related loss of engine power.

Single Engine, Retractable Gear

The second largest group of accidents was in aircraft with a single engine (piston) and retractable landing gear, and this type of aircraft had the second highest average adverse outcome score. One quarter of the accidents were fatal, nearly half of the persons on board were injured, nearly one quarter of the aircraft were destroyed, and 31% of the accidents were considered major. The pilots were the third oldest group, and this group had the largest percentage of private licenses (61%). The accident categories associated with single-engine, retractable gear flights are similar to the twin-engine flights, with the addition of powerplant system/component failure. Seven accident categories accounted for 66% of the accidents.

Single Engine, Fixed Gear

By far the largest group of accidents was in aircraft with a single-engine and fixed landing gear, with more than three times the number of accidents as single engine, retractable gear aircraft. Only 14% of the accidents were fatal, and 14% of the aircraft were destroyed. Only 19% of the accidents were major, but 37% of those on board were injured. The average adverse outcome score was fourth highest among the eleven aircraft types. Pilot age was a little lower than the overall average. Nearly half of the pilots held a private license, and more of the pilots held a student or recreational license than an air transport license. Five accident categories accounted for 63% of the accidents, including loss of control – on ground, runway excursion, loss of control – in flight, fuel related loss of engine power and abnormal runway contact.

Light Sport Aircraft

Thirty-eight percent of the people on board light sport aircraft were injured in these accidents, but only fourteen percent of the accidents were fatal. Only three percent of the aircraft were destroyed, and only 16% of the accidents were classified as major. All of this combined to give light sport aircraft the second lowest average adverse outcome score. The pilots were older than any other group, and more of them (30%) had either a student or recreational license. One third of the accidents were categorized as loss of control – in flight, and together with abnormal runway contact, runway excursion and loss of control – on ground, these four categories accounted for 83% of light sport accidents.

Conclusions

In general, accidents involving larger aircraft have lower rates of adverse outcomes, although accidents involving light sport aircraft have an average score second only to regional jets. Half of regional jet accidents were either encounters with turbulence or ground handling accidents, while more than half of light sport accidents were abnormal runway contact (mostly hard or bounced landings) or runway excursions. Accidents in these four categories have much lower rates of aircraft destruction (5.5% combined) and fatality (4.8% combined) than occurred among all accidents combined.

The two aircraft types with the highest risk of adverse outcomes are those with twin engines (piston) and single-engine retractable gear. Thirty-seven percent of twin-engine accidents, and 27% of single-engine retractable gear accidents were either loss of control – in flight or post-impact fire (or both). The accidents in these two categories have much higher rates of fatalities (55% combined), aircraft destruction (51% combined) and "major" accidents (64% combined). In fact, with the exception of light sport aircraft, higher rates of loss of control – in flight are associated with higher average adverse outcome scores, and higher rates of turbulence encounters are associated with lower average adverse outcome scores.

Certain accident categories were more commonly assigned than others. In particular, abnormal runway contact, runway excursions and non-powerplant system/component failures occur frequently within all but two or three aircraft types. In contrast, ground collisions, loss of control – on ground/water and powerplant system/component failure occur frequently within only one or two aircraft types.

Although in general, accidents in larger aircraft have less severe outcome, as discussed above, different accident categories are associated with different rates of adverse outcome. It may be that the observed differences in outcomes between types of aircraft are influenced as much by the type of accident as by the structural stability of the aircraft itself.

Appendix A

List of Specific Aircraft Make and Model Within Each Aircraft Group

	Wide-Body Jet Airliner	Narrow Body Jet Airliner
Airbus	A300 A310 A330 A340 A380	A318 A319 A320 A321
Boeing	747 767 777 787	707 717 727 737 757
Lockheed	L-1011 TRISTAR	
McDonnell-Douglas	DC-10 MD-11	DC-8 DC-9 MD-80 MD-90
British Aerospace		BAE-146
British Aircraft Corporation		BAC One-Eleven

Regional Jet

Canadair-Bombardier	CRJ-100 CRJ-200 CRJ-700 CRJ-900 CRJ-5000
Embraer	ERJ-135 ERJ-140 ERJ-145 ERJ-170 ERJ-190
Fairchild	DO-328 (series 300)
Fokker	F-100 F-28

Medium Business Jet

Aero Commander	Jet Commander 1121
Aerospatiale	Corvette
Bombardier	Challenger BD-100
Cessna	Citation II (CE-550) Citation V (CE-560) Citation III (CE-650) Citation Sovereign Citation X (CE-750)
Dassault	Falcon 10-100 Falcon 20-200 Falcon 50 Falcon 900 Falcon 2000
Gulfstream	GA-1159 Gulfstream II Gulfstream III Gulfstream IV Gulfstream V
Hamburger Flugzeugbau	320
Beech	Hawker-800
HS-BAE Systems	125-HAWKER
Raytheon	125-HAWKER BeechJet 400
Israel Aircraft Industries	Astra Gulfstream G150 Gulfstream G200 Westwind

Medium Business Jet (continued)

Learjet	24 25 31 35 36 45 55 60
Lockheed	Jetstar
Mitsubishi	300
Rockwell	Sabreliner

Small Business Jet

Cessna	Citation I CitationJet Mustang T-37 (military)
Eclipse	500
Embraer	EMB-500
Learjet	23
Morane Saulnier	MS-760
Raytheon	390

Large Turbo-prop

ATR	42 72
Convair	CV-580 CV-600 CV-640
De Havilland	Dash 7 Dash 8
Fokker	F-27
HS-BAE Systems	BAE-ATP
Lockheed	L-188 L-382
NAMC	YS-11

Medium Turbo-prop

Aerospatiale	NORD-262
Air Tractor	602 802
Beech/Raytheon	BE-100 BE-200 BE-300 99 1900
CASA	212
De Havilland	DHC-6
Douglas	DC-3 (Turbo conversion)
Embraer	EMB-110 EMB-120

Medium Turbo-prop (continued)

Fairchild	DO-228 DO-328 (series 100)
Fairchild-Swearingen Metro	SA-226 SA-227
GAF-ASTA	Nomad
Grumman	73-T
Gulfstream	Gulfstream I
Jetstream-BAE Systems	31 41
Rockwell	OV-10
Saab	340
Short Brothers	3-60 SC.7 Skyvan

Small Turbo-prop

Ayres	Turbo Thrush
Air Tractor	AT-400 AT-402 AT-503 AT-504
Beech/Raytheon	BE-18 (conversions) BE-36 (conversions) BE-45 (T-34C) BE-60-T BE-90
De Havilland	DHC-2-MKIII DHC-3T

Small Turbo-prop (continued)

Cessna	CE-206 CE-207 CE-208 CE-210 CE-421 CE-425 CE-441
Fairchild-Swearingen	SA-26
Grumman	G-164
Gulfstream	GA-164 GA-680 GA-681 GA-690 GA-695
McKinnon	G-21
Mitsubishi	MU-2B
Partenavia	AP-68-TP
Piaggio	P180
PZL-Mielec	M-18/T-45
Pilatus	PC-6 PC-7 PC-12
Piper	PA-31T PA-42 PA-46-310TP, PA-46-350TP, PA-46-500TP
Quest	Kodiak
Reims	F406
SIAI Marchetti	SF-260-TP
Socata	TBM-700

Heavier Multi-Engine (Reciprocating)

Boeing	B-17
	B-307
Convair	CV-240
	CV-340
	CV-440
Curtiss	C-46
De Havilland	DHC-4
Douglas	DC-3
	DC-4
	DC-6
	DC-7
	DC-A20
	DC-A26
Fairchild	C-119
	C-123
Grumman	C-1
	G-111
	HU-16
	S-2F
	TS-2A
Lockheed	L-1049
	L-18
	L-49
	P-2V
	P-38
Martin	B26

Lighter Multi-Engine (Reciprocating)

Beagle	206
Beech	BE-18 BE-50, BE-55, BE-56, BE-58 BE-60, BE-65, BE-70, BE-76, BE-95
Beriev	BE-103
Britten-Norman	Islander Tri-Islander Defender
Stout Bushmaster	2000
Camair	480
Cessna	CE-303, CE-310, CE-320 CE-335, CE-336, CE-337, CE-340 CE-401, CE-402, CE-404 CE-411, CE-414, CE-421 T-50 (Military)
Champion	Lancer
De Havilland	DHC-90
Dornier	DO-28
Grumman	21, 44, 73
Gulfstream	GA-7, GA-500, GA-520, GA-560 GA-680, GA-685 GA-700, GA-720
Lockheed	L-12
Navion	D-16
Piper	PA-23 PA-30, PA-30A, PA-30B PA-31, PA-34, PA-39 PA-44, PA-60

Lighter Multi-Engine (Reciprocating) (continued)

Partenavia	P-68
STOL Aircraft Corp	UC-1
Tecnam	P2006T
Wing Aircraft	D-1

Single-Engine (Reciprocating) Retractable Gear

Beech	BE-17 BE-23 (series codes 24R, A24R, B24R, C24R) BE-33, BE-35, BE-36 BE-45 (except BE-45-T34C)
Bellanca	BL-14, BL-17, BL-260
Cavalier	Mustang
Cessna	CE-172-RG CE-177-RG CE-182-RG CE-182-TR CE-210
Colonial Aircraft	C-1, C-2
Columbia	XJL
Culver	LCA, LFA, V, TD-2, PQ-14
Curtiss-Wright	P-40
Diamond	DA-42
Globe	GC-1
Grob	G-115, G-120

Single-Engine (Reciprocating) Retractable Gear (continued)

Grumman	Avenger
Gulfstream	GA-112, GA-114
Lake	LA-4
Meyers	Aero Commander 200 MAC-145
Mooney	M-18, M-20, M-22
North American	AT-6 SNJ-2, SNJ-4, SNJ-5, SNJ-6 Harvard
Navion	NAV-1, NAV-4 NAV-A, NAV-B, NAV-D NAV-G, NAV-H, NAV-L
Piper	PA-24, PA-28R, PA-28RT PA-32S-300 PA-32R, PA-46
Raytheon	Commander 114
Reims	FR-182
SIAI Marchetti	S-205 SF-260 FN-333
Socata	TB-20
Spartan	7W
STOL Aircraft	RC-3
Thurston	Teal TSC-1A
Yakovlev	Yak-3

Single-Engine (Reciprocating) Fixed Gear

Aero Mercantil	Gavilan 358
Air Tractor	AT-301 AT-400, AT-401 AT-501, AT-502
AMD	Alarus-2000
American Legend	AL-11 AL-3
Avions Robin	R-2160
Arctic	S1A, S1B
Aeronca	AR-7, BL-7, AR-11, AR-15 AR-50, AR-65 AR-C3, AR-K, AR-L3 Bubeck-Irving
Aviat	A-1
Ayres	Thrush
Bellanca	BL-7, BL-8, BL-11 BL-DW1
Beech	BE-19, BE-23, BE-77
Boeing	B-75
Call Aircraft	A-2, A-3, A-9
Centaur	Longren
Cessna	CE-120, CE-140, CE-145, CE-150, CE-152 CE-165, CE-170, CE-172, CE-175, CE-177 CE-180, CE-182, CE-185, CE-188 CE-190, CE-195, CE-205, CE-206, CE-207, CE-305
Champion	Champ-7, Champ-8

Single-Engine (Reciprocating) Fixed Gear (continued)

Cirrus	SR-20, SR-22
Columbia	350
Commonwealth	Skyranger, Sportster
Convair – General Dynamics	BT-13, BT-15, CV-L13
Cub Crafters	CC-18
Culver	Dart-G
DeHavilland	DHC-1, DHC-2, DHC-3, DHC-60, DHC-82, U-6
Diamond	DA-20, DA-40
Dornier	DO-27
Eagle	DW-1
ERCO	Alon-415 Ercoupe-415 Forney-415
Emigh	Trojan
Extra	EA
Fairchild	F-24, M-62 PT-19, PT-23, PT-26
Fieseler	Fi-156
Fleet	Model 16
Found	FBA-2
Funk	Model B
Great Lakes	2T1
Grumman	G-164

Single-Engine (Reciprocating) Fixed Gear (continued)

Gulfstream	GA-AA, GA-AG
Helio	H-250, H-295, H-391, H-395 H-700, H-800
Helton	Lark-95
Howard	DGA-15
Lancair	LC-40, LC-41, LC-42
Liberty	XL-2
Lockheed	L-402
Luscombe	LL-8, LL-11 Phantom
Maule	M-4, M-5, M-6, M-7, M-8 MX-7, MT-7, MXT-7
MBB	BO-209
Meyers	OTW
Monocoupe	D-145
Morane-Saulnier	MS-880, MS-893, MS-894
Mooney	M-10
Moravan	Zlin-242
Mudry	CAP-10
Naval Aircraft Factory	N3N-3
New Standard	D-25
Noordyun	UC-64
OMF	Symphony

Single-Engine (Reciprocating) Fixed Gear (continued)

Pilatus	PC-6-350
Piper	L-21, L-4 PA-11, PA-12, PA-14, PA-15, PA-16 PA-17, PA-18, PA-19 PA-20, PA-22, PA-25, PA-28 PA-32, PA-36, PA-38 PA-J2, PA-J3, PA-J3C, PA-J3F, PA-J3L, PA-J4, PA-J5
Pitts	S-1, S-2
Porterfield	CP-35, CP-50, CP-55, CP-65, FP-65, LP-65
PZL-Mielec	M-18, M-104, M-150, M-160, AN-2
Quartz Mountain	11E
Rawdon	T-1
Rearwin	Cloudster
Reims	FA-150, FR-172
Rockwell	Commander-100
Rose	Parakeet
Ryan	ST-A, ST-3, SCW-145
Socata	TB-9, TB-10, TB-200, MS-Ralleye
Stinson	AT-19, SR-7, SR-8, SR-10, SR-V77, SR-JR, SR-L5, SR-108
Stampe	SV-4
Sukhoi	SU-26, SU-29
Taylorcraft	15A, 19, 20, 21, 22 BC, BF, BL DC, DF, DL
Tecnam	P-2002

Single-Engine (Reciprocating) Fixed Gear (continued)

Timm	N2T
Varga	2150A, 2180
Volaircraft	Aero Commander 100
WACO	AGC, AQC, ARE, ASO, ATO, AVN BSO, CRG, CUC, GXE, HRE, QCF RNF, SRE, UBF, UIC, UKC, UKS, UPF VKS, YKS, YMF, YPF, ZPF
Weatherly	201, 620
XtremeAir GMBH	Sbach-342
Zenair	CH-2000

Light Sport Aircraft

Aero Ltd.	AT-4
Aeropro	Eurofox
Aerosport	Ikarus
Aerospool	WT-9 (Dynamic)
AMD	CH-601 (Zodiac)
Arion	Lightning
Aveko	VL-3
B&F Technik	FK-9
Bush Caddy	LSA
Cessna	CE-162
Colyaer	Freedom
Cub Crafters	CC-11
Czech Aircraft Works	Dynamic Mermaid Parrot Sport Cruiser PiperSport
Diamond	DV-20
Dova	DV-1
Evektor	Sportstar
Fantasy Air	Allegro 2000
Flight Design	CT
FPNA	A-22
Gryf Aircraft	MD-3

Light Sport Aircraft (continued)

Higher Class Aviation	Sport Hornet
Indus	Thorp T-11 Thorp T-211
Iniziative	Sky Arrow 600
Jabiru	J-170, J-230, J-250
Jihlavan	KP-5
M-Squared	Breese II
Moravan/Zlin	Savage
Paradise	P1
Quicksilver	GT-500
Rans	S-7LS
Remos	G3, GX
Skykits	Savannah
SportAir	Stingsport Sting S-3
Tecnam	P-92, P-2004

Appendix B

Aviation Occurrence Categories

The CAST/ICAO Common Taxonomy Team (CICTT) was jointly chartered by the International Civil Aviation Organization (ICAO) and the Commercial Aviation Safety Team (CAST), and was charged with developing common taxonomies and definitions for aviation accident and incident reporting systems (for additional information see http://www.intlaviationstandards.org/). The occurrence categories are listed below, with brief descriptions of each. The information is taken from a document dated October 2008.

CICTT Categories

Abnormal Runway Contact (ARC): Any takeoff or landing involving abnormal contact with the runway or landing surface. Included are hard/heavy landings, long/fast landings, crabbed landings, nose wheel first touchdowns, tail strikes, wing/nacelle strikes and gear up landings.

Abrupt Maneuver (AMAN): The intentional abrupt maneuvering of the aircraft (in-flight or on-ground) by the flight crew to avoid a collision with terrain, objects, weather or other aircraft.

Aerodrome (ADRM): Occurrences involved aerodrome design, service or functionality issues. The aerodrome includes runways, taxiways, ramp areas, parking areas, buildings and structures, lighting, signage Crash/Fire/Rescue (CFR) services.

ATM/CNS (ATM): Occurrences involving air traffic management (ATM) or communication, navigation or surveillance (CNS) service issues.

Bird Strike (BIRD): Occurrences involving collisions or near collisions with bird(s) or wildlife.

Cabin Safety Events (CABIN): Includes significant events in the passenger cabin, related to carry-on baggage, supplemental oxygen, missing/non-operational emergency equipment, the inadvertent deployment of emergency equipment, and the medical emergency (not caused by turbulence encounters) of persons other than the flight crew or medical evacuation patients.

Collision with Obstacle(s) During Takeoff and Landing (CTOL): A collision with an object or obstacle during airborne phases of take-off or landing.

Controlled Flight into or toward Terrain (CFIT): In-flight collision or near collision with terrain, water or obstacle without indication of loss of control. Excludes intentional low altitude operations, intentional flight into terrain and runway undershoot/overshoot.

Evacuation (EVAC): Occurrences including one or more of the following: an unnecessary evacuation was performed, person(s) were injured during the evacuation, evacuation equipment failed to perform as required, or the evacuation was a factor in the outcome.

External Load Related Occurrences (EXTL): Occurences during or as a result of external load or external cargo operations. Includes cases where external load or the load lifting equipment contacts terrain, water surface or objects.

Fire/Smoke Non-Impact (FI-NI): Fire or smoke in the aircraft (in-flight or on-ground) which was not the result of an impact.

Fire/Smoke Impact (FI-POST): Fire or smoke resulting from impact.

Fuel Related (FUEL): One or more powerplants experienced reduced or no power output due to fuel exhaustion (no usable fuel on board), fuel starvation (usable fuel is not available to the engine), fuel contamination (by water, sand, dirt, bugs) or wrong fuel, or carburetor and/or induction icing.

Glider Towing Related Events (GTOW): Premature release, inadvertent release or non-release during towing, entangling with towing, cable, loss of control, or impact into towing aircraft/winch.

Ground Handling (RAMP): Occurrences during (or as a result of) ground operations, including preflight configuration errors that lead to subsequent events (such as improperly latched doors, pitot tube contamination, or weight/balance issues).

Ground Collision (GCOL): Collision with an aircraft, person, animal, ground vehicle, building, etc., while taxiing to or from the runway in use.

Icing (ICE): The accumulation of snow, ice, freezing rain or frost on aircraft surfaces to the extent that aircraft control or performance is adversely affected.

Loss of Control – Ground (LOC-G): Loss of aircraft control while the aircraft is on the ground, which may result from a contaminated runway, evasive action due to a runway incursion, or the failure or malfunction of a system or component.

Loss of Control – In flight (LOC-I): Loss of aircraft control while in flight; may occur in Instrument Meteorological Conditions (IMC) or Visual Meteorological Conditions (VMC).

Loss of Lifting Conditions En-Route: (LOLI): Landing en-route due to loss of lifting conditions. Applicable only to aircraft that rely on static lift to maintain or increase flight attitude, namely sailplanes, gliders, hang gliders, and paragliders, balloons and airships.

Low Altitude Operations (LALT): Collision or near collision with terrain/objects/obstacles while intentionally operating near the surface (excludes landing and takeoff phases). Includes aerobatics, sight-seeing, aerial photography, aerial application, scud running, and flying in close proximity to mountains or box canyons where the aircraft aerodynamic capability is not sufficient to avoid impact.

Airprox/TCAS Alert/Loss of Separation/Near Mid-Air Collision/Mid-Air Collision (MAC): Airprox, TCAS alerts and loss of separation, as well as near collisions or collisions between aircraft in flight.

Other (OTHER): Any occurrence not covered under another category.

Runway Excursion (RE): A veer off the side or overrun off the end of the runway.

Runway Incursion – Vehicle, Aircraft or Person (RI-VAP): The incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for takeoffs or landings.

Security Related (SEC): Criminal or security related acts such as hijacking, aircraft theft, flight control interference, sabotage or suicide.

System/Component Failure or Malfunction – Non-powerplant (SCF-NP): Failure or malfunction of an aircraft system or component other than the powerplant.

System/Component Failure or Malfunction – Powerplant (SCF-PP): Failure or malfunction of an aircraft system or component related to the powerplant.

Turbulence Encounter (TURB): In flight encounter with turbulence; includes clear-air or cloud turbulence, mountain wave and wake vortex.

Unintended Flight in Instrument Meteorological Conditions (UIMC): Applicable if the pilot was flying according to Visual Flight Rules (VFR), and by any reason found oneself inadvertently in IMC. Only to be used if pilot not qualified to fly in IMC and/or aircraft not equipped to fly in IMC, and only in the case of a loss of visual references.

Undershoot/Overshoot (USOS): A touchdown off the runway surface but in close proximity to the runway. Excludes off-airport emergency landings.

Unknown or Undetermined (UNK): Insufficient information exists to categorize the accident; includes missing aircraft.

Wildlife (WILD): Collision with, risk of collision with, or evasive action taken by an aircraft to avoid an animal (other than birds) on the runway in use. Previously known as Runway Incursion – Animal (RI-A).

Windshear or Thunderstorm (WSTRW): Flight into windshear or thunderstorm; includes hail and heavy rain.

Additional Categories

Many of the following categories were added in order to completely capture the event sequence. An emergency landing is required in most cases of System/Component Failure/Malfunction and Loss of Engine Power, and may be performed after an encounter with adverse weather; this landing often is not without further incident. Control of the aircraft may be lost, hard or bounced landings may occur, terrain unsuitable for a proper landing may be encountered, the aircraft may collide with power lines, fences or ground vehicles during an off-airport landing, the aircraft may be unable to avoid rising terrain due to degraded performance. The single category of "Loss of Engine Power" is not sufficient to explain why the aircraft was destroyed.

Several categories (collisions with terrain or objects and loss of control) were further subdivided by general phase of flight (ground, takeoff, in flight, approach/landing) because either the root cause or the consequences of the occurrence differ by phase of flight.

Collision with Object – Precautionary Landing (CWO-PL): A collision with an object or obstacle occurred during a precautionary landing approach. CFIT is not an appropriate category in these cases because a system/component failure/malfunction or non-mechanical loss of engine power necessitated the landing.

Collision with Terrain – Precautionary Landing (CWT-PL): A collision with terrain occurred during a precautionary landing approach. CFIT is not an appropriate category in these cases because a system/component failure/malfunction or non-mechanical loss of engine power necessitated the landing. This code was also used in cases where the pilot "ditched" the aircraft in water.

Encounter with Terrain – Precautionary Landing (EWT-PL): An encounter with terrain occurred on the ground away from an airport environment during a precautionary landing, causing damage to the aircraft. The difference between this category and CWT-PL is primarily the force with which the aircraft strikes the ground at touchdown. An encounter with terrain involves a normal touchdown, with rough terrain encountered during the landing roll. Included here are intentional gear-up off-airport landings.

Pilot Incapacitation or Severe Impairment (INCAP): Pilot became incapacitated (due to illness or fatigue) or severely impaired (due to illness, alcohol or illegal drugs). Does not include minor impairment caused by fatigue or the use of unapproved prescription medications.

Loss of Engine Power – Fuel Related (PL-FUEL): Loss of engine power due to fuel exhaustion (no usable fuel on board), fuel starvation (usable fuel is not available to the engine), fuel contamination (by water, sand, dirt, bugs) or wrong fuel, or carburetor and/or induction icing (see FUEL above).

Loss of Engine Power – Other Reasons (PL-OTHER): Loss of engine power due to other non-mechanical reasons. Reasons include foreign object damage (e.g. bird strikes), ice ingestion, improper simulated engine out procedures, other improper procedures.

Loss of Engine Power – Unknown Reasons (PL-UNK): Loss of engine power occurred but the exact cause was undetermined.

System/Component Failure or Malfunction – Stress Limits Exceeded (SCF-SLE): Structural failure due to exceeding the designed stress limits of the aircraft, most often resulting from loss of control, from forces associated with severe weather or from pilot actions such as excessive airspeed or abrupt maneuvering.

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14. ABSTRACT

Civilian aircraft are available in a variety of sizes, engine types, construction materials and instrumentation complexity. For the analysis reported here, eleven aircraft categories were developed based mostly on aircraft size and engine type, and these categories were applied to twenty consecutive years of civil aviation accidents. Differences in various factors were examined among these aircraft types, including accident severity, pilot characteristics and accident occurrence categories. In general, regional jets and very light sport aircraft had the lowest rates of adverse outcomes (injuries, fatal accidents, aircraft destruction, major accidents), while aircraft with twin (piston) engines or with a single (piston) engine and retractable landing gear carried the highest incidence of adverse outcomes. The accident categories of abnormal runway contact, runway excursions and non-powerplant system/component failures occur frequently within all but two or three aircraft types. In contrast, ground collisions, loss of control – on ground/water and powerplant system/component failure occur frequently within only one or two aircraft types. Although accidents in larger aircraft tend to have less severe outcomes, adverse outcome rates also differ among accident categories. It may be that the type of accident has as much or more influence on the outcome as the type of aircraft.

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