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Analysis of Aviation Safety Reporting System Incident Data Associated With the Technical Challenges of the System-Wide Safety and Assurance Technologies Project

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April 2015

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Summary

The Aviation Safety Program (AvSP) System-Wide Safety and Assurance Technologies (SSAT) Project asked the AvSP Systems and Portfolio Analysis Team to identify SSAT-related trends. SSAT had four technical challenges: advance safety assurance to enable deployment of NextGen systems; automated discovery of precursors to aviation safety incidents; increasing safety of human-automation interaction by incorporating human performance, and prognostic algorithm design for safety assurance. This report reviews incident data from the NASA Aviation Safety Reporting System (ASRS) for system-component-failure-or-malfunction- (SCFM-) related and human-factor-related incidents for commercial or cargo air carriers (Part 121), commuter airlines (Part 135), and general aviation (Part 91). The data was analyzed by Federal Aviation Regulations (FAR) part, phase of flight, SCFM category, human factor category, and a variety of anomalies and results. There were 38 894 SCFM-related incidents and 83 478 human-factor-related incidents analyzed between January 1993 and April 2011.

1.0 Introduction

This analysis was conducted to support the Aviation Safety Program (AvSP) System-Wide Safety and Assurance Technologies (SSAT) Project milestone SSAT3.2.SA.01 (Ref. 1): "Identification of SSAT-Related Trends." In particular, this is a review of the incident data from the NASA Aviation Safety Reporting System (ASRS) (Ref. 2). The following four SSAT-related technical challenges (TCs) were the focus of the incidents searched in the ASRS database:

TC1: Advance safety assurance to enable deployment of NextGen systems
TC2: Automated discovery of precursors to aviation safety incidents
TC3: Increasing safety of human-automation interaction by incorporating human performance
TC4: Prognostic algorithm design for safety assurance

The database was searched for incidents that listed either primary problems or contributing factors with the following problems:

- Aircraft equipment failure or malfunction (system component failure or malfunction, or SCFM, incidents)
- Human factors (human-factor-related incidents)

The AvSP is primarily interested in Federal Aviation Regulations (FAR) Parts 121, 135, and 91 aircraft operations. Part 121 applies to major airlines and cargo carriers that fly large transport category aircraft. Part 135 applies to commercial aircraft carriers, also referred to as "commuter airlines." Prior to March 1997, Part 121 operations included aircraft with 30 or more seats. In March 1997, the definition of

Part 121 operations changed to include aircraft with 10 or more seats. Part 91 applies to general aviation and noncommercial operations. Acronyms used in this report are defined in Appendix A and TCs are mapped to the incident data shown in Appendix B, Table B.1.

2.0 Aviation Safety Reporting System Database

The ASRS database includes incidents only, not accidents. The following definitions are used for incidents and accidents in aviation and are listed in the International Civil Aviation Organization (ICAO) Annex 13 (Ref. 3).

- An incident is an occurrence, other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operation.
- An accident is 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 until such time as all such persons have disembarked, in which (a) a person is fatally or seriously injured or (b) the aircraft sustains damage or structural failure which: adversely affects the structural strength, performance, or flight characteristics of the aircraft and would normally require major repair or replacement of the affected component (*except* for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wingtips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin); or (c) the aircraft is missing or is completely inaccessible.

There are caveats to be aware of when using ASRS data: incidents are reported voluntarily, are subject to self-reporting biases, are not corroborated by the Federal Aviation Administration (FAA) or the National Transportation Safety Board, and often not enough information is given to determine exact cause or category without reading each narrative. Voluntary incident reports cannot be considered to be a representative sample of the underlying population of events they describe (Ref. 4). Also, only a fraction of the incidents reported are found in the public database because of the lack of resources for reviewing and categorizing incidents as they are received. Even though the data cannot be used for statistical or trend analysis, they can be used to identify vulnerabilities and to gain a better understanding of the root causes of human error. Also, they should be considered to complement data generated by mandatory, statistical, and monitoring systems.

The data received from ASRS contained a variety of information for each incident including FAR part, phase of flight, and narrative. The following SSAT search criteria categories were used in this analysis:

(1) Aircraft results
(2) Anomalies
    a. Conflict
    b. Ground event or encounter
    c. Ground excursion
    d. Ground incursion
    e. In-flight event or encounter
(3) Communication breakdown between parties
(4) Component problems
(5) FAR part
(6) Flight crew results
(7) Human factor (subcategorized since June 2009)

(8) Phase of flight
(9) SCFMs
(10) Time of day

ASRS category definitions used in this report are listed in Appendix D. Most category options are not mutually exclusive, which can cause an incident to have multiple values under a single category. For example, an SCFM-related incident by phase of flight could be counted twice if the incident occurred during both cruise and descent phases of flight.

2.1 ASRS Data Sets

Two data sets were requested from ASRS in June 2011: SCFM-related incidents and human-factor-related incidents. The search was restricted from January 1993 to April 2011 for FAR Parts 121, 135, and 91.

2.1.1 SCFM-Related Incidents

The SCFM-related incidents data set used "aircraft" as the primary problem and/or contributing factor for the search criteria and 38 894 incidents were found. SCFM-related incidents apply to TC1, TC2, and TC4. TC1, which is tied to the verification and validation of flight-critical systems (VVFCS) subproject, applies to SCFM-related incidents because TC1 addresses safety issues that are based on errors in large-scale software, avionics, and distribution systems and are covered by some of the SCFM categories. TC2, which is tied to the data mining and knowledge discovery (DMKD) subproject, applies because the analysis of large data sets that contain SCFM failures could help to identify anomalies and lead to potential automated discoveries of precursors to aviation safety incidents. TC4, which is tied to prognostic and decision making, applies because TC4 will assist in estimating the remaining useful life of components and subsystems throughout the aircraft so that parts can be replaced before failure, thus helping to reduce incidents. TC3 is not included here because no correlation was found between SCFM-related incidents and human system solutions (HSS).

2.1.2 Human-Factor-Related Incidents

The human-factor-related incidents data set applies to TC2 and TC3. TC2, automated discovery of precursors to aviation safety incidents, applies because TC2 is tied to the DMKD subproject and will help to understand the impact of degradations in human performance on aircraft performance and help to predict adverse events from affecting new NextGen technologies. TC3, increasing safety of human-automation interaction by incorporating human performance, applies because TC3 is tied to HSS methods and tools appropriate for designers, trainers, and operators, and enables the prediction of human performance to identify, evaluate, and resolve safety issues due to human-automation interaction.

The human-factor-related data set contained a total of 83 478 incidents based on the following search methods:

(1) Human factor as the primary problem (72 414 incidents)
(2) Human factor as the contributing problem (54 219 incidents)
(3) Human factor category (only available since May 2009) (12 583 incidents)

3.0 System Component Failure or Malfunction Incident Analysis

This section of the analysis looks at SCFM-related incidents by considering the aircraft as the primary problem or contributing factor, then concentrating on individual components to determine which components are directly related to the problem. The 508 individual components in the ASRS data set were sorted into the following 18 SCFM categories and are listed in Appendix D (Ref. 5).

(1) Automated flight control
(2) Brakes
(3) Communication
(4) Control surface
(5) Electrical power
(6) Environmental control system
(7) Furnishings and equipment
(8) Fuel system
(9) Hydraulic or pneumatic
(10) Icing
(11) Landing gear
(12) Miscellaneous
(13) Monitoring and management
(14) Navigation
(15) Oil system
(16) Propulsion system
(17) Structure
(18) Weather system

There were 38 894 total incidents from January 1993 to April 2011 that involved FAR Part 121, 135, and 91 operations. Of the total, 25 049 incidents listed aircraft as the primary problem and 29 253 incidents listed aircraft as a contributing factor. Some reports listed aircraft as both a primary problem and contributing factor. The data presented here will help researchers determine future SCFM research areas.

3.1 Phase of Flight and FAR Part

Phase of flight and FAR part can help to explain when SCFMs occur and what aircraft category is impacted. Of the 35 943 incidents that listed a FAR part, 26 346 incidents were listed for Part 121, 1837 incidents were listed for Part 135, and 7760 incidents were listed for Part 91. There were 37 562 SCFM incidents that listed at least one phase of flight: taxi had 2477 incidents, takeoff had 4410 incidents, initial climb had 3191, climb had 4453, cruise had 9035, descent had 2759, initial approach had 4803, final approach had 222, landing had 4115, and parked had 8862 incidents.

There were 34 837 total incidents that listed both a phase of flight and a FAR part. Figure 1 shows the number of incidents for each of the 10 phases of flight by FAR part. The largest category for Part 121 was the parked phase of flight with 7353 incidents, followed by cruise with 5371 incidents. Cruise had the most incidents with 420 for Part 135, followed by parked with 347 incidents. The most frequent phase of flight for Part 91 occurred during cruise with 2422 incidents, followed by landing with 1807 incidents.

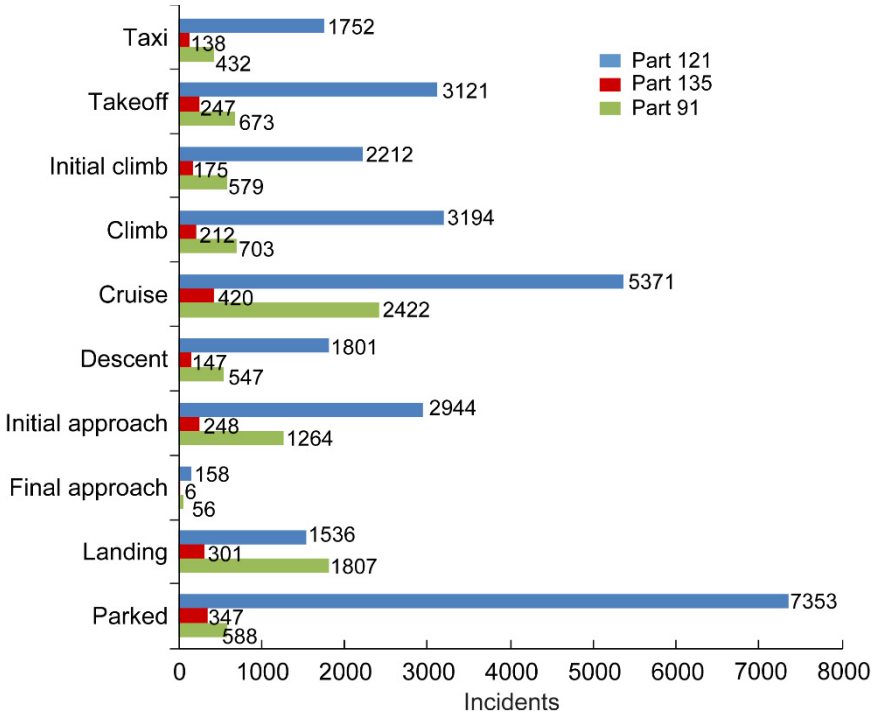


Figure 1.—SCFM-related incidents by phase of flight.

3.2 System Component Failure or Malfunction

There were 38 894 total incidents that had an SCFM problem. Propulsion was the largest SCFM category with 3954 incidents, followed by monitoring and management with 3088 incidents, and landing gear with 2805 incident. Of the total SCFM incidents, 28 407 listed both a phase of flight and FAR part as displayed in Figure 2(a) (with more detail shown in Appendix B, Table B.2). The top three tall poles for SCFM categories and phase of flight are propulsion during cruise with 981 incidents, landing gear during landing with 939 incidents, and propulsion during parked with 817 incidents.

The SCFM categories and phases of flight are broken down further by FAR Parts 121, 135, and 91 as shown in Figure 2(b), (c), and (d) (with more detail in Table B.3, Table B.4, and Table B.5). There were 20 652 incidents that had an SCFM category and phase of flight for Part 121, but only 1289 incidents for Part 135 and 5636 incidents for Part 91. The top three tall poles for Part 121 were landing gear during parked with 685 incidents, monitoring and management during parked also with 685 incidents, and propulsion during parked with 652 incidents. The top three tall poles for Part 135 were landing gear during landing with 92 incidents, propulsion during cruise with 62, and propulsion during parked with 47 incidents. The top three tall poles for Part 91 were landing gear during landing with 565 incidents, propulsion during cruise with 413, and electrical power during cruise with 297 incidents.

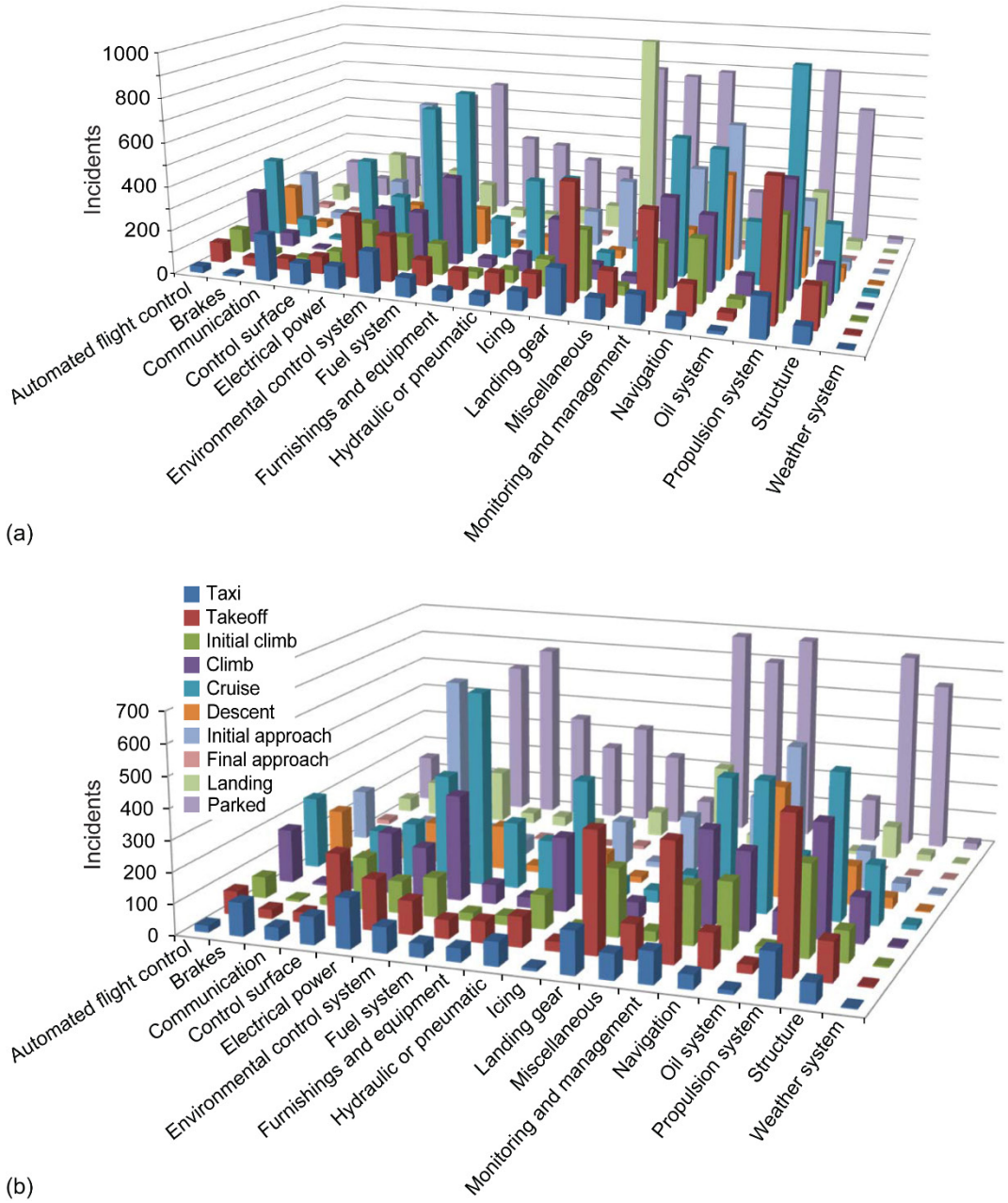
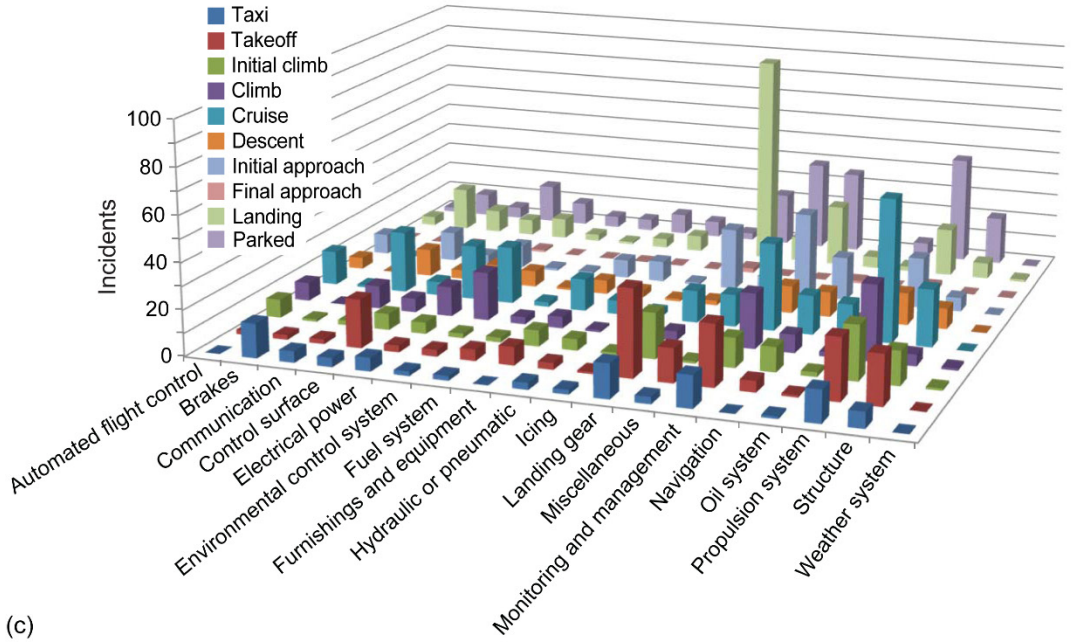


Figure 2.—SCFM-related incidents by SCFM category, phase of flight, and FAR part. (a) Parts 121, 135, and 91 combined. (b) Part 121. (c) Part 135. (d) Part 91.



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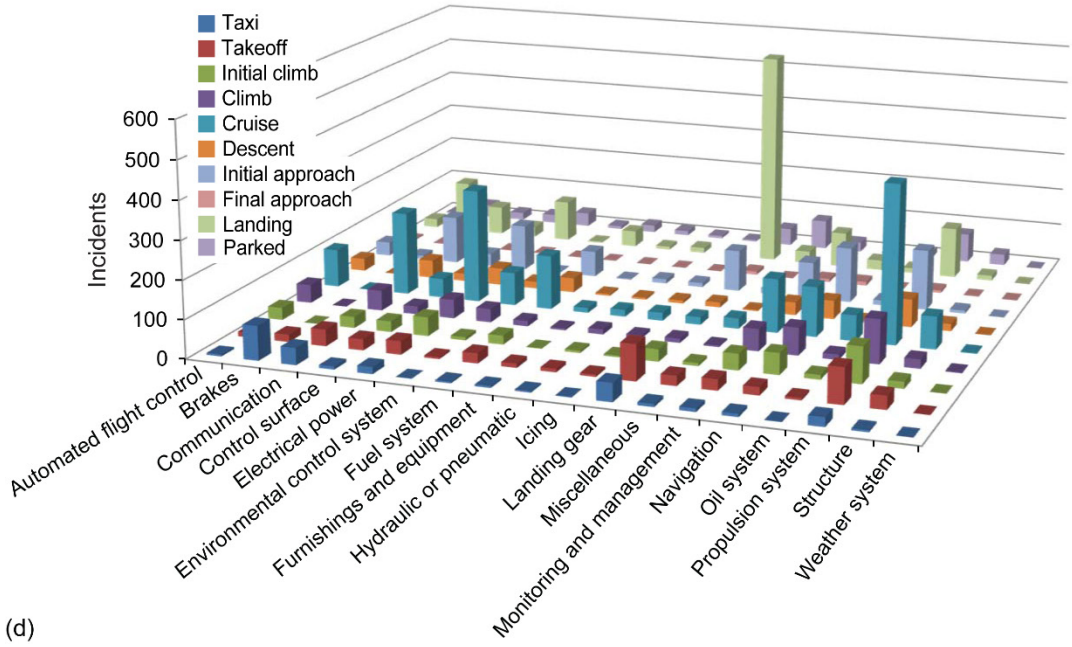


(d)

Figure 2.—Concluded.

3.3 Component Problems

The ASRS database field “component problems” has four options that pertain to severity of the problem: design, failed, improperly operated, and malfunctioning. There were 26 249 incidents in the SCFM data set that listed a component problem: 18 503 for Part 121, 1289 for Part 135; and 5681 for Part 91. Figure 3 shows component problem categories by FAR part. Malfunction was the most frequent component problem for all three FAR parts with 11 244 incidents for Part 121, 793 for Part 135, and 3050 for Part 91. Failed component problems came in second for all three FAR parts with 4465 incidents for Part 121, 268 for Part 135, and 1602 for Part 91.

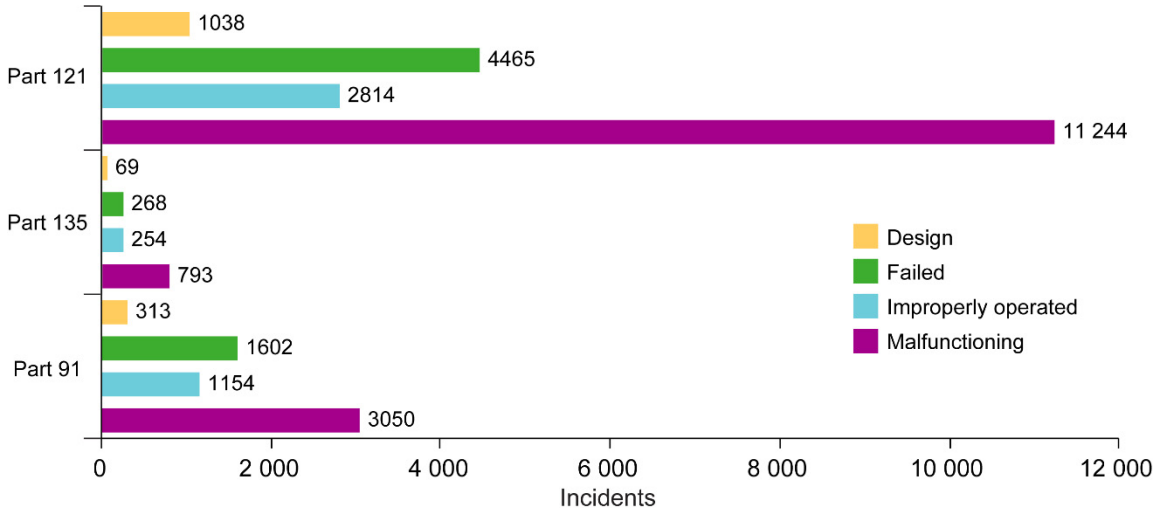


Figure 3.—SCFM-related incidents by component problem and FAR part.

Figure 4(a) shows SCFM categories by component problem for FAR Part 121. All SCFM categories, except miscellaneous, listed malfunctioning as the largest component problem. Monitoring and management, with 1535 incidents, was the most frequent component problem followed by propulsion with 1346 incidents, and control surface with 1256 incidents. The second largest component problem—failed—occurred in 12 out of the 18 SCFM categories. The improperly operated component problem was the second largest for automated flight control, communication, fuel system, navigation, and structures. Design was the smallest component problem for all SCFM categories except for navigation with 403 incidents.

FAR Part 135 had fewer component problems than Part 121 as shown in Figure 4(b). The top three tall poles were malfunctioning propulsion with 140 incidents, malfunctioning monitoring and management with 134 incidents, and malfunctioning landing gear with 113 incidents. The propulsion system failed in 57 incidents and the landing gear failed in 48 incidents.

Six SCFM categories had almost as many failed components as malfunctioning components for Part 91 as shown in Figure 4(c). The propulsion system had 537 malfunctions and 374 failures, landing gear had 388 malfunctions and 308 failures, and electrical power had 312 failures and 279 malfunctions. Design was the smallest category and within design navigation was the tallest pole with 72 incidents.

3.4 Aircraft Results

The aircraft results category has three options: aircraft damaged, automation overrode the flight crew, and equipment problem dissipated. Of the 5500 incidents that listed an aircraft result, 4429 incidents were aircraft damaged. Equipment problem dissipated had 957 incidents and automation overrode flight crew had 132 incidents. Figure 5 shows the aircraft results by FAR part. The aircraft were damaged 1989 times for Part 121 and 1788 times for Part 91.

Figure 6(a), (b), and (c) show the aircraft results by SCFM categories for FAR Parts 121, 135, and 91. For all three FAR parts, landing gear with aircraft damaged was the tallest pole with 426, 82, and 584 incidents, respectively, followed by propulsion with aircraft damage with 385, 51, and 227 incidents, respectively. Structures with aircraft damaged came in third for both Parts 121 and 135 with 243 and 30 incidents, and brakes with aircraft damaged was third for Part 91with 126 incidents. There were far fewer incidents that reported the aircraft automation overrode the flight crew. The most frequent categories for Part 121 were automated flight control with 33 incidents, navigation with 28, and control surface with 7 incidents.

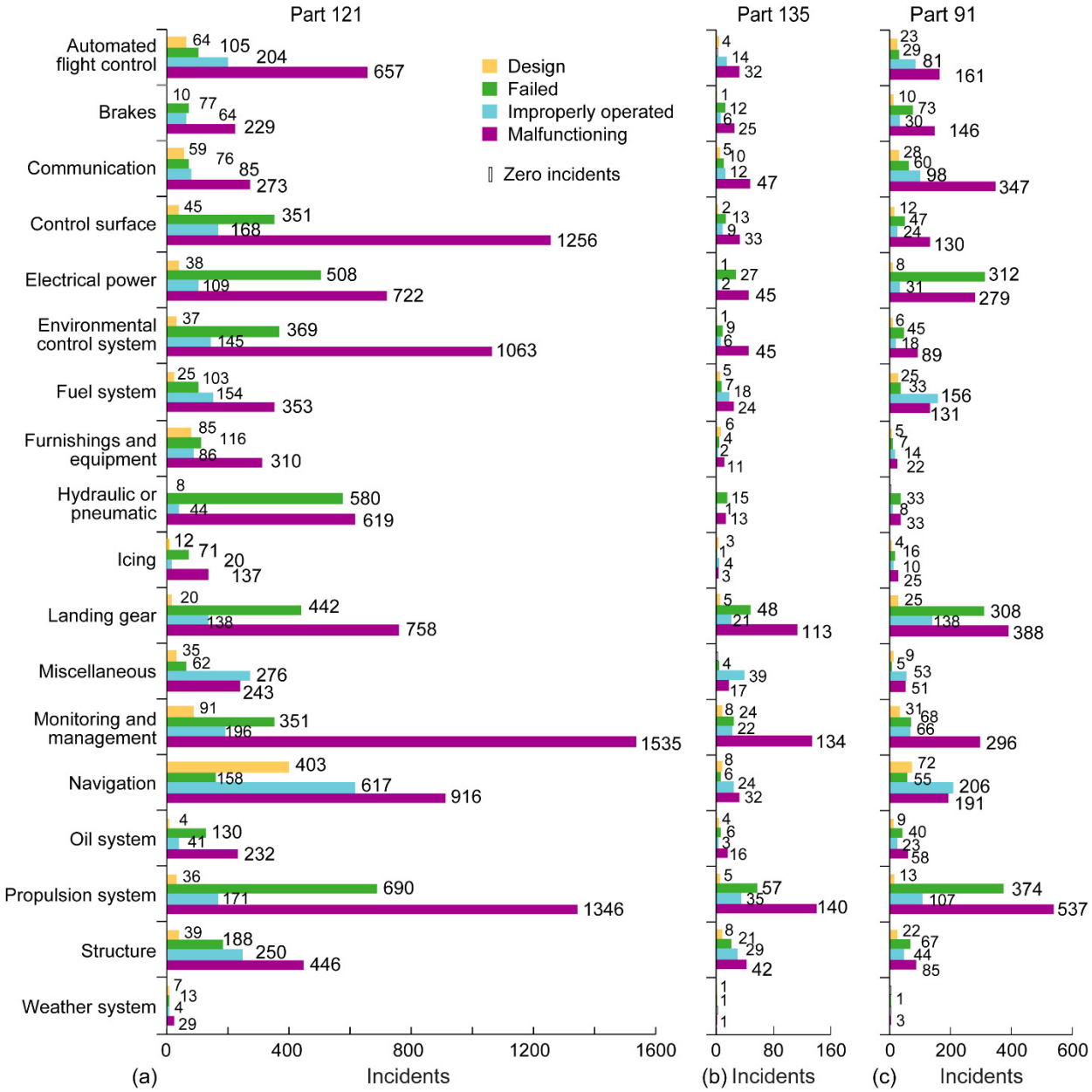


Figure 4.—SCFM-related incidents by SCFM category, component problem, and FAR part. (a) Part 121. (b) Part 135. (c) FAR Part 91.

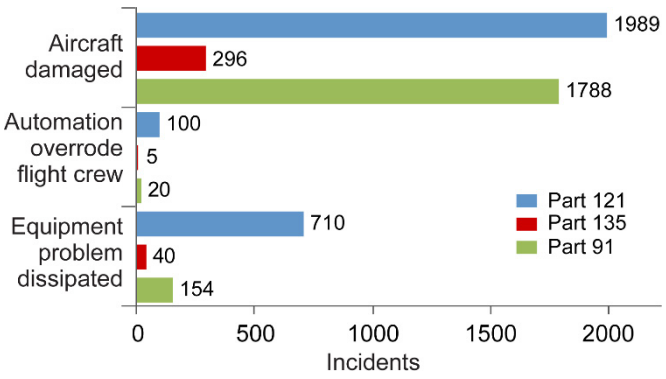


Figure 5.—SCFM-related incidents by aircraft results and FAR part.

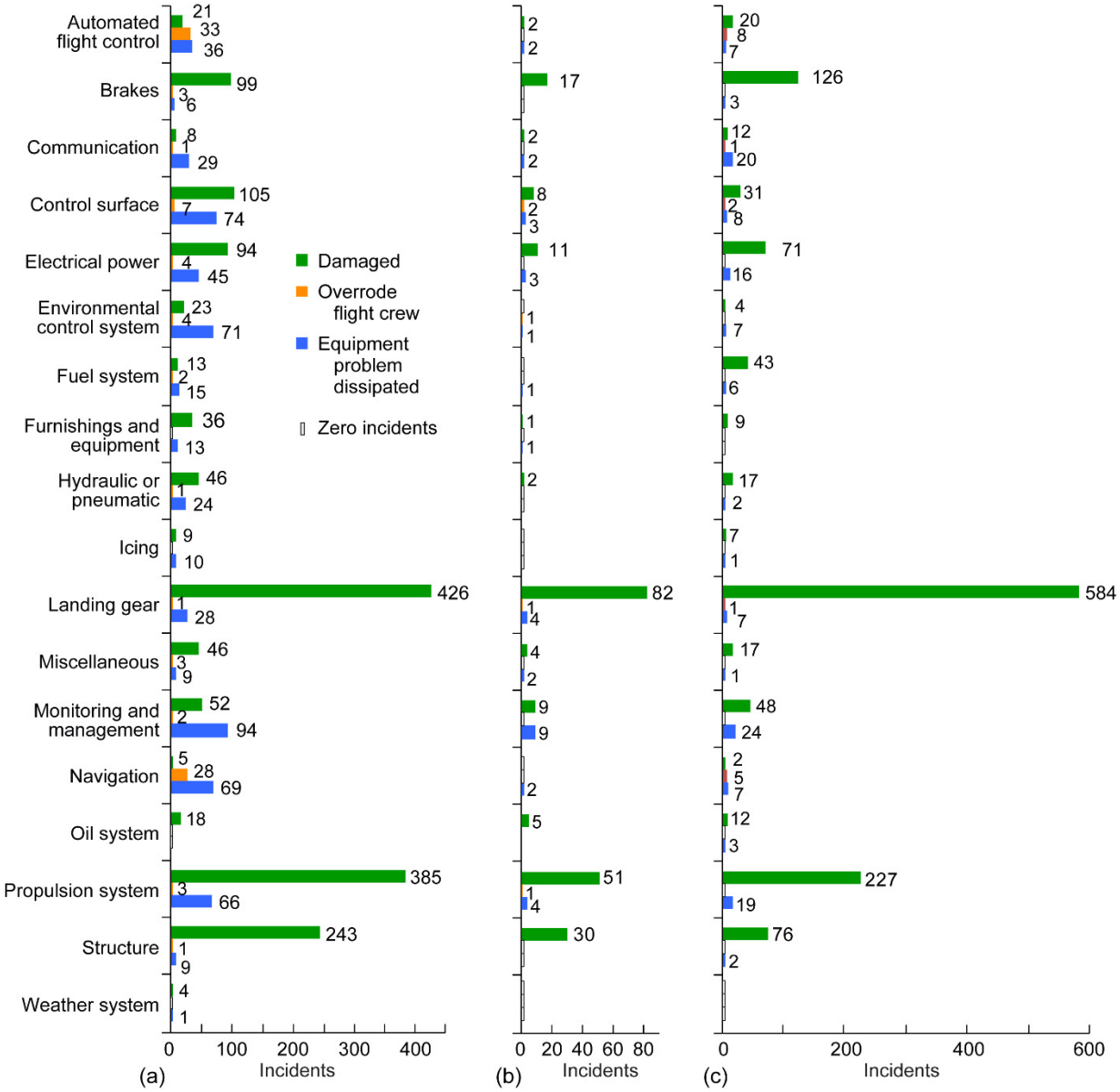


Figure 6.—SCFM-related incidents by SCFM category, aircraft results, and FAR part. (a) Part 121. (b) Part 135. (c) Part 91.

3.5 Flight Crew Results

Flight crew results is the last area directly applicable to SCFM incident analysis. Table 1 shows flight crew results by FAR part for SCFM-related incidents. Part 121 had 4043 diverted incidents, 2982 that overcame equipment problems, and 2572 that landed in emergency conditions. The top category for Part 135 was overcame equipment problem with 228 incidents, followed by diverted with 157 incidents. Both landed in emergency conditions and returned to clearance had 114 incidents. Part 91 had 1029 landed in emergency conditions incidents, 972 diverted incidents, and 825 overcame equipment problems.

Figure 7(a) (with more detail in Appendix B, Table B.6) shows the number of incidents by flight crew results and SCFM category for FAR Part 121. There were 10 345 incidents that listed an SCFM and a flight crew result. The most frequent combinations were propulsion and diverted with 648 incidents, navigation and returned to clearance with 492 incidents, and propulsion and landed in emergency conditions with 485. The diverted flight crew result had 5 of the top 10 tall poles for the combination of flight crew results and SCFM category.

The number of incidents by flight crew results and SCFM category for Part 135 can be seen in Figure 7(b) (with more detail in Table B.7). Only 588 incidents listed both a flight crew result and an SCFM for FAR Part 135. The most frequent were propulsion and diverted with 36 incidents, followed by propulsion and landed in emergency conditions with 27 incidents, and propulsion and overcame equipment problem with 23.

Flight crew results and SCFM category for FAR Part 91 can be seen in Figure 7(c) (with more detail in Table B.8). Of the 776 total incidents propulsion and landed in emergency conditions was the most frequent with 324 incidents, followed by propulsion and diverted with 207 incidents, and electrical power and diverted with 154.

TABLE 1.—SCFM[a]-RELATED INCIDENTS BY FLIGHT CREW RESULTS AND FAR[b] PART
[Shaded entries indicate the most frequent incidents for each FAR part (top 3 tall poles).]

Flight crew results	Part 121	Part 135	Part 91
Became reoriented	463	42	267
Diverted	4043	157	972
Executed go around/missed approach	705	58	310
Exited penetrated airspace	18	5	106
Flight crew complied with automation or advisory	0	0	0
In-flight shutdown	104	11	43
Landed as precaution	1719	77	486
Landed in emergency conditions	2572	114	1029
Overcame equipment problem	2982	228	825
Overrode automation	549	13	87
Regained aircraft control	529	56	313
Rejected takeoff	965	71	109
Requested ATC[c] assistance/clarification	0	0	0
Returned to clearance	1492	114	498
Returned to departure airport	624	24	111
Returned to gate	208	4	8
Took evasive action	870	49	339
Total	12511	752	3892

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.
[c]Air traffic control.

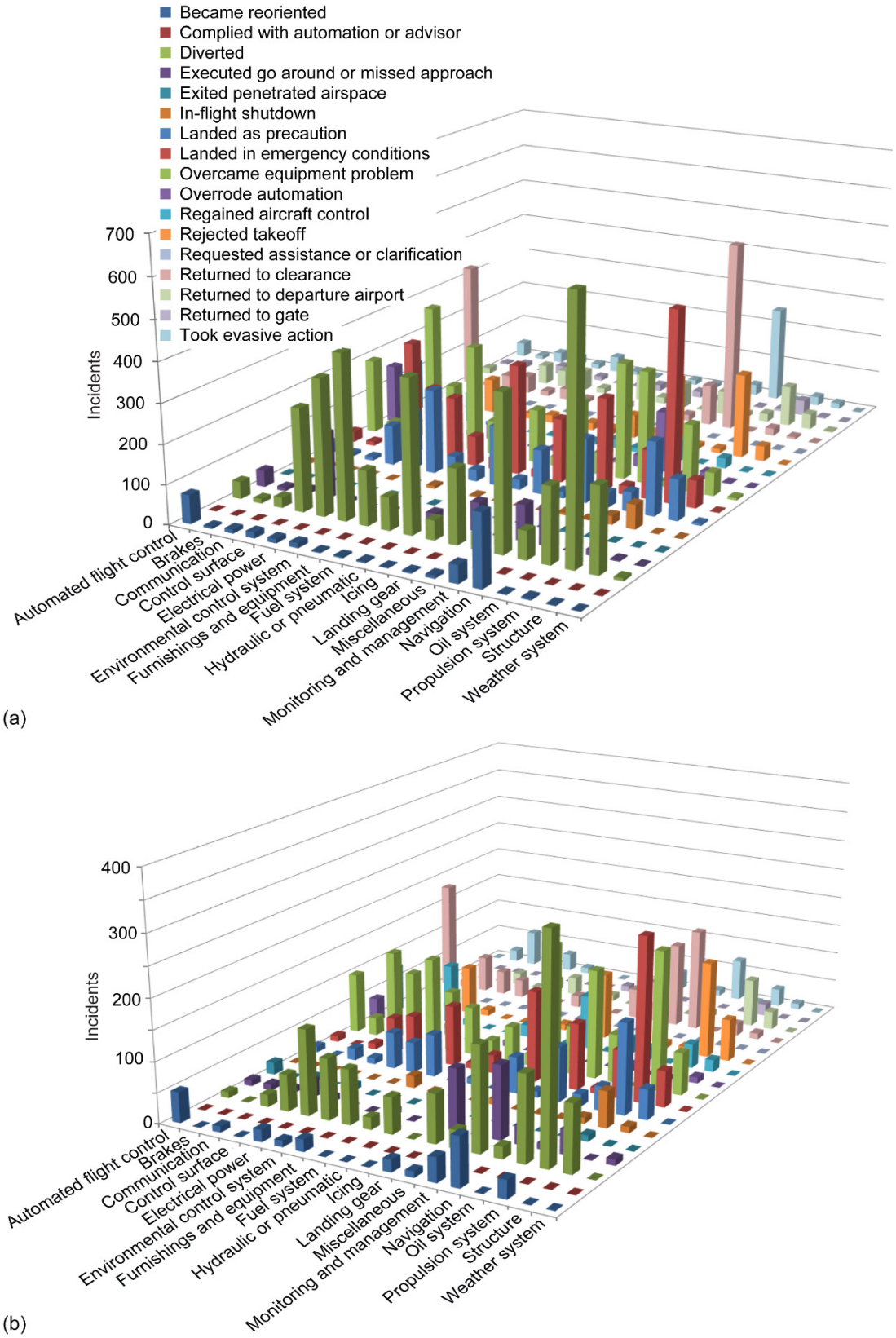
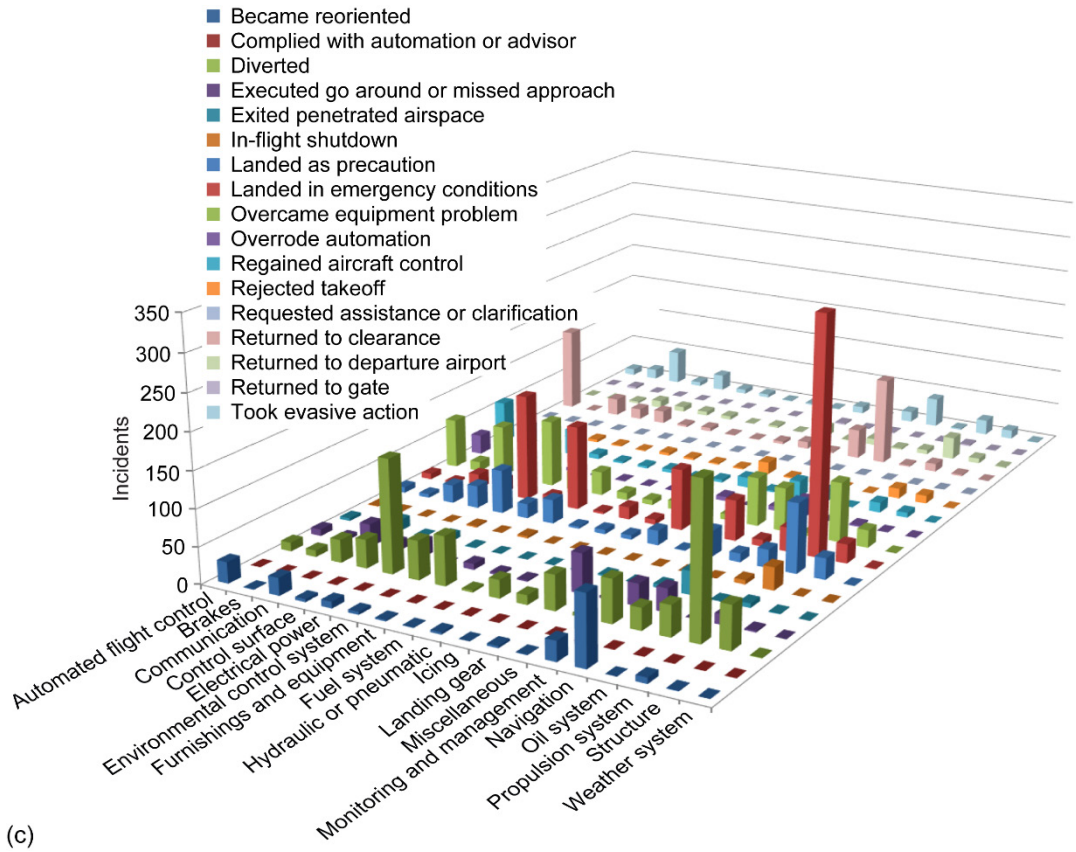


Figure 7.—SCFM-related incidents by SCFM category, flight crew results, and FAR part (a) Part 121. (b) Part 135. (c) Part 91.



(c)

Figure 7.—Concluded.

3.6 System Component Failure or Malfunction Conclusion

The SCFM analysis looked at aircraft as the primary problem or contributing factor and an initial data set containing 38 894 incidents. The analysis looked at FAR Parts 121, 135, and 91 along with phase of flight, SCFM category, the type of problem the component had, the aircraft result, and the flight crew results. There were 26 346 incidents for FAR Part 121, 1837 incidents for Part 135, and 7760 incidents for Part 91.

Table 2 summarizes the top three categories for SCFM-related incident by FAR part. Table 2(a), phase of flight, shows that parked had the greatest number of incidents for Part 121 and cruise had the most for Parts 135 and 91. Table 2(b), the SCFM category, shows that propulsion had the most incidents for all three FAR parts. Table 2(c), component problem, shows that component malfunctioning also had the most incidents for all three FAR parts. The top aircraft result was aircraft damaged as shown in Table 2(d). The top flight crew results are shown in Table 2(e) and the diverted category had almost a third of all Part 121 incidents.

Table 3 summarizes the top three SCFM category results for SCFM-related incident by FAR part. Table 3(a) displays the top 3 phases of flight and SCFM category. Part 121 had 685 incidents for both monitoring and management during the parked phase of flight and landing gear during parked. Table 3(b) shows the top component problems and SCFM category. Eight out of the nine top categories were malfunctioning components. Malfunctioning monitoring and management and propulsion were the top two for Part 121. Table 3(c) shows the aircraft results and SCFM category, with aircraft damaged and landing gear as the top result for each FAR part.

The final category analyzed for SCFM incidents, flight crew results and SCFM category, is shown in Table 3(d). Diverted with propulsion was the largest category for both Parts 121 and 135, but landed in emergency conditions with propulsion was the largest for Part 91.

TABLE 2.—TOP THREE CATEGORY RESULTS FOR SCFM[a]-RELATED INCIDENT FOR FAR[b] PARTS 121, 135, AND 91

(a) Phase of flight

		Part 121		Part 135		Part 91	
Cruise	9035	Parked	7353	Cruise	420	Cruise	2422
Parked	8862	Cruise	5371	Parked	347	Landing	1807
Initial approach	4803	Climb	3194	Landing	301	Initial approach	1264
Totals	37562		25540		1765		7532

(b) SCFM

		Part 121		Part 135		Part 91	
Propulsion	3954	Propulsion	2557	Propulsion	234	Propulsion	1039
Monitoring and management	3088	Monitoring and management	2341	Landing gear	189	Landing gear	836
Landing gear	2805	Control surface	2038	Monitoring and management	188	Electrical power	615
Totals	29323		21241		1340		5808

(c) Component problem

		Part 121		Part 135		Part 91	
Malfunctioning	15597	Malfunctioning	11244	Malfunctioning	793	Malfunctioning	3050
Failed	6467	Failed	4465	Failed	268	Failed	1602
Improperly operated	4366	Improperly operated	2814	Improperly operated	254	Improperly operated	1154
Totals	26249		18503		1289		5681

(d) Aircraft results

		Part 121		Part 135		Part 91	
Aircraft damaged	4429	Aircraft damaged	1989	Aircraft damaged	296	Aircraft damaged	1788
Equipment problem dissipated	957	Equipment problem dissipated	710	Equipment problem dissipated	40	Equipment problem dissipated	154
Automation overrode flight crew	132	Automation overrode flight crew	100	Automation overrode flight crew	5	Automation overrode flight crew	20
Totals	5500		2784		340		1961

(e) Flight crew results

		Part 121		Part 135		Part 91	
Diverted	5253	Diverted	4043	Overcame equipment problem	228	Landed in emergency conditions	1029
Overcame equipment problem	4479	Overcame equipment problem	2982	Diverted	157	Diverted	972
Landed in emergency conditions	3768	Landed in emergency conditions	2572	Landed in emergency conditions	114	Overcame equipment problem	825
				Returned to Clearance	114		
Totals			12511		752		3892

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE 3.—TOP THREE SCFM CATEGORY RESULTS FOR SCFM[a]-RELATED INCIDENTS BY FAR[b] PARTS 121, 135, AND 91

(a) Phase of flight and SCFM category

		Part 121		Part 135		Part 91	
Cruise/propulsion	981	Parked/monitoring and management	685	Landing/landing gear	92	Landing/landing gear	565
Landing/landing gear	939	Parked/landing gear	685	Cruise/propulsion	62	Cruise/propulsion	413
Parked/propulsion	817	Parked/propulsion	652	Parked/propulsion	47	Cruise/electrical power	297
Totals	28407		20652		1289		5636

(b) Component problem and SCFM category

		Part 121		Part 135		Part 91	
Malfunctioning/propulsion	2087	Malfunctioning/monitoring and management	1535	Malfunctioning/propulsion	140	Malfunctioning/propulsion	537
Malfunctioning/monitoring and management	2046	Malfunctioning/propulsion	1346	Malfunctioning/monitoring and management	134	Malfunctioning/landing gear	388
Malfunctioning/control surface	1464	Malfunctioning/control surface	1256	Malfunctioning/landing gear	113	Failed/propulsion	374
Totals	25823		18264		1259		5530

(c) Aircraft results and SCFM category

		Part 121		Part 135		Part 91	
Aircraft damage/landing gear	1119	Aircraft damaged/landing gear	426	Aircraft damaged/landing gear	82	Aircraft damaged/landing gear	584
Aircraft damaged/ propulsion	685	Aircraft damaged/ propulsion	385	Aircraft damaged/ propulsion	51	Aircraft damaged/ propulsion	227
Aircraft damaged/ structures	361	Aircraft damaged/ structures	243	Aircraft damaged/ structures	30	Aircraft damaged/brakes	126
Totals	4134		2312		262		1455

(d) Flight crew results and SCFM category

		Part 121		Part 135		Part 91	
Diverted/propulsion	910	Diverted/propulsion	648	Diverted/propulsion	36	Landed in emergency conditions/propulsion	324
Landed in emergency conditions/propulsion	850	Returned to clearance/ navigation	492	Landed in emergency conditions/propulsion	27	Diverted/propulsion	207
Returned to clearance/ navigation	654	Landed in emergency conditions/propulsion	485	Overcame equipment problems/propulsion	23	Diverted/electrical power	154
Totals	14379		10345		588		776

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

4.0 Human Factor Incident Analysis

The human factor incident data applies to SSAT in two areas: understanding the impact of degradation in human performance on aircraft performance and enabling the prediction of human performance to identify, evaluate, and resolve safety issues caused by human-automation interaction. Of the 83 478 total human factor incidents in the data set, 72 414 incidents listed human factor as the primary problem and 54 219 incidents listed human factor as the contributing factor between January 1993 and April 2011. The category of human factors, available since May 2009, was searched through April 2011 and 12 583 incidents were found.

Table 4 and Figure 8 summarize the human-factor-related incident data. Of the 83 478 total human factor incidents, 27 228 incidents listed human factor as a primary problem only; 37 011 as a primary problem and contributing factor; 13 as a primary problem and a human factor category; and 8162 as a primary problem, a contributing factor, and a human factor category, adding up to 72 414 incidents. Of

the 74 168 of the total human factor incidents that listed a FAR part, Part 121 had 46 063 incidents, Part 135 had 4496 incidents, and Part 91 had 23 609 incidents.

Some human factors could have been influenced by the time of day that the incidents occurred. The ASRS divides time of day into four equal groups starting at a minute past midnight. The time periods and FAR parts for the human factor incidents are shown in Figure 9. There were 3231 human factor incidents between 0001 and 0600 for Part 121; 13 987 incidents between 0601 and 1200; 15 348 incidents between 1201 and 1800; and 10 710 incidents between 1801 and 2400. For all three FAR parts, the greatest number of incidents occurred in the afternoon between 1201 and 1800 and the fewest number of incidents occurred at night between 0001 and 0600, which is also when the fewest number of flights take place.

There were 80 259 human-factor-related incidents that listed a phase of flight and the breakdown by FAR part is shown in Figure 10. The greatest number of incidents took place during cruise with 17 351 incidents, followed by initial approach with 14 899 incidents, and parked with 14 020 incidents. The greatest number of incidents occurred during the parked phase of flight for Part 121 with 10 468 incidents, followed by cruise for with 8100, and initial approach with 7609 incidents. The greatest number of incidents occurred during cruise with 888 incidents for Part 135 and with 6137 incidents for Part 91. Final approach had the fewest human-factor-related incidents for all three FAR parts.

TABLE 4.—HUMAN FACTOR DATA SUMMARY

Human factor type	Primary problem	Contributing factor	Human factor category
Human factor as a primary problem only	27 228		
Human factor as a contributing factor only		6656	
Human factor as a category only			2018
Human factor as a primary problem and contributing factor only	37 011	37 011	
Human factor as a primary problem and human factor category only	13		13
Human factor as a contributing factor and human factor category only		2390	2390
Human factor as a primary problem, contributing factor, and category	8162	8162	8162
Total human factor as primary problem	72 414		
Total human factor as contributing problem		54 219	
Total human factor as category			12 583
Total of all human factor types combined			83 478

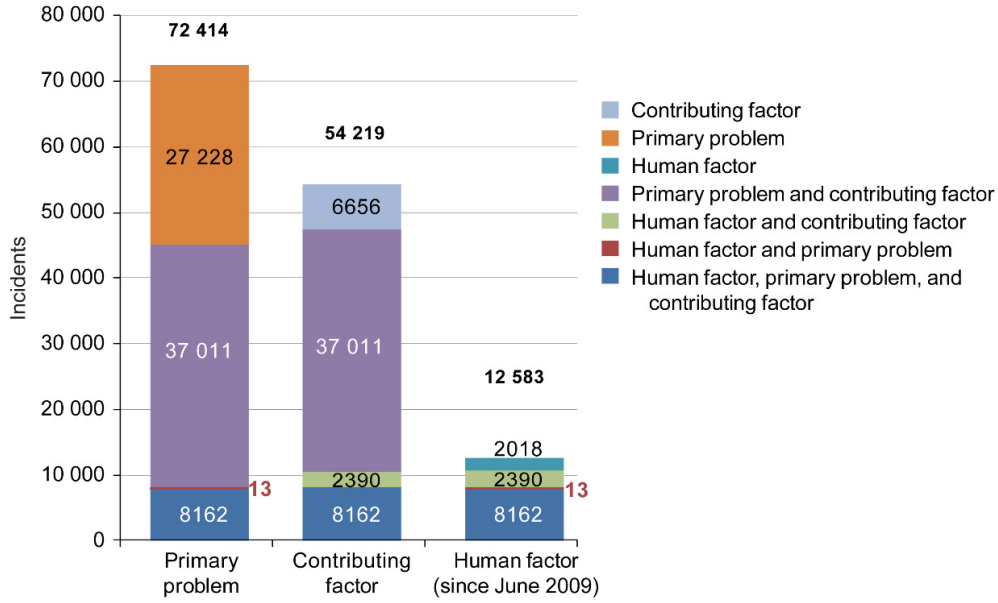


Figure 8.—Human-factor-related incidents by human factor search method.

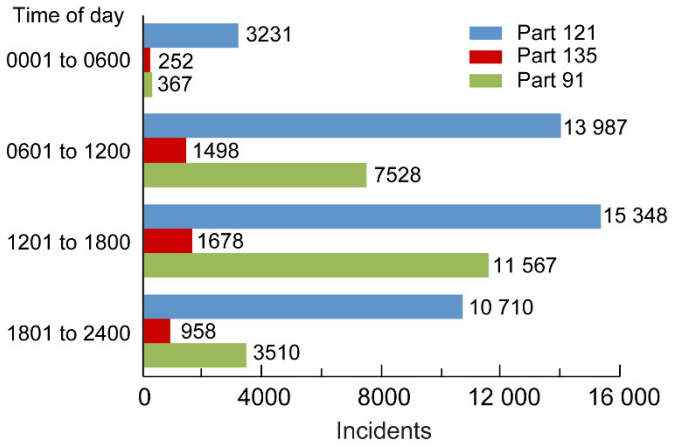


Figure 9.—Human-factor-related incidents by time of day and FAR part.

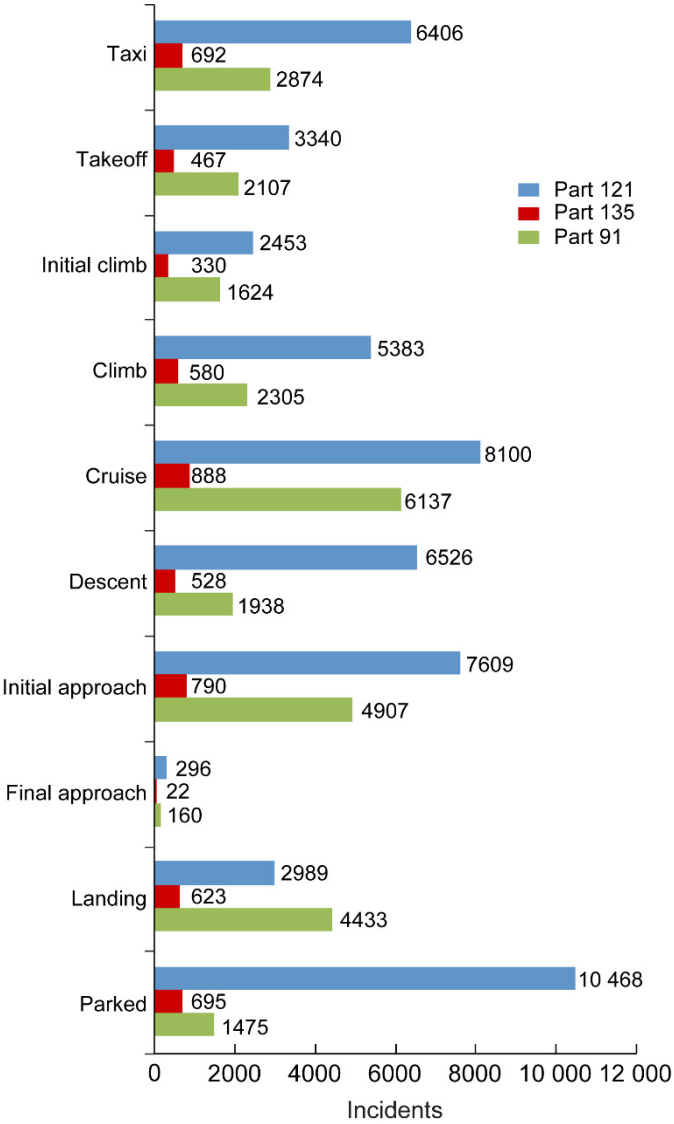


Figure 10.—Human-factor-related incidents by phase of flight and FAR part.

4.1 Human Factor Analysis and Classification System

The Human Factors Analysis and Classification System (HFACS) (Ref. 6) was developed to determine which causal factors led to accidents. Human factors were broken down into four levels of failure:

(1) Unsafe acts
(2) Unsafe aircrew conditions (preconditions for unsafe acts)
(3) Unsafe supervision
(4) Organizational influences

Appendix E shows the four failure levels and corresponding human factor examples for each category. The analysis team tried to use this classification system for the human- factor related incidents in the ASRS database, but it was more efficient to classify the human factor categories into HFACS levels. Assumptions had to be made to map the other ASRS categories to HFACS levels. For example, under the ASRS flight crew results category, executed go around or missed approach could be classified as HFACS unsafe acts if they occurred because of an improper procedure, misjudged distance, or another aircraft on the runway that made an error. Because not enough information is given to determine the cause or category without reading each narrative, only the human factor and communication breakdown categories are classified using the HFACS in this report. The rest of the human factors data will be presented without HFACS classification.

The 12 ASRS human factor categories were mapped to HFACS categories. There is a great deal of overlap between ASRS human factor categories and HFACS levels as shown in Table 5. The ASRS would need to create more detailed categories to map each incident more precisely.

Unsafe acts are both errors (decision, skill based, or perceptual) and violations (routine or exceptional). Errors are an individual's activities, both physical and mental, that do not accomplish the planned outcome. Five ASRS human factor categories were mapped to the HFACS unsafe acts category: confusion, distraction, human-machine interface, training/qualification, and troubleshooting. Confusion could include decision errors, like misdiagnosing an emergency and perceptual errors, like visual illusions. An example of distraction is the breakdown of visual scans and failure to prioritize. Many of the unsafe acts could be related to training/qualification, or troubleshooting because what most closely matches unsafe acts due to poor decisions or omitting steps in procedures.

Unsafe aircrew conditions are related to most aviation accidents including substandard conditions of operators—adverse mental state, adverse physiological state, and physical or mental limitations, and substandard operator practices such as crew resource mismanagement and personal readiness. Nine human factor categories are listed under unsafe aircrew conditions. Fatigue, physiological-other, and communication breakdown are very much related to substandard conditions of operators, where workload and time pressures are considered substandard operator practices.

Unsafe supervision is related to six ASRS human factor options. The HFACS unsafe supervision category includes inadequate supervision, resource management, planned inappropriate operations, supervisory violations, and failure to correct problems. ASRS human factor categories of training/qualification falls under unsafe supervision along with workload and fatigue when flight crews do not get enough rest opportunities.

Organizational influence, the final level, includes resource management, organizational climate, and organizational processes. Six ASRS human factor categories are related to organizational influence as shown in Table 5. Time pressure, training, purchasing unsuitable equipment, schedules, and communications align directly with the ASRS categories.

TABLE 5.—ASRS[a] HUMAN FACTOR CATEGORIES MAPPED TO HFACS[b] CATEGORIES

ASRS human factor category	HFACS category			
	Unsafe act	Unsafe aircrew conditions	Unsafe supervision	Organizational influences
Communication breakdown		✓	✓	✓
Confusion	✓	✓		
Distraction	✓	✓		
Fatigue		✓	✓	
Human-machine interface	✓	✓		✓
Other-unknown				
Physiological-other		✓	✓	✓
Situational awareness		✓		
Time pressure		✓	✓	✓
Training/qualification	✓		✓	✓
Troubleshooting	✓			
Workload		✓	✓	✓

[a]Aviation Safety Reporting System.

[b]Human Factors Analysis and Classification System.

4.2 Human Factor Categories

There were 12 583 incidents that listed a human factor category with 9359 for Part 121, 357 for Part 135, and 1993 for Part 91. Figure 11 shows each human factor category by FAR part. Of the 5771 troubleshooting incidents, the largest category, 4761 incidents were for Part 121. Of the 4673 time pressure incidents, the next largest category, 4018 incidents were for Part 121. Troubleshooting with 152 incidents and situational awareness with 962 incidents were the largest categories for Parts 135 and 91, respectively. Surprisingly, fatigue and physiological-other were the smallest categories with only 307 and 228, respectively, for all FAR parts combined.

Figure 12(a) to (d) break down the incidents by human factor category and time of day. Figure 12(a) shows the 11 209 incidents for FAR Parts 121, 135, and 91 combined. Troubleshooting was the most frequent human factor category during all four time periods, followed by time pressure and situational awareness.

Figure 12(b) shows the 8117 total incidents for FAR Part 121. There were 2454 incidents occurring during 0601 to 1200 and 2447 incidents during 1201 to 1800. The top Part 121 human factor category for all time periods was troubleshooting followed by time pressures.

Figure 12(c) shows the 335 total incidents for Part 135. Troubleshooting and situational awareness each had 138 incidents for all four time periods combined, and the afternoon was also the largest time period for both.

Figure 12(d) shows the 1912 total Part 91. Situational awareness was the most frequent for all time periods, with 437 incidents occurring in the afternoon.

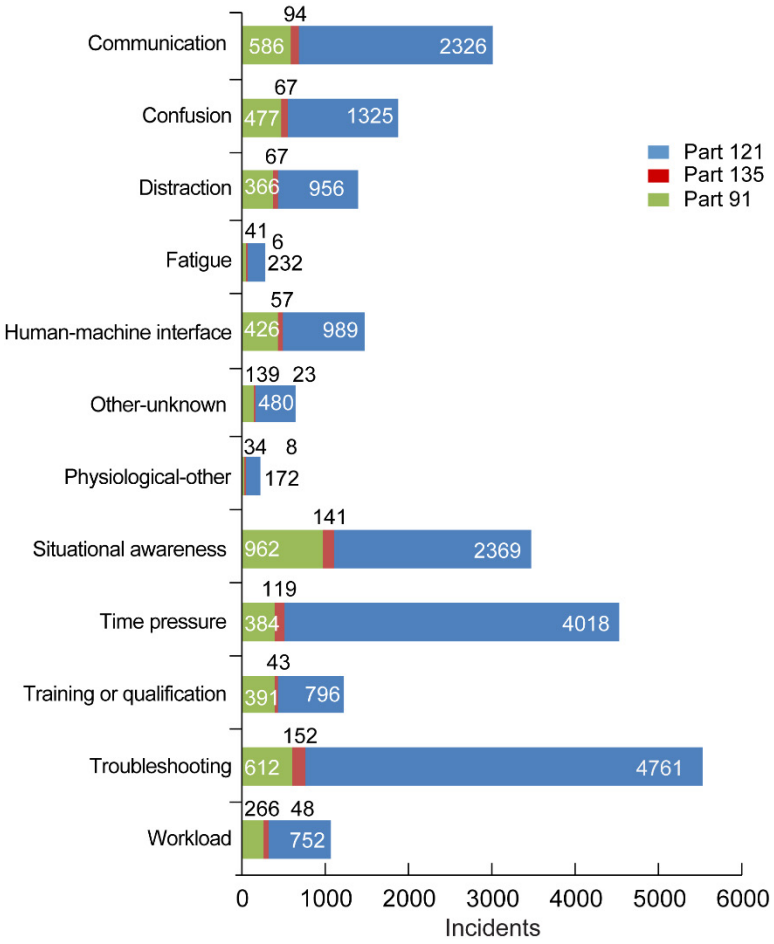


Figure 11.—Human-factor-related incidents by human factor category and FAR part.

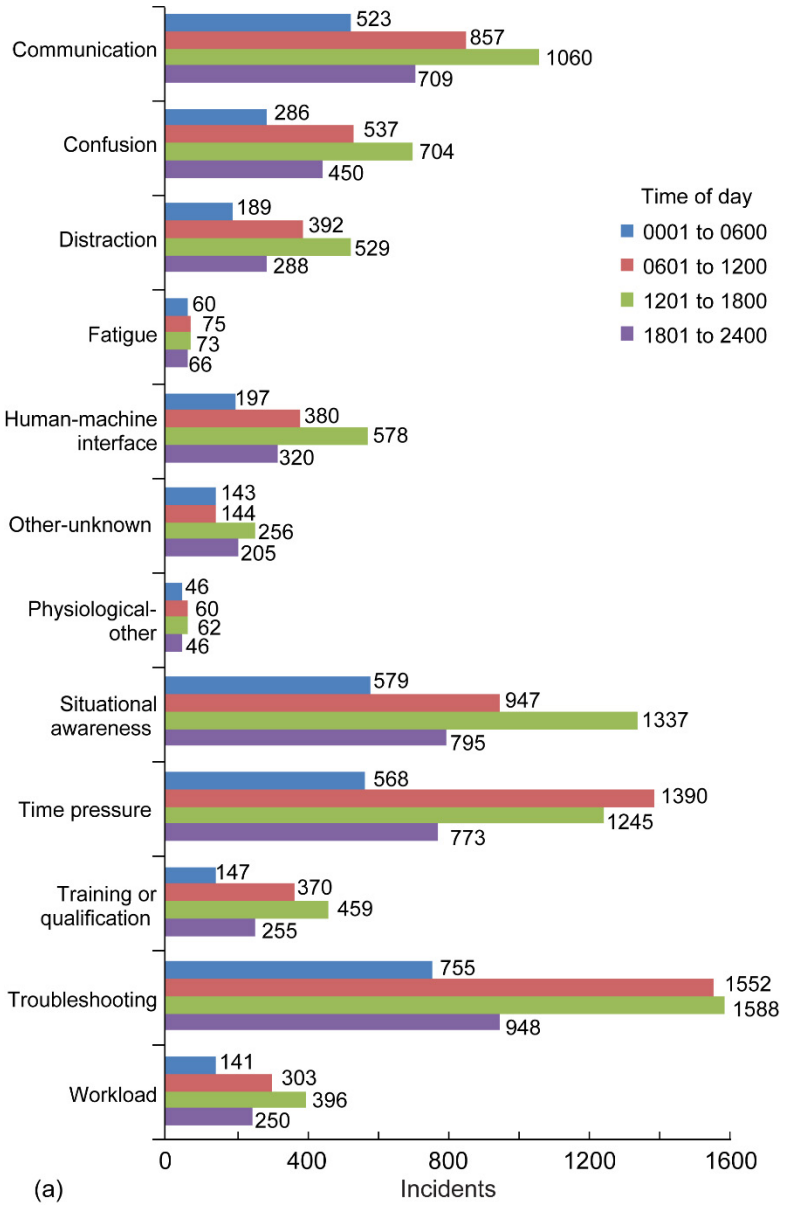


Figure 12.—Human-factor-related incidents for human factors category by time of day and FAR part. (a) FAR Parts 121, 135, and 91 combined (b) FAR Part 121. (c) FAR Part 135. (d) FAR Part 91.

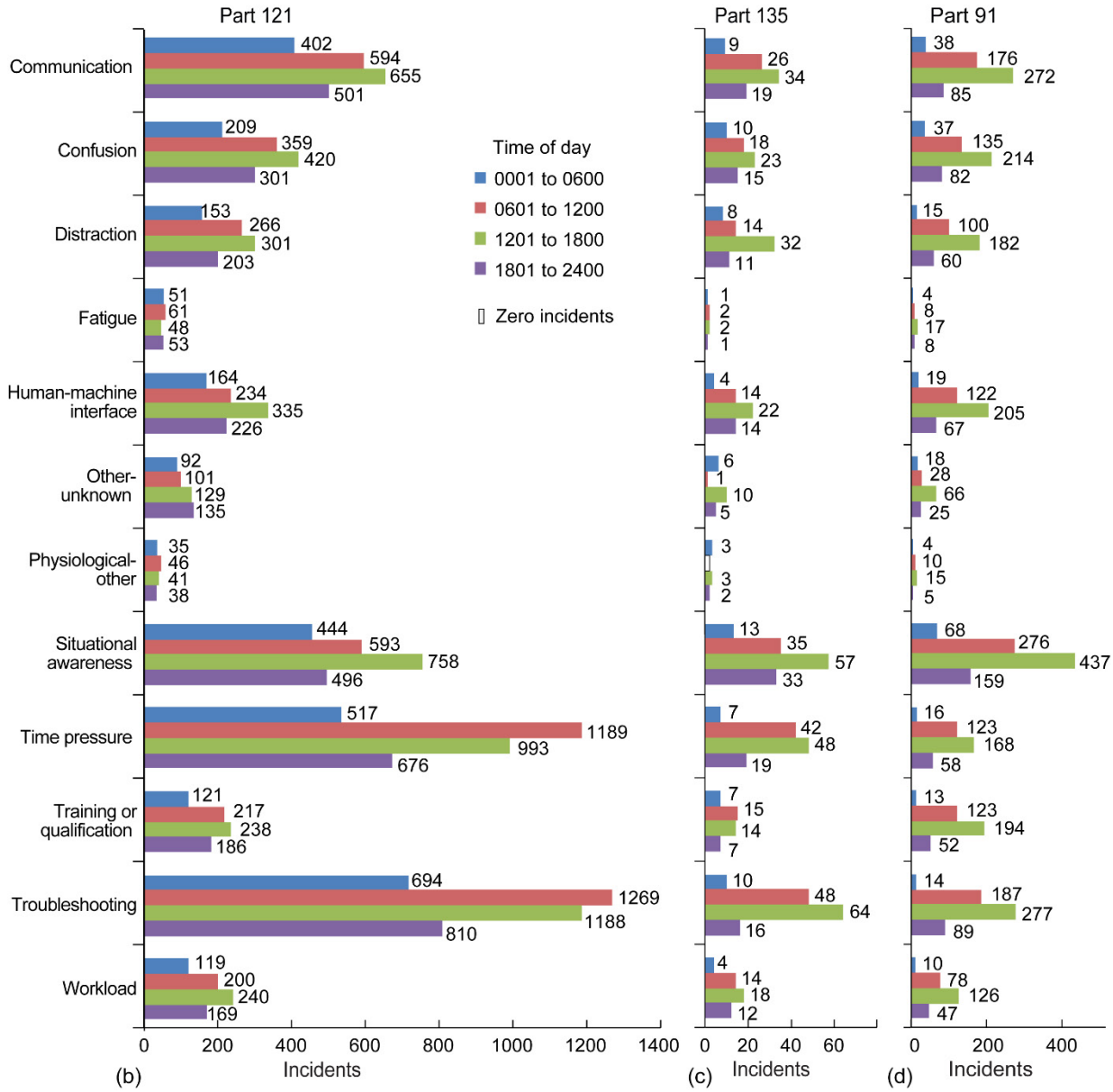


Figure 12.—Concluded.

4.3 Flight Crew Results

Flight crew results were analyzed for the human-factor-related incidents to determine what specific human factors were involved. There were 33 977 human-factor-related incidents with a flight crew result. The flight crew took evasive action in 11 124 incidents and returned to clearance in 10 321 incidents. No incidents were reported for flight crew complied with automation/advisory or for requested air traffic control (ATC) and therefore are not shown in the following figures.

Figure 13 displays the flight crew results for FAR Parts 121, 135, and 91 combined. There were 18 764 incidents that listed a flight crew result for Part 121, 1837 incidents for Part 135, and 10 108 incidents for Part 91. Returned to clearance with 6190 incidents was the largest category for Part 121, followed by took evasive action with 5665 incidents. Returned to clearance and took evasive action were also the top two categories for Part 135, but took evasive action with 3469 incidents followed by returned to clearance were the top two categories for Part 91.

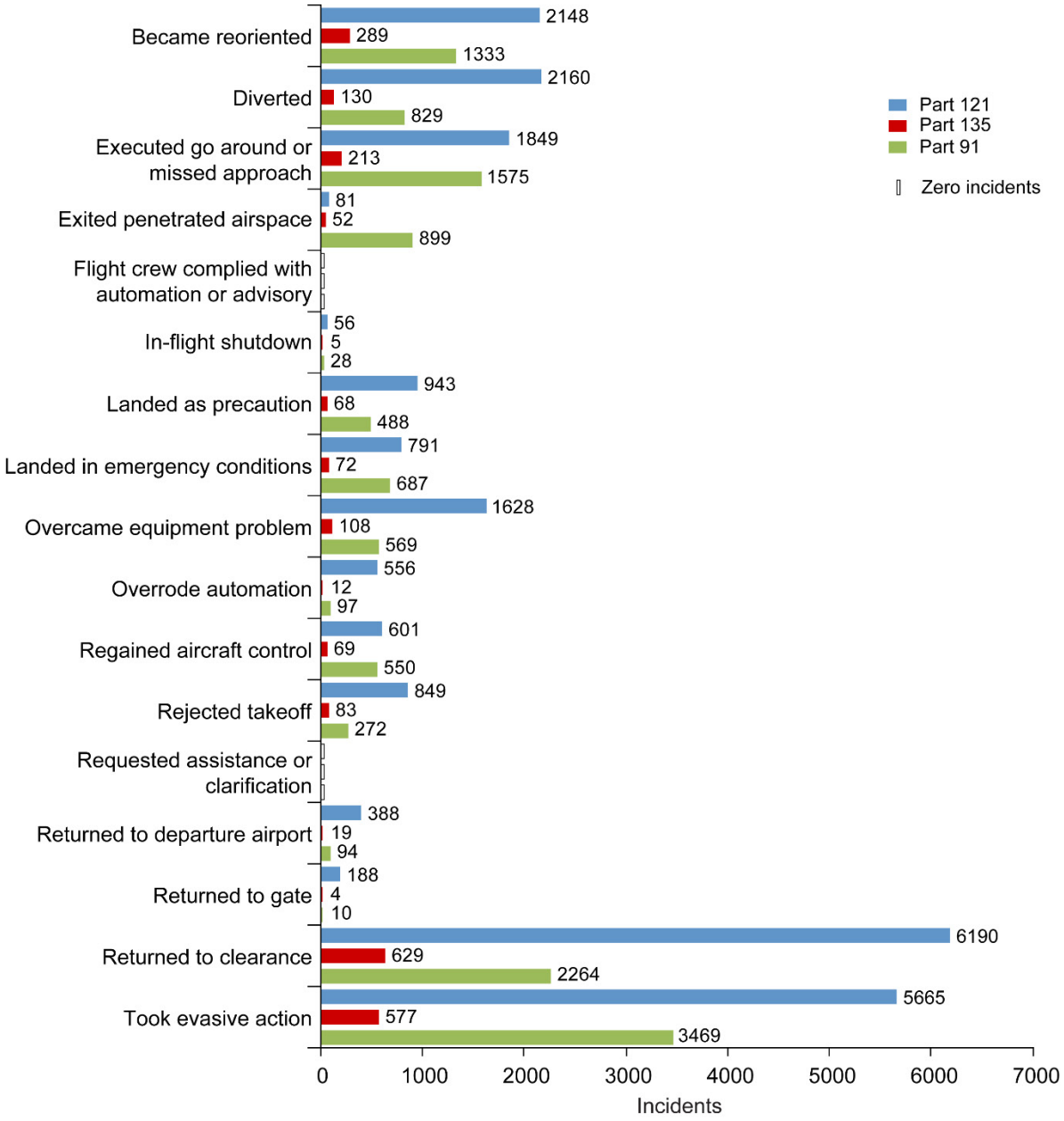


Figure 13.—Human-factor-related incidents by flight crew results and FAR part.

A comparison of the human factor categories and flight crew results can be seen in Figure 14 (with more detail in Appendix B, Table B.9). Although there were a total of 3904 incidents that listed both a human factor category and a flight crew result, it cannot be assumed that any of the human factors caused the flight crew result without reading each narrative. The most frequent category was troubleshooting during the diverted flight crew result with 720 incidents, followed by situational awareness and took evasive action with 469 incidents. Four of the top nine tall poles are the situational awareness human factor category and three are the flight crew result of diverted.

There were 32 945 incidents that listed a flight crew result and a time of day as shown in Figure 15. The most frequent, took evasive action, occurred from 1201 to 1800 with 5013 incidents, followed by returned to clearance from 1201 to 1800 with 4123 incidents. Took evasive action and returned to clearance were the largest categories for all four time periods.

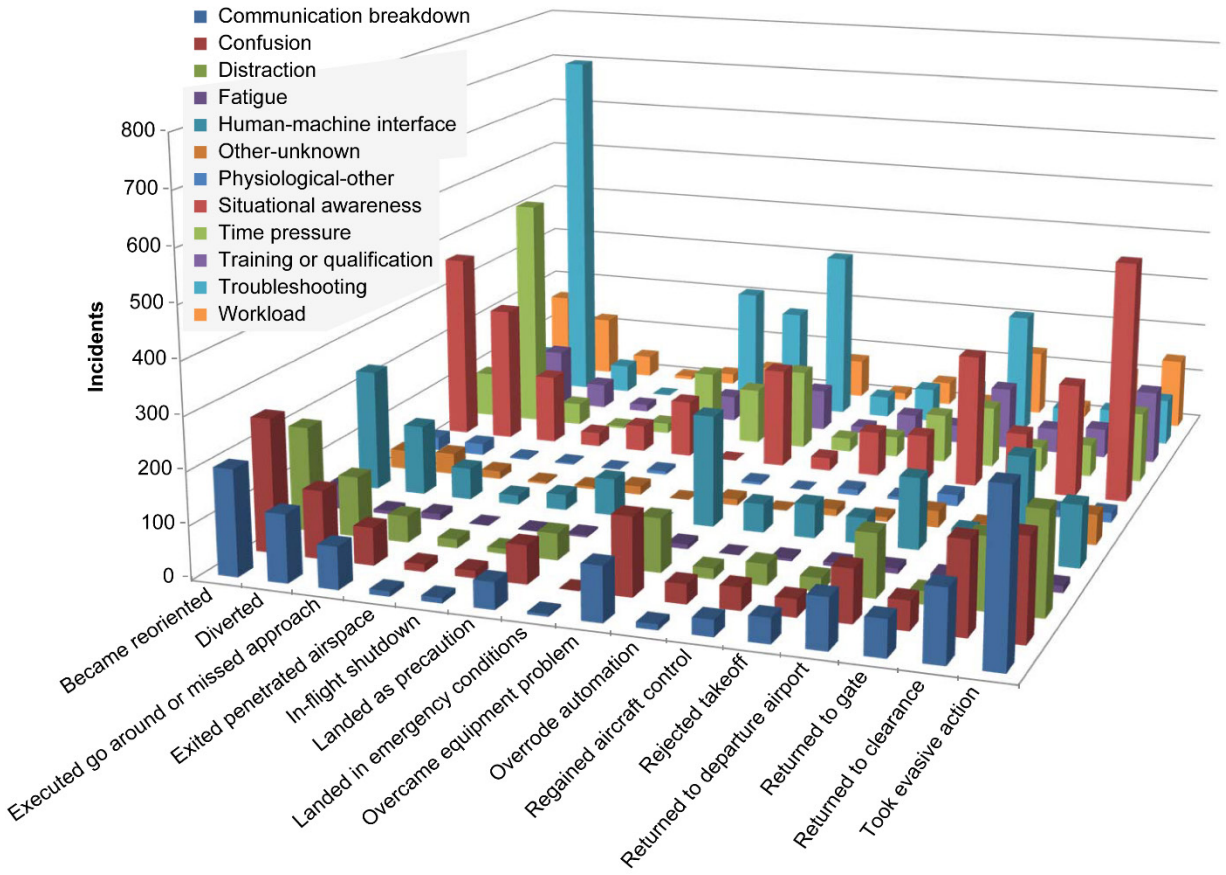


Figure 14.—Human-factor-related incidents by flight crew results and human factor category.

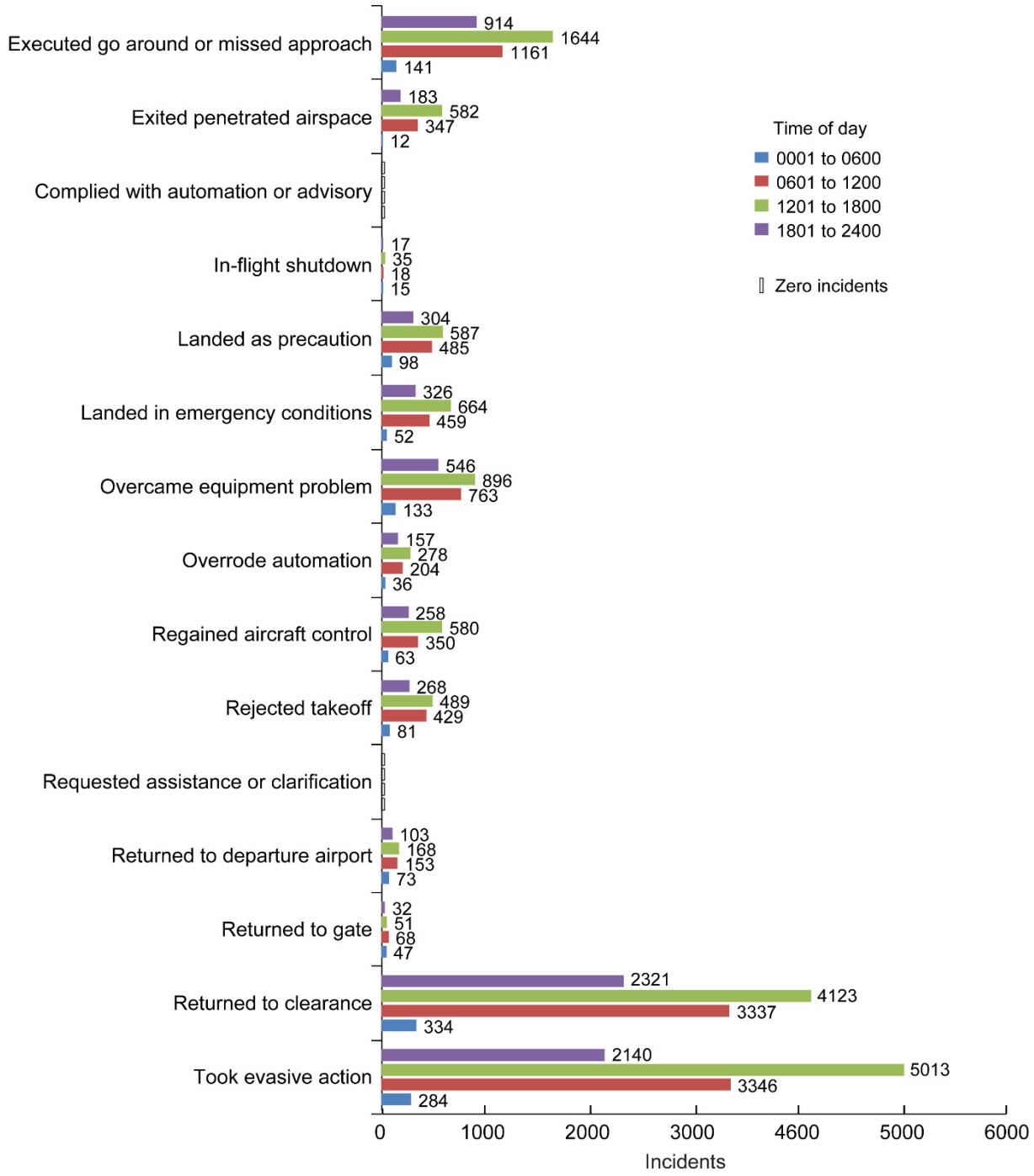


Figure 15.—Human-factor-related incidents by flight crew results and time of day.

4.4 Communication Breakdown Results

Communication breakdown refers to communication between two parties. The parties are air traffic controllers, dispatchers, flight attendants, flight crew, ground personnel, maintenance workers, and others.

Only 2625 incidents listed a breakdown between two parties for FAR Parts 121, 135, and 91 combined; ATC to flight crew had the greatest number of incidents with 1005, followed by flight crew to flight crew with 471 incidents. Communication breakdown by FAR part can be seen in Figure 16. The most communication breakdowns were for Part 121 with 1735 total incidents, followed by 544 incidents for Part 91, and 85 incidents for Part 135. ATC to flight crew had 558 incidents for Part 121, followed by maintenance to maintenance with 339 incidents. ATC to flight crew had 34 incidents and flight crew to flight crew had 31 incidents for Part 135. ATC to flight crew also had the greatest number of incidents with 324 for Part 91 followed by flight crew to flight crew with 173 incidents.

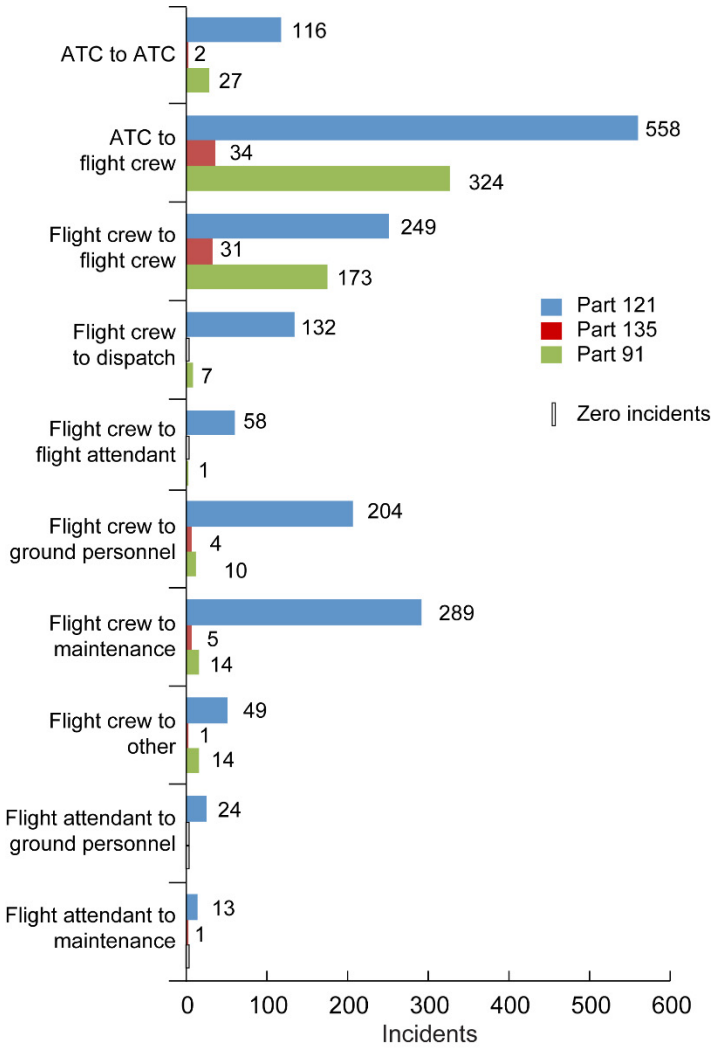


Figure 16.—Human-factor-related incidents by communication breakdown between parties and FAR part.

A comparison of communication breakdown between two parties and the human factor category can be seen in Figure 17 (with more detail in Appendix B, Table B.10 to Table B.13). There were 2625 incidents that listed both a communication breakdown and a human factor category. Only the categories with more than 15 incidents are shown in Figure 17, although all data is shown in Table B.13. The largest category was ATC to flight crew and communication breakdown with 1005 incidents and ATC to flight crew with situational awareness human factor was the next largest with 516 incidents. Five out of the top 10 tall poles were in the communication breakdown human factor category and 4 out of the top 10 tall poles were in the ATC to flight crew communication between parties category.

Table B.11 subcategorizes the 1735 total communication breakdown between parties and human factor category incidents for FAR Part 121. The most frequent was ATC to flight crew with a communication breakdown with 558 incidents. The greatest number of tall poles was in the communication breakdown human factor with 6 out of 10 tall poles and ATC to flight crew had the largest number of tall poles for communication breakdown between two parties with 3 out of 10 tall poles.

Table B.12 subcategorizes the 85 total communication breakdown between parties and human factor category incidents for FAR Part 135. The most frequent was also ATC to flight crew with a communication breakdown with 34 incidents. The largest number of tall poles was in the communication breakdown human factor with 3 out of 10 tall poles. ATC to flight crew had the largest number of tall poles for communication breakdown between two parties with 7 out of 10 tall poles.

Table B.13 subcategorizes the 544 total communication breakdown between parties and human factor category incidents for FAR Part 91. The most frequent was ATC to flight crew with a communication breakdown with 324 incidents. The greatest number of tall poles was in the communication breakdown human factor with 2 out of 10 tall poles. ATC to flight crew had the largest number of tall poles for communication breakdown between two parties with 9 out of 10 tall poles.

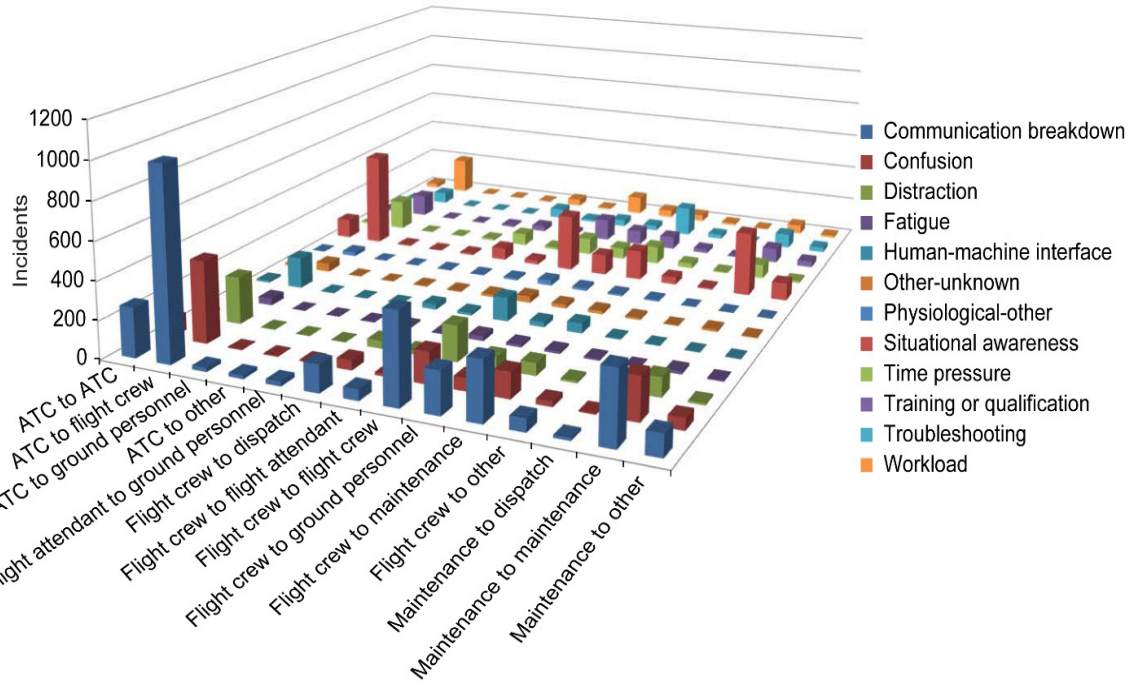


Figure 17.—Human-factor-related incidents by communication breakdown between parties and human factor category.

4.5 Conflict Anomalies

There are four types of conflict anomalies and the definitions are in Appendix C:

(1) Near-midair collision (NMAC)
(2) Airborne
(3) Ground, critical
(4) Ground, less severe

Of the 9879 incidents that listed a conflict anomaly, 4667 incidents were categorized as NMAC; 3065 incidents as ground conflict critical; and 2342 as ground conflict, less severe. No incidents were categorized as airborne.

Figure 18 shows the conflict anomalies by FAR part. There were 3677 conflict anomaly incidents for Part 121, 711 incidents for Part 135, and 4310 incidents for Part 91. The greatest number of NMACs—2347—were for Part 91, followed by 1289 for Part 121.

Conflict anomalies were also subcategorized by phase of flight as shown in Figure 19. It is interesting to note that 1604 NMACs occurred during initial approach, followed by 1223 during cruise. Most critical and less severe ground conflict incidents occurred during taxi.

Conflict anomalies and human factors are shown in Figure 20. There were 498 incidents that listed both a conflict anomaly and a human factor category. It cannot be assumed that there is a direct correlation between the human factor category and the conflict anomaly without reading each narrative. Situational awareness with 350 incidents and communication breakdown with 294 incidents had the greatest number of conflict anomalies both combined and individually.

Finally, conflict anomalies and the time of day are shown in Figure 21 with a total of 9639 incidents. NMACs as well as critical and less severe ground conflicts occurred most frequently between 1201 and 1800.

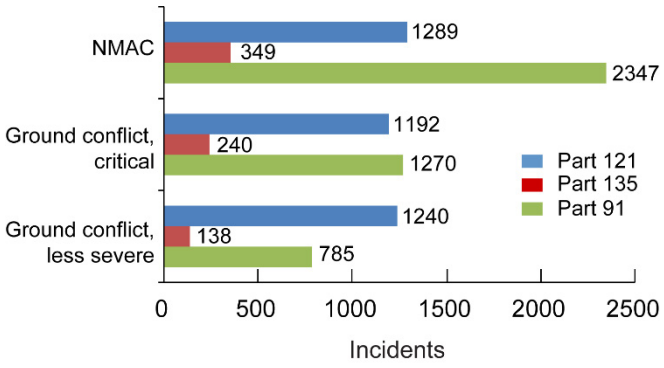


Figure 18.—Human-factor-related incidents by conflict anomaly and FAR part.

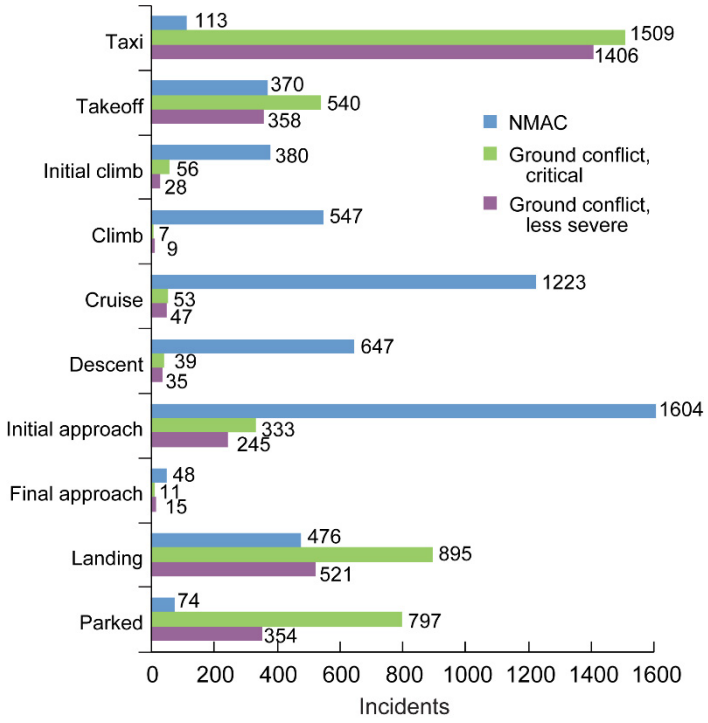


Figure 19.—Human-factor-related incidents by conflict anomaly and phase of flight.

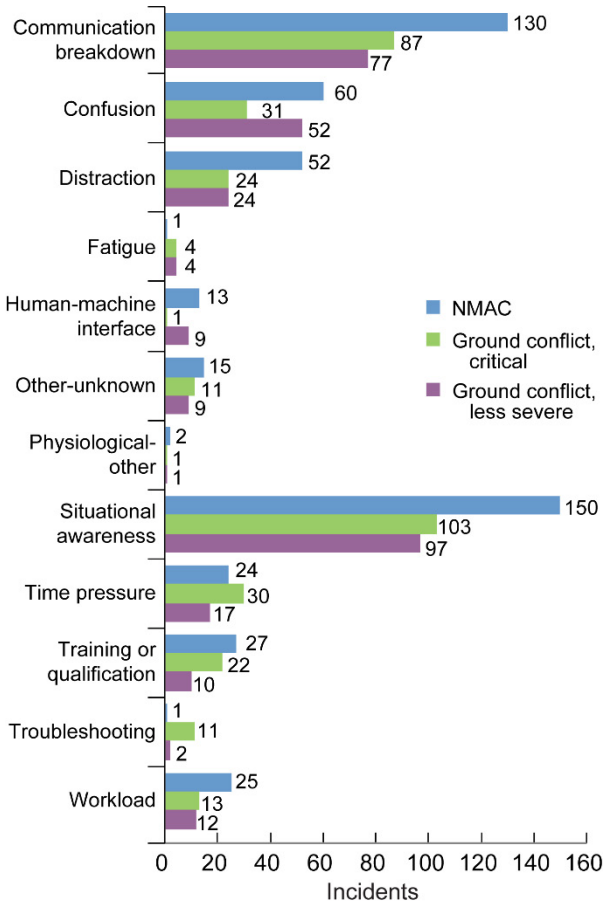


Figure 20.—Human-factor-related incidents by conflict anomaly and human factor category.

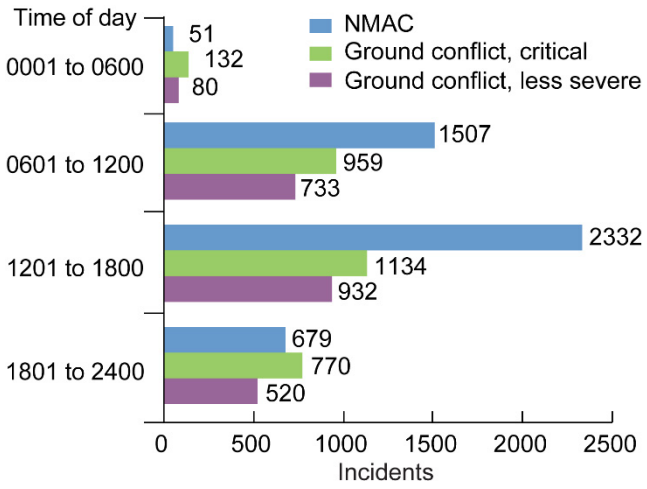


Figure 21.—Human-factor-related incidents by conflict anomaly and time of day.

4.6 In-Flight Event or Encounter Anomalies

There were 9120 incidents associated with in-flight events or encounter anomalies. A description of each in-flight event or encounter anomaly can be found in Appendix C. Weather and turbulence had the most with 4657 incidents, followed by other-unknown with 1670 incidents, loss of aircraft control with 1528, and controlled flight toward [or into] terrain (CFTT or CFIT) with 1480 incidents. Only 62 bird or animal and 25 object incidents were reported for this data set.

In-flight event or encounter anomaly data by FAR part is shown in Figure 22. Weather or turbulence incidents were the most frequent for all three FAR parts with 2083 incidents for Part 121, 305 incidents for Part 135, and 1794 incidents for Part 91. Unstabilized approach was next with 648 incidents and CFTT or CFIT with 524 incidents for Part 121. LOC incidents were the second most frequent with 77 incidents and CFTT or CFIT with 75 incidents for Part 135. LOC incidents were also the second most frequent with 903 incidents and CFTT or CFIT with 616 incidents for Part 91.

In-flight event or encounter anomalies by phase of flight can be seen in Figure 23. The greatest number of incidents occurred for weather or turbulence during cruise with 1472 incidents, followed by weather or turbulence during initial approach with 1367 incidents, and weather or turbulence during landing with 750 incidents. Weather or turbulence incidents were highest for each phase of flight except for final approach, which was CFFT or CFIT. LOC incidents were the second most frequent for takeoff, climb, and landing, but CFFT or CFIT was second for initial climb, cruise, descent, and initial approach. Bird or animal encounters were the highest during initial approach, parked, and takeoff.

A comparison of in-flight event or encounter anomalies and human factor categories can be seen in Figure 24 (with more detail in Appendix B, Table B.14). There were 915 total incidents with an in-flight anomaly and a human factor. Weather or turbulence and situational awareness was the most frequent type with 164 incidents, followed by CFFT or CFIT and situational awareness with 107 incidents. Note that a direct correlation between the anomaly and the human factor cannot be determined unless each narrative is read.

There were 8836 incidents with both an in-flight event or encounter anomaly and a time of day as shown in Figure 25. The greatest number of incidents occurred for weather or turbulence from 1201 to 1800 with 1893 incidents, followed by 0601 to 1200 with 1385 incidents, and 1801 to 2400 with 1036 incidents. There were 524 CFTT or CFIT incidents that occurred from 1201 to 1800, 434 incidents from 0601 to 1200, and 395 incidents from 1801 to 2400. The afternoon time period had the highest frequency for each in-flight event or encounter anomaly.

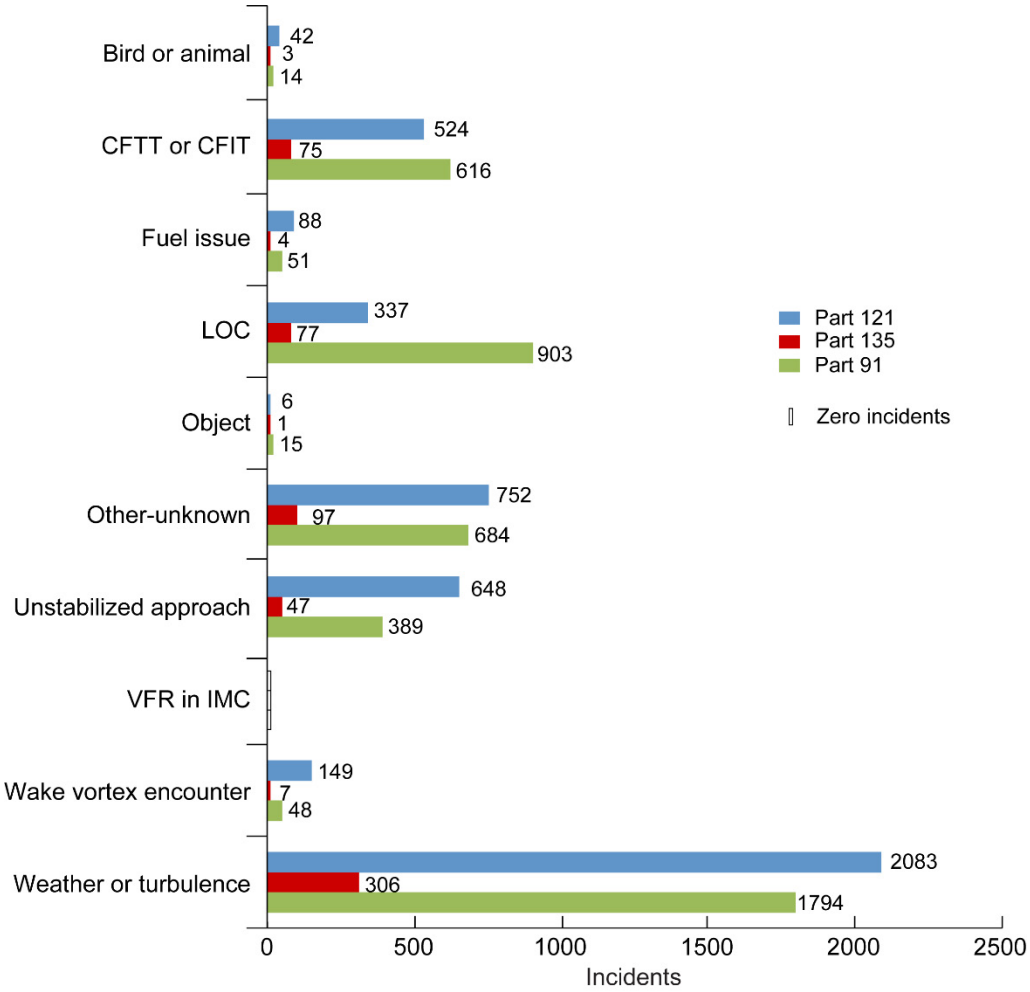


Figure 22.—Human-factor-related incidents by in-flight event or encounter and FAR Part.

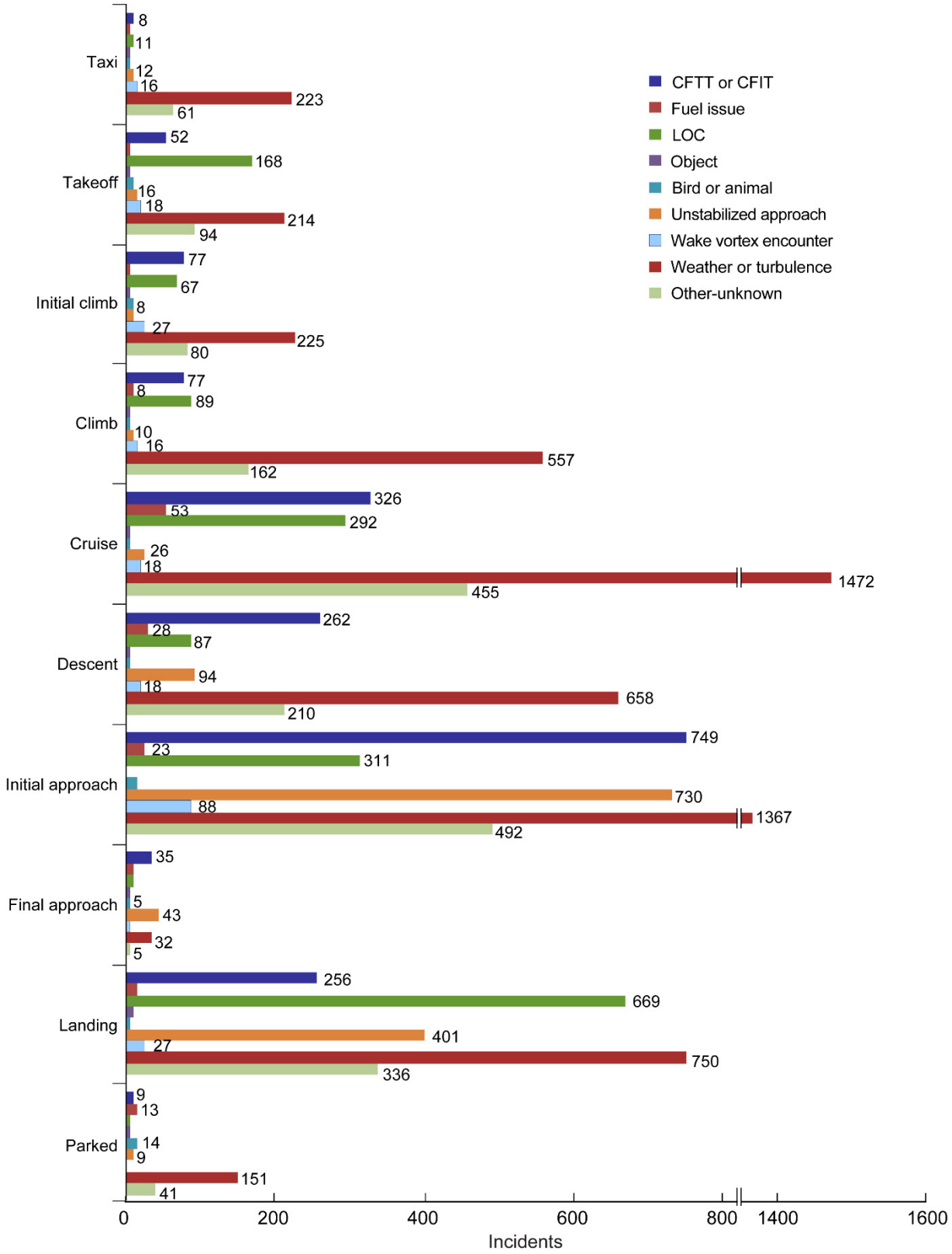


Figure 23.—Human-factor-related incidents by in-flight event or encounter and phase of flight.

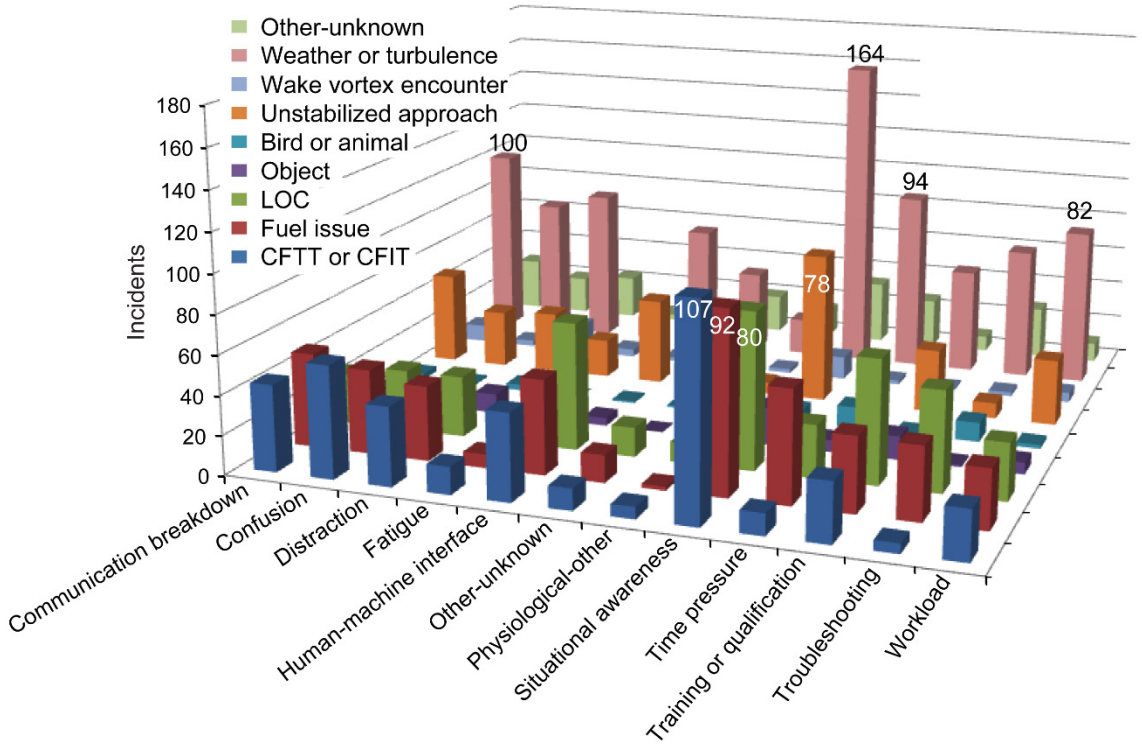


Figure 24.—Human-factor-related incidents by in-flight event or encounter and human factor category.

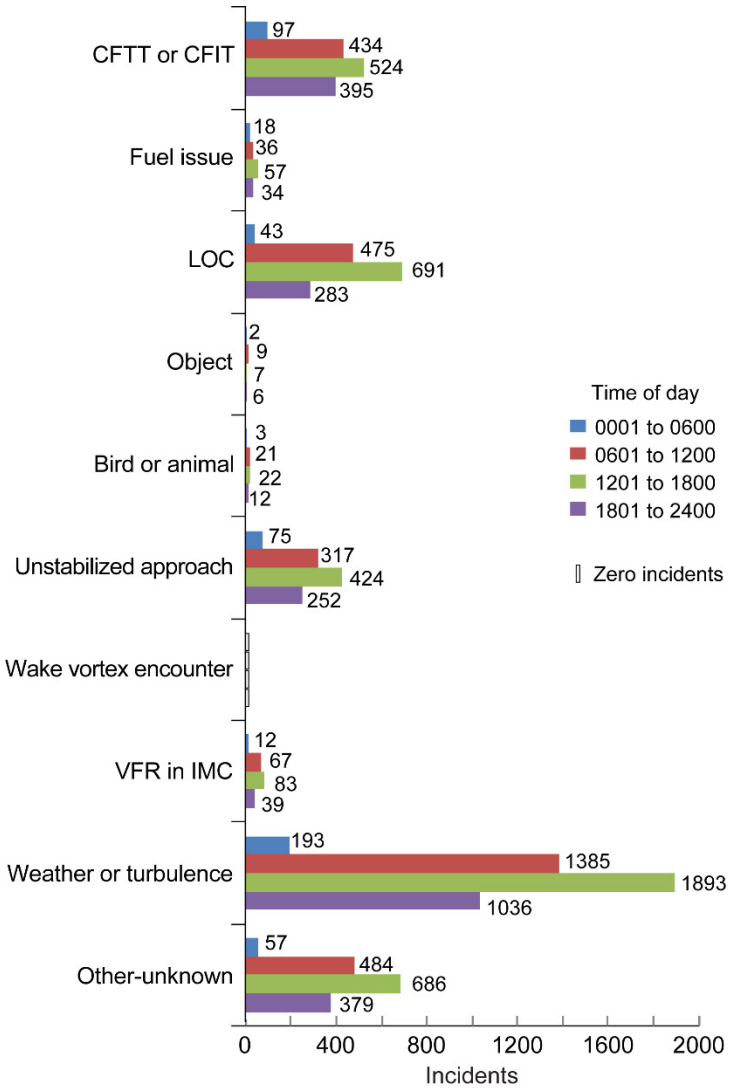


Figure 25.—Human-factor-related incidents by in-flight event or encounter and time of day.

4.7 Ground Incursion Anomalies

Ground incursion incidents occur when aircraft, vehicles, or people on the runway or taxiway enter a confined, marked, or identified standard movement area when they should not be there. A description of ground incursion anomalies can be found in Appendix C. There were 6555 incidents that listed a ground incursion anomaly for the human-factor-related data.

Runway incursions, with 5759 incidents, were more than 6 times greater than taxiway incursions with 899 incidents. There were 2471 runway and 529 taxiway incursions for FAR Part 121, 462 runway and 42 taxiway incursions for FAR Part 135, and 2345 runway and 261 taxiway incursions for Part 91.

Human factor categories were added to the ground incursion data and are shown in Figure 26. Of the 265 incidents that had both a ground incursion and a human factor, situational awareness has the greatest number of runway incursions with 128, followed closely by communication breakdown with 126 incidents. Fatigue, human-machine interface, and physiological-other each had 11 incidents or less. Again, it cannot be assumed that the human factor caused the ground incursion without reading each narrative to make the connection.

There were 6410 incidents that listed both a ground incursion and a time of day as shown in Figure 27. Runway ground incursions occurred more frequently from 1201 to 1800, with 2372 incidents and from 0601 to 1200, with 1848 incidents.

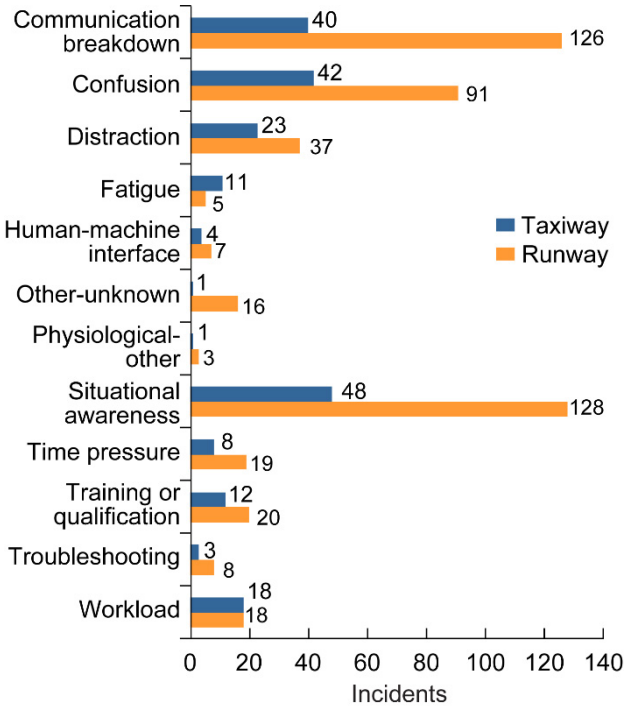


Figure 26.—Human-factor-related incidents by ground incursion anomaly and human factor category.

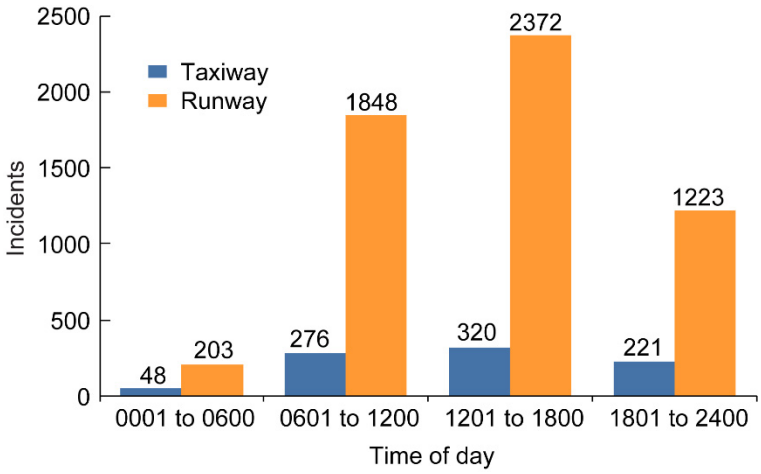


Figure 27.—Human-factor-related incidents by ground incursion anomaly and time of day.

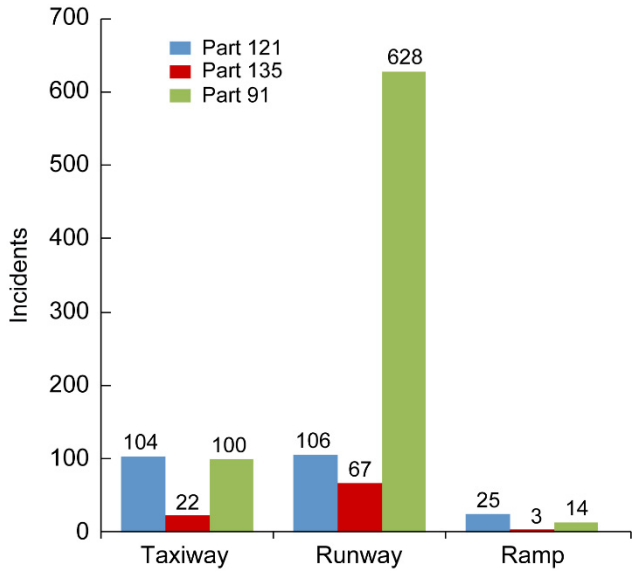


Figure 28.—Human-factor-related incidents by ground excursion and FAR part.

4.8 Ground Excursion Anomalies

A ground excursion is an incident in which the aircraft departs or veers off the runway surface and is subcategorized as runway, taxiway, or ramp. Of the 1089 ground excursions in the ASRS, 824 incidents were runway excursions. Figure 28 shows ground excursions by FAR part. The greatest number of incidents occurred on the runway with 628 for Part 91, followed by 106 incidents for Part 121.

The 136 incidents that listed a ground excursion and a human factor category are shown in Figure 29. The situational awareness human factor and runway excursion was the highest with 54 incidents, followed by training or qualification and runway excursion with 49 incidents. There were only 18 ground excursion anomalies for Part 121, 5 anomalies for Part 135, and 108 anomalies for Part 91.

Figure 30 shows the ground excursion anomalies versus time of day results. Of the 1051 incidents that listed a time of day and a ground excursion, 391 runway excursions occurred from 1201 to 1800 and 220 occurred from 0601 to 1200.

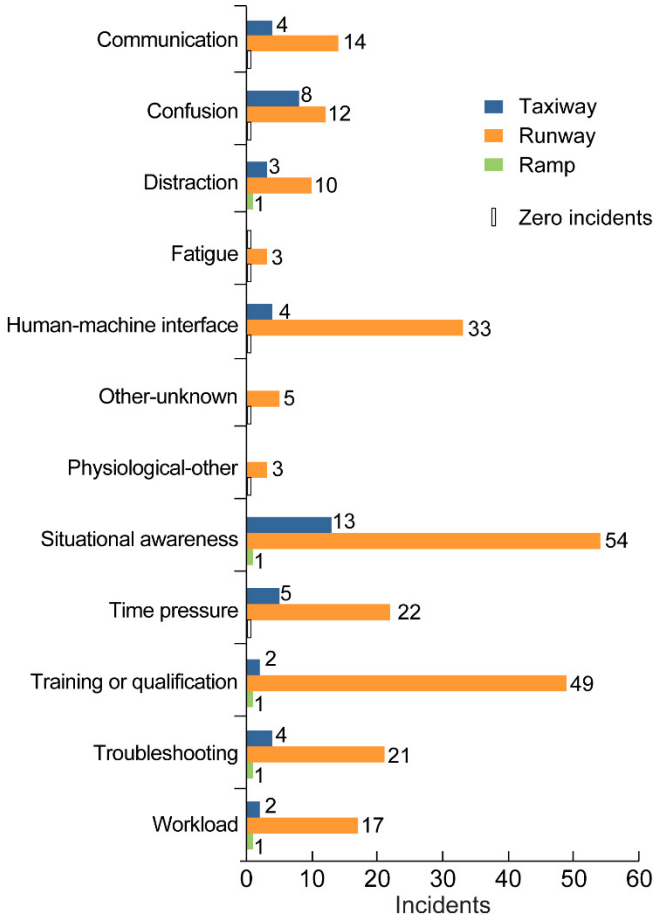


Figure 29.—Human-factor-related incidents by ground excursion and human factor category.

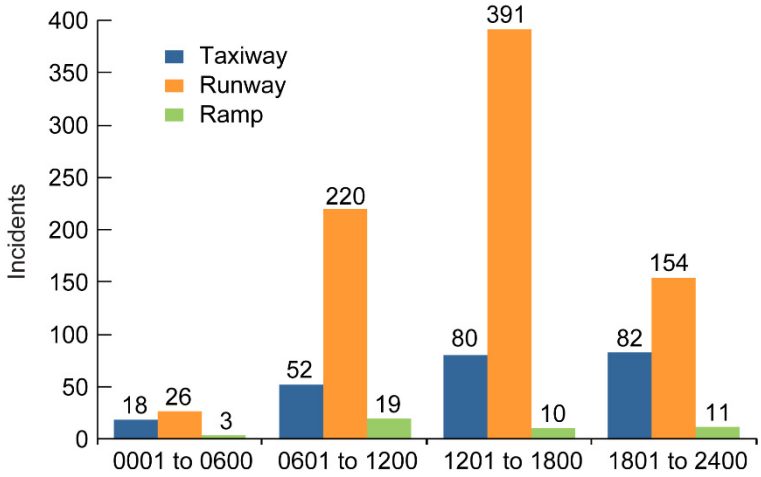


Figure 30.—Human-factor-related incidents by ground excursion and time of day.

4.9 Ground Event or Encounter Anomalies

Figure 31 displays ground event or encounter anomalies by FAR part. Of the 2108 ground events or encounters in the human factor data set, 1302 were aircraft anomalies, followed by 390 vehicle anomalies, and 353 gear-up landing anomalies. No LOC or person, animal, or bird incidents anomalies were reported. The greatest number of anomalies occurred with aircraft in 853 incidents for Part 91, followed by gear-up landing in 321 incidents for Part 91. There were 311 aircraft incidents and 271 vehicle incidents for Part 121. Foreign object debris (FOD) with 73, ground strike-aircraft with 60, and object with 56, made up just a small number of the reported incidents.

Ground events or encounters and human factors data is shown in Figure 32. For aircraft, situational awareness, with 79 incidents, was the most frequent category, followed by training or qualification with 57 incidents, troubleshooting with 51 incidents, and human-machine interface with 48.

For gear-up landing, situational awareness was the most frequent with 14 incidents, followed by distraction with 11 incidents, and troubleshooting with 10 incidents. For ground strike-aircraft, situational awareness was also the most frequent with 42 incidents, followed by training or qualification with 29 incidents. For both object and vehicle, situational awareness was the most frequent category with 43 and 27 incidents, respectively.

Ground event or encounter anomalies and time of day can be seen in Figure 33. The greatest number of incidents occurred from 1201 to 1800, followed by 0601 to 1200 in all categories.

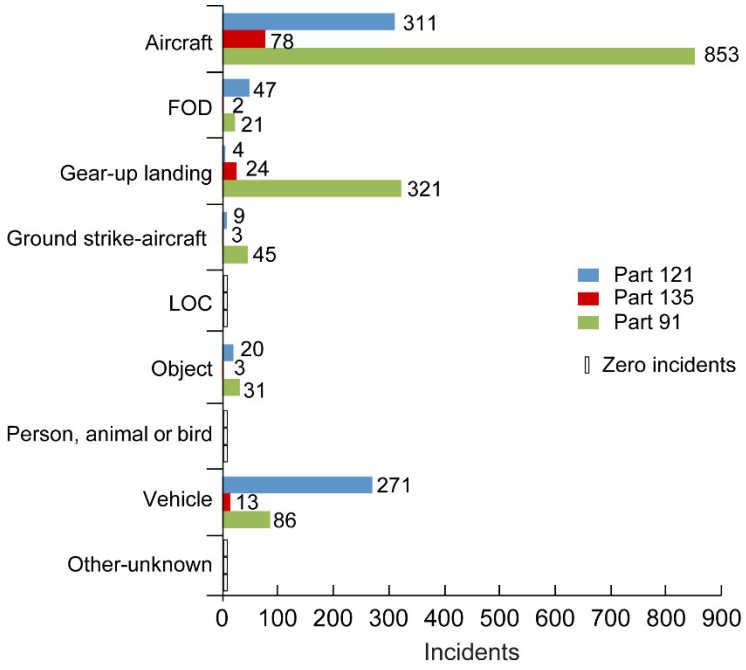


Figure 31.—Human-factor-related incidents by ground event or encounter anomaly and FAR part.

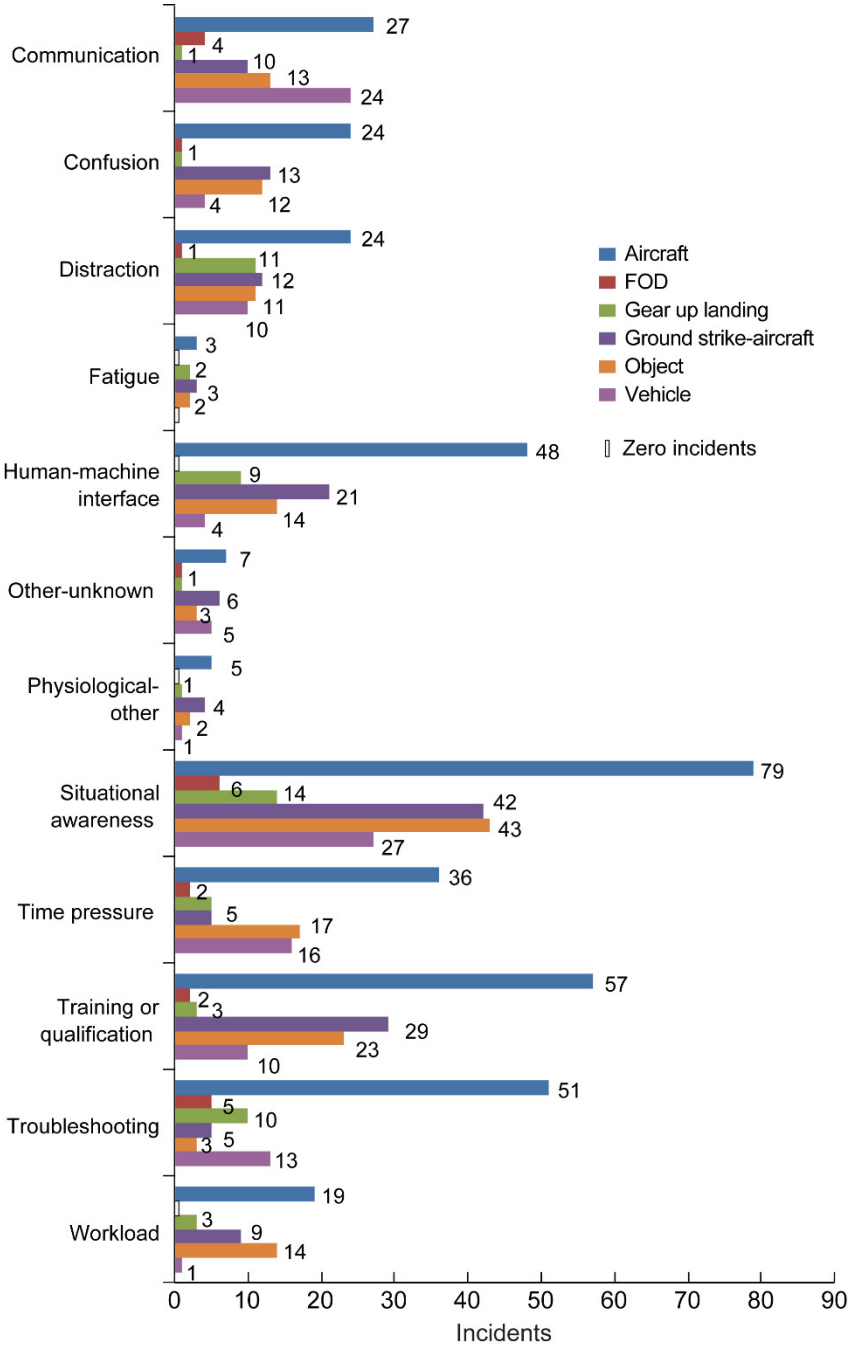


Figure 32.—Human-factor-related incidents by ground event or encounter anomaly and human factor category.

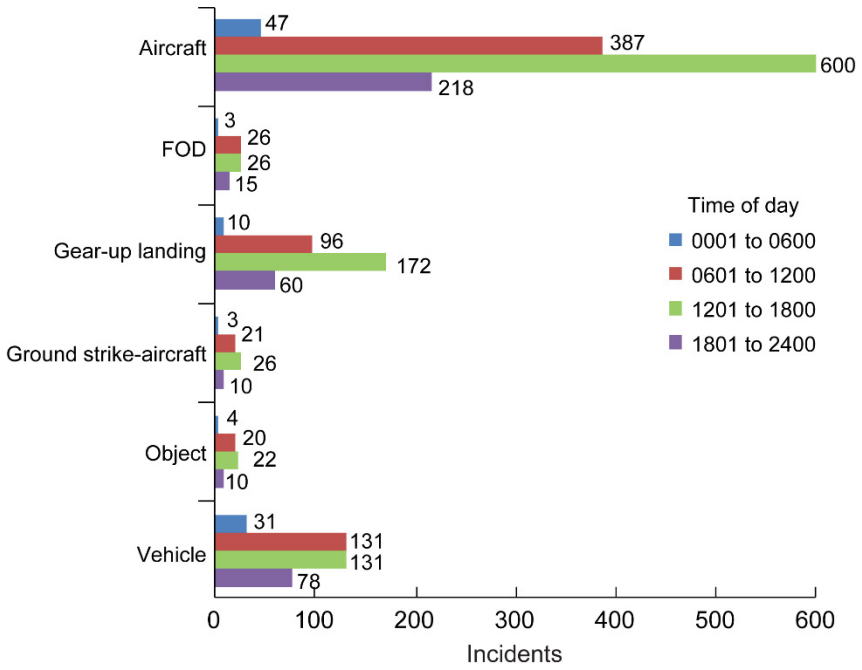


Figure 33.—Human-factor-related incidents by ground event or encounter anomaly and time of day.

4.10 Human Factor Summary

The ASRS human factors data set of 83 478 incidents contained three groups of human factor data: human factor category, human factor as a primary problem, and human factor as a contributing factor. The human factor category listed 12 583 incidents, human factor as a primary problem listed 72 414 incidents, human factor as a contributing factor listed 54 219 incidents, and many of the incidents were listed in multiple groups.

The data set contained 46 063 incidents for FAR Part 121, 4496 incidents for Part 135, and 23 609 incidents for Part 91. The majority of the incidents, 79 486, listed the time of day, and the two most frequent time periods were 1201 to 1800 and 0601 to 1200, respectively, for FAR Parts 121, 135, and 91.

Under the flight crew results category, took evasive action and returned to clearance were the most frequent type of incidents. NMAC was the most frequent conflict anomaly, and weather or turbulence, with almost 50 percent of the incidents, was the most frequent in-flight event or encounter category. Aircraft was the most frequent type of ground event or encounter anomaly and for ground incursions and excursions occurred most frequently on the runway versus the taxiway for FAR Parts 121, 135, and 91.

In the communication breakdown between parties category, the greatest number of incidents occurred between flight crew and ATC, followed by flight crew to flight crew, and maintenance to maintenance. Maintenance to maintenance was the most frequent communication breakdown for both Parts 121 and 135.

In the conflict anomaly and phase of flight category, the greatest number of incidents were NMAC during initial approach, followed by critical ground conflict during taxi, and less severe ground conflict during taxi. Cruise and initial approach with weather-turbulence was the most frequent in-flight anomaly.

Human factors categories were analyzed for a variety of anomalies and problems. The greatest number of human factor problems were troubleshooting, time pressure, situational awareness, and communication breakdown. It is interesting to note that fatigue and physiological-other had the fewest incidents for FAR Parts 121, 135, and 91.

Combining the human factor and conflict anomaly, NMAC and situational awareness, and NMAC and communication breakdown were the top categories. The combination of situational awareness and weather or turbulence or CFTT was the biggest factor for in-flight anomalies. Situational awareness was the biggest issue for the ground incursions and excursions and ground event or encounters. The comparison of communication breakdown between parties versus human factors show that ATC to flight crew with communication breakdown human factor was the largest category for FAR Parts 121, 135, and 91.

5.0 Conclusion

An analysis was performed for the Aviation Safety Program (AvSP) System-Wide Safety and Assurance Technologies (SSAT) Project to help determine if the technologies in the project could have a large impact on the current aviation safety issues. This study analyzed the human factor and system component failure or malfunction (SCFM) categories in the ASRS incident database. The entire data set received in June 2011 contained 104 499 incidents for the January 1993 through April 2011 timeframe. There were 38 894 incidents that listed the aircraft as the primary problem or contributing factor, and 83 478 incidents that listed human factor as a category, the primary problem, or a contributing factor. The human factor category, available only since May 2009, contained 12 583 incidents. The human factor data set was analyzed for conflict anomaly, in-flight event or encounter, ground incursion, ground excursion, ground event or encounter, and communication breakdown between parties.

The aircraft SCFM data set was analyzed for component problems, aircraft results, and flight crew results. The greatest number of incidents occurred during the parked and cruise phases of flight. Propulsion was the largest SCFM category, followed by monitoring and management, and landing gear. Components were more likely to malfunction than to fail, and aircraft were more likely to be damaged than the problem dissipating or flight crew overriding automation. The most frequent flight crew results were aircraft diverted, overcame equipment problem, or landed in emergency conditions.

The human-factor-related data set was analyzed for the human factor category, flight crew results, communication breakdown between parties, conflict, in-flight and ground event or encounter, and ground incursion and excursion. The categories selected help to detect safety issues caused by human performance. There were a total of 83 478 human-factor-related incidents with 46 063 for Part 121, 4496 for Part 135, and 23 609 incidents for Part 91. The majority of incidents occurred from 1201 to 1800 followed by 0601 to 1200. Parked and cruise were the largest phase of flight categories for Part 121. It was interesting to note that NMACs were involved in almost half of the conflict anomaly incidents; there were many more ground incursions or excursions on the runway than taxiway; and another aircraft was involved with the largest number of incidents for ground events or encounters. Weather or turbulence had the highest number of in-flight anomalies. For communication breakdown, the greatest number of incidents were between ATC and flight crew and maintenance to maintenance was the largest category for Parts 121 and 135.

A variety of categories listed fewer incidents than expected. For the human factor category there were fewer fatigue and physiological-other incidents and the time of day category had a much lower number incidents for dark time periods when it was hard to see objects. It was also interesting to note the small number of NMACs for final approach. For in-flight anomalies, the number of bird or animal encounters was not as high as expected and that wake vortex encounters was relatively low too. There were also very few reported ramp ground excursion incidents.

Appendix A.—Acronyms

ASRS	Aviation Safety Reporting System
ATC	air traffic control
AvSP	Aviation Safety Program
CFTT or CFIT	controlled flight toward terrain or controlled flight into terrain
DMKD	data mining and knowledge discovery
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FOD	foreign object damage
HAT	height above terrain
HFACS	Human Factors Analysis and Classification System
HSS	Human System Solutions
ICAO	International Civil Aviation Organization
IMC	instrument meteorological conditions
LOC	loss of control or loss of aircraft control
NMAC	near-midair collision
PDM	prognostics and decision making
SCFM	system component failure or malfunction
SSAT	System-Wide Safety and Assurance Technologies
TC	technical challenge
VFR	visual flight rules
VMC	visual meteorological conditions
VVFCS	verification and validation of flight-critical systems

Appendix B.—Detailed Supplementary Tables

Table B.1 to Table B.14 provide more details about SCFM-, LOC-, and human-factor-related incidents, respectively.

TABLE B.1.—TECHNICAL CHALLENGES (TCs), RELATED SUBPROJECTS, AND POTENTIAL BENEFITS

Data set	Technical challenge			
	TC1 Advance safety assurance to enable deployment of NextGen systems	TC2 Automated discovery of precursors to aviation safety	TC3 Increasing safety of human-automation interaction by incorporating human performance	TC4 Prognostic algorithm design for safety assurance
	Related subproject			
	Verification and validation of flight critical systems (VVFCS)	Data mining and knowledge discovery (DMKD)	Human system solutions (HSS)	Prognostics and decision making (PDM)
Aircraft SCFM[a]	Availability of safety assurance methods for confident and reliable certification, enabling manufacturers and users to exploit latest technological advances and operational concepts	Identifying fleet-wide anomalies due to mechanical and other related issues that can impact safety, maintenance schedules, and operating costs		New class of verifiable prognostic algorithms and methods (predict remaining useful life)
		Development of advanced methods to predict adverse events due to introduction of new technologies in NextGen		
Human factor		Understanding the impact of degradations in human performance on aircraft performance	Methods and tools appropriate for designers, trainers, and operators	
		Development of advanced methods to predict adverse events due to introduction of new technologies in NextGen	Enable prediction of human performance to identify, evaluate, and resolve safety issues due to human-automation interaction	

[a]System component failure or malfunction.

TABLE B.2.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY AND PHASE OF FLIGHT FOR FAR[b] PARTS 121, 135, AND 91 COMBINED
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

SCFM category	Phase of flight										
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Incidents
Automated flight control	29	93	110	249	365	190	221	19	74	170	1343
Brakes	212	52	9	9	11	4	29	5	274	217	703
Communication	97	80	55	122	404	120	224	4	119	140	1089
Control surface	102	285	206	230	245	163	625	55	217	576	2318
Electrical power	187	209	158	228	678	108	210	6	157	646	2195
Environmental control system	88	117	143	406	762	173	55	3	39	376	1894
Furnishings and equipment	51	86	32	43	185	21	23	2	34	354	725
Fuel system	50	95	59	83	381	68	115	1	72	289	1055
Hydraulic or pneumatic	85	110	125	259	405	96	166	11	108	256	1405
Icing	14	39	24	63	87	30	33	1	12	94	335
Landing gear	205	529	276	71	74	39	327	25	939	779	2740
Miscellaneous	95	159	42	34	145	17	50	0	76	751	1106
Monitoring and management	129	441	251	407	632	174	416	22	265	782	2993
Navigation	57	141	287	344	595	443	634	27	90	196	2467
Oil system	15	35	39	91	286	28	38	2	26	175	661
Propulsion	181	625	425	532	981	219	310	12	267	817	3829
Structure	77	192	139	178	307	64	43	3	43	640	1484
Weather	4	5	6	9	19	4	6	1	4	23	65
Incidents	1678	3293	2386	3358	6562	1961	3525	199	2816	7281	28 407

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE B.3.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND PHASE OF FLIGHT FOR FAR[b] PART 121
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

SCFM category	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Total
Automated flight control	22	76	69	174	233	141	164	15	46	153	961
Brakes	107	30	8	8	9	4	20	4	114	168	405
Communication	42	33	23	56	144	57	79	2	30	110	490
Control surface	88	233	168	198	179	133	576	52	172	514	1986
Electrical power	159	164	104	161	350	51	76	3	35	585	1481
Environmental control system	82	108	127	342	636	144	50	3	33	346	1633
Furnishings and equipment	43	69	29	34	168	13	19	2	25	327	643
Fuel system	44	60	26	63	216	22	35	1	20	250	663
Hydraulic or pneumatic	77	96	109	240	376	84	145	11	82	234	1273
Icing	10	31	19	49	60	20	18	1	6	83	258
Landing gear	137	388	218	55	40	23	183	14	259	685	1674
Miscellaneous	81	112	32	27	102	12	28	0	33	602	862
Monitoring and management	102	379	189	312	429	127	273	14	137	685	2279
Navigation	46	112	213	255	430	364	451	16	56	180	1872
Oil system	13	28	23	75	200	23	20	1	11	143	494
Propulsion	142	495	293	369	478	127	125	3	107	652	2487
Structure	64	126	100	146	194	35	28	2	22	559	1137
Weather	4	5	5	6	15	4	5	1	3	22	54
Total	1263	2545	1755	2570	4259	1384	2295	145	1191	6298	20 652

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE B.4.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND PHASE OF FLIGHT FOR FAR[b] PART 135
[Shaded entries indicate the most frequent incidents (top 9 tall poles).]

SCFM category	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Total
Automated flight control	0	2	8	8	15	5	9	0	4	2	46
Brakes	15	2	1	0	1	0	0	0	19	10	38
Communication	5	2	2	10	27	12	13	0	10	5	67
Control surface	4	21	7	6	6	4	4	0	7	17	63
Electrical power	6	3	5	13	24	8	10	1	9	10	73
Environmental control system	2	3	2	21	25	7	1	0	3	5	61
Furnishings and equipment	2	5	2	3	2	1	1	0	1	5	20
Fuel system	0	8	7	5	14	6	8	0	4	9	50
Hydraulic or pneumatic	3	3	5	1	6	3	9	0	7	7	30
Icing	2	1	1	4	3	1	1	0	2	3	11
Landing gear	15	38	20	4	14	2	27	2	92	23	182
Miscellaneous	3	15	1	3	14	2	7	0	11	39	63
Monitoring and management	14	27	13	24	38	12	37	0	27	36	178
Navigation	0	5	11	8	17	11	19	1	5	3	67
Oil system	1	1	2	2	15	0	4	0	2	6	27
Propulsion	14	27	24	33	62	14	22	2	21	47	225
Structure	7	22	15	5	25	9	6	0	7	21	85
Weather	0	0	1	1	0	0	0	0	1	0	3
Total	93	185	127	151	308	97	178	6	232	248	1289

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE B.5.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND PHASE OF FLIGHT FOR FAR[b] PART 91
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

SCFM category	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Total
Automated flight control	5	12	32	48	100	33	37	4	23	3	265
Brakes	89	19	0	0	0	0	9	1	137	34	248
Communication	44	43	29	53	218	47	126	2	76	20	492
Control surface	8	29	28	21	50	20	33	2	28	23	208
Electrical power	18	35	49	49	297	45	121	2	109	37	598
Environmental control system	1	5	8	35	86	18	2	0	3	8	151
Furnishings and equipment	5	11	1	5	13	5	2	0	8	12	47
Fuel system	4	26	23	14	141	38	68	0	43	19	311
Hydraulic or pneumatic	4	9	6	13	18	5	11	0	14	7	73
Icing	1	6	4	8	21	8	11	0	4	4	55
Landing gear	48	94	32	11	20	13	109	9	565	46	817
Miscellaneous	8	26	8	4	27	3	14	0	32	78	141
Monitoring and management	9	29	43	58	140	34	96	8	93	25	438
Navigation	8	21	56	72	130	49	145	10	26	4	450
Oil system	1	6	12	14	67	5	13	1	13	16	124
Propulsion	24	93	95	115	413	73	158	7	134	77	1005
Structure	5	35	18	24	85	19	8	1	13	29	209
Weather	0	0	0	2	2	0	0	0	0	0	4
Total	282	499	444	546	1828	415	963	47	1321	442	5636

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE B.6.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND FLIGHT CREW RESULTS FOR FAR[b] PART 121
[Shaded entries indicate the most frequent incidents (top 10 tall poles)]

SCFM category	Became reoriented	Complied with automation or advisory	Diverted	Executed go around/missed approach	Exited penetrated airspace	In-flight shutdown	Landed as precaution	Landed in emergency conditions	Overcame equipment problem	Overrode automation	Regained aircraft control	Rejected takeoff	Requested ATC[c] assistance or clarification	Returned to clearance	Returned to departure airport	Returned to gate	Took evasive action	Total
Automated flight control	73	0	44	42	1	1	25	27	191	150	132	31	0	326	16	4	38	682
Brakes	5	0	11	9	0	0	8	10	34	2	29	16	0	7	2	12	9	117
Communication	10	0	26	15	2	0	9	21	107	1	1	4	0	38	6	0	27	211
Control surface	15	0	261	169	0	0	102	291	358	43	78	89	0	46	51	23	23	1074
Electrical power	11	0	344	9	0	0	147	182	162	13	8	57	0	13	45	15	13	711
Environmental control	13	0	415	0	0	0	215	167	274	42	9	15	0	29	53	11	42	887
Fuel system	3	0	139	5	1	7	53	76	88	8	0	20	0	10	14	2	9	304
Furnishings and equipment	4	0	84	0	0	0	29	30	57	3	4	10	0	3	5	4	4	183
Hydraulic or pneumatic	4	0	385	23	2	3	152	281	138	8	12	19	0	15	70	16	20	800
Icing	2	0	50	3	0	0	26	20	24	1	7	14	0	4	17	1	13	134
Landing gear	4	0	188	73	0	0	113	163	180	7	23	60	0	6	64	16	10	631
Miscellaneous	8	0	42	3	0	0	17	21	57	7	11	24	0	16	3	5	9	154
Monitoring and management	46	0	390	91	2	6	163	237	298	31	14	178	0	106	62	27	28	1177
Navigation	182	0	72	97	5	0	37	23	287	155	51	10	0	492	11	2	247	1146
Oil system	2	0	191	1	0	22	50	126	15	1	0	11	0	0	21	6	3	296
Propulsion	5	0	648	15	0	62	188	485	172	19	26	217	0	19	105	40	23	1412
Structure	2	0	215	3	0	0	105	71	60	2	1	39	0	6	40	3	15	409
Weather	1	0	7	1	0	0	5	1	6	0	1	0	0	0	3	0	0	17
Total	390	0	3512	559	13	101	1444	2232	2508	493	407	814	0	1136	588	187	533	10345

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

[c]Air traffic control.

TABLE B.7.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND FLIGHT CREW RESULTS FOR FAR[b] PART 135
[Shaded entries indicate the most frequent incidents (top 9 tall poles)]

SCFM category	Became reoriented	Complied with automation or advisory	Diverted	Executed go around/missed approach	Exited penetrated airspace	In-flight shutdown	Landed as precaution	Landed in emergency conditions	Overcame equipment problem	Overrode automation	Regained aircraft control	Rejected takeoff	Requested ATC[c] assistance or clarification	Returned to clearance	Returned to departure airport	Returned to gate	Took evasive action	Total
Automated flight control	5	0	1	1	2	0	1	1	10	4	8	2	0	18	0	0	0	32
Brakes	0	0	0	1	0	0	0	0	3	0	3	0	0	1	0	0	2	7
Communication	1	0	2	1	1	0	2	1	15	1	1	1	0	6	0	0	6	28
Control surface	0	0	6	3	0	0	1	6	12	2	10	8	0	4	2	0	0	35
Electrical power	2	0	14	1	1	0	6	7	15	2	1	1	0	3	0	0	3	38
Environmental control	1	0	10	0	0	0	5	4	10	0	0	0	0	1	2	0	1	25
Fuel system	2	0	9	0	0	2	7	10	8	0	0	0	0	0	3	0	0	27
Furnishings and equipment	0	0	2	1	0	0	0	1	3	1	2	1	0	2	0	0	0	8
Hydraulic or pneumatic	0	0	6	0	0	0	1	3	6	0	0	1	0	0	1	1	0	14
Icing	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
Landing gear	2	0	8	10	0	1	6	15	21	1	9	11	0	5	3	1	3	71
Miscellaneous	1	0	3	0	0	0	1	0	8	0	0	2	0	7	0	0	0	16
Monitoring and management	4	0	17	12	0	0	9	11	18	0	3	7	0	14	0	0	1	80
Navigation	8	0	2	3	0	0	2	1	8	1	2	1	0	17	1	0	7	43
Oil system	0	0	14	1	0	1	4	8	0	0	0	1	0	0	0	0	0	18
Propulsion	3	0	36	4	1	6	15	27	23	0	4	16	0	2	8	2	3	110
Structure	0	0	11	0	0	1	5	6	7	1	2	7	0	1	3	0	1	32
Weather	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	29	0	141	39	5	11	65	101	169	13	45	59	0	81	23	4	28	588

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

[c]Air traffic control.

TABLE B.8.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY
AND FLIGHT CREW RESULTS FOR FAR[b] PART 91
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

SCFM category	Became reoriented	Complied with automation or advisory	Diverted	Executed go around/missed approach	Exited penetrated airspace	Inflight shutdown	Landed as precaution	Landed in emergency conditions	Overcame equipment problem	Overrode automation	Regained aircraft control	Rejected takeoff	Requested ATC[c] assistance or clarification	Returned to clearance	Returned to departure airport	Returned to gate	Took evasive action	Total
Automated flight control	29	0	12	9	4	1	8	8	68	27	58	2	0	117	0	0	9	207
Brakes	1	0	9	5	0	0	5	3	13	0	29	5	0	0	1	3	14	64
Communication	24	0	31	31	15	0	25	21	71	2	5	1	0	24	3	0	48	218
Control surface	4	0	39	13	1	0	31	20	57	3	36	4	0	15	10	0	6	145
Electrical power	9	0	154	22	9	2	60	146	92	4	7	2	0	18	7	0	23	383
Environmental control	4	0	53	0	1	0	20	11	25	2	3	1	0	3	6	0	6	98
Fuel system	2	0	67	8	0	3	33	116	33	1	3	4	0	5	5	0	5	213
Furnishings and equipment	1	0	3	3	0	0	3	3	10	0	5	3	0	1	0	0	1	22
Hydraulic or pneumatic	3	0	25	2	0	0	6	17	7	1	0	2	0	1	3	0	2	49
Icing	0	0	13	2	1	0	6	7	12	1	4	2	0	4	0	0	1	34
Landing gear	3	0	48	54	2	0	20	84	56	6	14	17	0	10	14	2	10	248
Miscellaneous	1	0	4	3	0	0	1	5	8	0	2	2	0	2	1	0	1	23
Monitoring and management	27	0	59	30	5	0	35	56	67	6	23	6	0	41	9	1	15	264
Navigation	95	0	30	32	32	0	12	9	60	23	17	1	0	121	2	0	41	302
Oil system	0	0	42	0	0	6	25	33	4	0	0	0	0	2	6	0	2	85
Propulsion	8	0	207	14	6	31	95	324	82	2	14	14	0	11	31	2	21	640
Structure	1	0	59	2	1	0	29	26	24	0	7	11	0	2	7	0	12	118
Weather	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	3
Total	55	0	116	80	29	0	72	139	136	9	86	32	0	121	5	0	121	776

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

[c]Air traffic control.

TABLE B.9.—HUMAN-FACTOR-RELATED INCIDENTS BY FLIGHT CREW RESULTS AND HUMAN FACTOR CATEGORY
[Shaded entries indicate the most frequent incidents (top 9 tall poles).]

Flight crew results	Human factor												
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload	Total
Became reoriented	200	254	199	46	234	37	26	367	90	123	68	163	508
Diverted	128	129	114	7	135	41	23	267	460	112	720	120	1006
Executed go around/missed approach	80	71	50	12	61	16	3	136	43	49	56	44	241
Exited penetrated airspace	10	14	17	1	18	4	3	28	4	14	0	7	40
Inflight shutdown	10	14	10	1	30	5	1	52	20	30	28	21	87
Landed as precaution	51	73	51	4	71	16	7	112	135	51	241	43	397
Landed in emergency conditions	5	0	0	0	0	0	0	0	110	0	206	0	226
Overcame equipment problem	104	148	102	9	214	12	5	195	157	82	336	78	576
Overrode automation	11	37	20	0	55	0	0	25	27	13	42	15	98
Regained aircraft control	32	43	40	5	65	14	11	88	40	48	68	47	171
Rejected takeoff	48	34	26	7	50	9	6	91	95	36	82	14	224
Returned to clearance	138	175	137	23	198	24	14	221	63	58	60	102	388
Returned to departure airport	97	101	120	10	137	32	22	260	120	123	241	130	478
Returned to gate	71	56	25	8	48	16	8	115	49	49	54	21	189
Took evasive action	322	193	196	13	119	58	19	469	137	144	91	140	665
Total	1017	954	784	113	980	211	106	1787	1145	676	1682	663	3904

TABLE B.10.—HUMAN-FACTOR-RELATED INCIDENTS VERSUS COMMUNICATION BREAKDOWN BETWEEN PARTIES AND HUMAN FACTORS

[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

Parties	Human factor												
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload	Total
ATC[a] to ATC	260	94	18	0	12	12	0	107	7	17	1	25	260
ATC to dispatch	5	3	1	0	1	0	0	3	2	1	1	1	5
ATC to flight attendant	11	3	1	1	2	1	0	9	1	4	3	3	11
ATC to flight crew	1005	431	250	38	169	45	23	516	165	121	61	206	1005
ATC to ground personnel	22	5	3	0	1	0	0	6	0	1	0	1	22
ATC to maintenance	4	2	0	1	0	1	0	3	0	0	0	0	4
ATC to other	19	5	1	0	0	0	0	3	0	0	0	2	19
Dispatch to dispatch	9	3	2	0	1	0	0	4	4	4	2	5	9
Flight attendant to flight attendant	5	2	1	0	0	1	1	2	3	3	0	2	5
Flight attendant to dispatch	4	1	2	1	2	0	0	2	2	1	3	1	4
Flight attendant to ground personnel	24	8	2	3	3	4	4	10	10	9	1	2	24
Flight attendant to maintenance	14	6	2	0	3	1	0	10	2	4	3	2	14
Flight attendant to other	11	3	0	0	2	3	1	6	3	4	2	2	11
Flight crew to dispatch	145	52	42	10	29	6	4	68	66	29	55	38	145
Flight crew to flight attendant	59	15	20	3	14	14	12	23	12	19	13	8	59
Flight crew to flight crew	471	164	188	26	128	35	28	310	91	120	36	101	471
Flight crew to ground personnel	222	67	61	14	28	21	15	111	62	79	28	42	222
Flight crew to maintenance	310	136	66	13	53	17	10	163	97	69	161	36	310
Flight crew to other	68	28	12	8	5	11	8	40	27	21	24	11	68
Ground personnel to dispatch	5	2	1	0	1	0	0	2	2	2	0	2	5
Ground personnel to ground personnel	11	2	2	0	1	0	0	5	0	6	0	1	11
Ground personnel to other	2	0	0	0	0	1	0	1	0	0	0	0	2
Maintenance to dispatch	15	8	4	0	2	0	0	8	6	3	4	4	15
Maintenance to ground personnel	9	6	3	0	0	0	0	9	1	2	1	0	9
Maintenance to maintenance	378	226	102	16	0	12	0	346	77	80	79	50	378
Maintenance to other	116	62	11	5	0	4	0	94	12	32	26	12	116
Other to dispatch	3	1	0	0	0	0	0	1	1	1	0	1	3
Other to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2625	1050	629	98	372	153	83	1511	499	504	356	462	2625

[a]Air traffic control.

TABLE B.11.—HUMAN-FACTOR-RELATED INCIDENTS VERSUS COMMUNICATION BREAKDOWN BETWEEN PARTIES AND HUMAN FACTORS FOR FAR[a] PART 121
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

Parties	Human factor												
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload	Total
ATC[b] to ATC	116	38	10	0	7	6	0	51	4	10	1	11	116
ATC to dispatch	5	3	1	0	1	0	0	3	2	1	1	1	5
ATC to flight attendant	5	1	1	1	2	0	0	4	1	2	2	1	5
ATC to flight crew	558	239	146	23	104	25	11	275	99	57	33	115	558
ATC to ground personnel	5	1	0	0	1	0	0	2	0	0	0	0	5
ATC to maintenance	1	1	0	1	0	0	0	1	0	0	0	0	1
ATC to other	4	2	0	0	0	0	0	0	0	0	0	1	4
Dispatch to dispatch	188	57	57	13	25	18	13	96	57	67	25	40	188
Flight attendant to flight attendant	256	98	54	13	51	17	11	123	84	61	132	32	256
Flight attendant to dispatch	240	92	53	13	51	15	10	117	81	57	131	30	240
Flight attendant to ground personnel	49	22	8	6	1	8	6	28	21	15	20	8	49
Flight attendant to maintenance	13	5	3	0	1	1	1	6	6	7	2	6	13
Flight attendant to other	4	1	2	1	2	0	0	2	2	1	3	1	4
Flight crew to dispatch	256	98	54	13	51	17	11	123	84	61	132	32	256
Flight crew to flight attendant	96	56	19	6	2	9	6	64	34	19	42	13	96
Flight crew to flight crew	49	35	11	0	1	1	0	38	13	5	22	5	49
Flight crew to ground personnel	13	5	3	0	1	1	1	6	6	7	2	6	13
Flight crew to maintenance	4	1	2	1	2	0	0	2	2	1	3	1	4
Flight crew to other	24	8	2	3	3	4	4	10	10	9	1	2	24
Ground personnel to dispatch	14	2	2	0	1	0	0	7	1	6	0	2	14
Ground personnel to ground personnel	3	0	0	0	0	0	0	2	1	0	0	1	3
Ground personnel to other	2	0	0	0	0	1	0	1	0	0	0	0	2
Maintenance to dispatch	344	208	97	15	1	9	0	316	76	70	76	48	344
Maintenance to ground personnel	13	7	5	0	1	0	0	12	4	3	2	3	13
Maintenance to maintenance	7	3	3	0	1	0	0	6	4	2	2	3	7
Maintenance to other	89	49	10	5	0	3	0	74	11	25	19	11	89
Other to dispatch	1	1	0	0	0	0	0	1	0	1	0	0	1
Other to other	2	1	0	0	0	0	0	0	1	0	0	0	2
Total	1735	710	440	78	262	110	62	1009	390	349	302	314	1735

[a]Federal Aviation Regulations.

[b]Air traffic control.

TABLE B.12.—HUMAN-FACTOR-RELATED INCIDENTS VERSUS COMMUNICATION BREAKDOWN BETWEEN PARTIES AND HUMAN FACTORS FOR FAR[a] PART 135
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

Parties	Human factor												
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload	Total
ATC[b] to ATC	2	1	1	0	0	0	0	1	0	0	0	0	2
ATC to dispatch	0	0	0	0	0	0	0	0	0	0	0	0	0
ATC to flight attendant	0	0	0	0	0	0	0	0	0	0	0	0	0
ATC to flight crew	34	19	9	2	7	2	2	24	9	2	0	13	34
ATC to ground personnel	1	0	0	0	0	0	0	0	0	0	0	0	1
ATC to maintenance	1	0	0	0	0	1	0	1	0	0	0	0	1
ATC to other	1	0	0	0	0	0	0	1	0	0	0	0	1
Dispatch to dispatch	4	0	0	0	1	0	0	1	0	2	0	0	4
Flight attendant to flight attendant	3	1	0	0	0	0	0	0	1	2	2	1	3
Flight attendant to dispatch	3	1	0	0	0	0	0	0	1	2	2	1	3
Flight attendant to ground personnel	1	0	0	1	0	0	0	0	1	0	0	1	1
Flight attendant to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight attendant to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to dispatch	3	1	0	0	0	0	0	0	1	2	2	1	3
Flight crew to flight attendant	3	0	1	1	0	1	0	1	1	1	0	1	3
Flight crew to flight crew	2	0	1	0	0	1	0	1	0	1	0	0	2
Flight crew to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to dispatch	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to dispatch	14	3	2	0	0	2	0	8	2	2	2	1	14
Maintenance to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to other	7	1	0	0	0	1	0	5	0	0	2	0	7
Other to dispatch	1	0	0	0	0	0	0	1	0	0	1	0	1
Other to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	85	32	21	3	13	6	3	56	16	11	5	22	85

[a]Federal Aviation Regulations.

[b]Air traffic control.

TABLE B.13.—HUMAN-FACTOR-RELATED INCIDENTS VERSUS COMMUNICATION BREAKDOWN BETWEEN PARTIES AND HUMAN FACTORS FOR FAR[a] PART 91
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

Parties	Human factor												
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload	Total
ATC[b] to ATC	27	14	2	0	0	1	0	12	0	2	0	1	27
ATC to dispatch	0	0	0	0	0	0	0	0	0	0	0	0	0
ATC to flight attendant	3	1	0	0	0	1	0	3	0	1	1	2	3
ATC to flight crew	324	147	89	11	51	15	9	184	53	62	27	71	324
ATC to ground personnel	1	0	0	0	0	0	0	0	0	0	0	0	1
ATC to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
ATC to other	3	2	1	0	0	0	0	0	0	0	0	1	3
Dispatch to dispatch	9	2	2	0	2	0	0	6	0	4	1	0	9
Flight attendant to flight attendant	8	6	1	0	1	0	0	3	1	2	2	0	8
Flight attendant to dispatch	7	5	1	0	1	0	0	2	1	2	2	0	7
Flight attendant to ground personnel	14	6	3	1	4	1	1	11	2	5	3	2	14
Flight attendant to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight attendant to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to dispatch	8	6	1	0	1	0	0	3	1	2	2	0	8
Flight crew to flight attendant	19	7	3	1	4	1	1	14	2	6	5	2	19
Flight crew to flight crew	7	2	0	0	0	0	0	5	0	1	3	0	7
Flight crew to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Flight crew to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to dispatch	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground personnel to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to dispatch	7	5	1	0	0	0	0	7	0	4	2	1	7
Maintenance to ground personnel	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance to other	8	5	0	0	0	0	0	4	0	3	4	0	8
Other to dispatch	0	0	0	0	0	0	0	0	0	0	0	0	0
Other to other	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	544	218	147	13	85	25	15	336	76	127	45	98	544

[a]Federal Aviation Regulations.

[b]Air traffic control.

TABLE B.14.—HUMAN-FACTOR-RELATED INCIDENTS VERSUS IN-FLIGHT EVENT OR ENCOUNTER ANOMALY AND HUMAN FACTORS CATEGORY
[Shaded entries indicate the most frequent incidents (top 10 tall poles).]

Human factors category	In-flight event or encounter anomaly									
	CFTT or CFIT[a]	Fuel issue	LOC[b]	Object	Bird or animal	Unstabilized approach	Wake vortex encounter	Weather/turbulence	Other-unknown	Totals
Communication breakdown	44	48	26	6	3	48	9	100	28	266
Confusion	57	43	31	4	1	30	3	73	20	229
Distraction	40	38	31	10	3	32	15	81	23	240
Fatigue	14	7	5	2	0	20	4	12	3	59
Human-machine interface	44	48	65	4	1	45	2	65	10	253
Other-unknown	11	14	15	0	1	7	2	43	20	96
Physiological-other	6	2	10	0	1	6	2	19	15	48
Situational awareness	107	92	80	19	6	78	12	164	33	520
Time pressure	11	57	27	6	11	20	2	94	26	221
Training/qualification	30	38	63	12	1	33	1	55	8	205
Troubleshooting	5	37	51	1	10	8	2	69	27	193
Workload	25	30	29	6	2	34	5	82	10	192
Total	136	146	176	24	18	106	27	304	90	915

[a]Controlled flight toward terrain or controlled flight into terrain

[b]Loss of control or loss of aircraft control

Appendix C.—Aviation Safety Reporting System Category Descriptions

Only some ASRS categories apply to Atmospheric Environment Safety Technology and if the category is discussed, all options are presented. Most of the descriptions and notes came from the ASRS Standard Operating Procedures (an internal document).

Aircraft results (3 options)

- Aircraft damaged: Damage caused by external forces, not a component failure of the aircraft (i.e., engine failure).
- Automation overrode the flight crew: An automated system intervened and overrode the pilot or flight crew.
- Equipment problem dissipated: The equipment problem was either resolved without human intervention, or continued to exist but no longer has significant effect on the safe operation of the aircraft.

Component problem (4 options)

- Design
- Failed
- Improperly operated
- Malfunctioning

Conflict anomaly (4 options)

- Near-midair collision: Conflict between two airborne aircraft with LESS than 500 ft vertical *and* horizontal separation.
- Airborne conflict: Two or more airborne aircraft in conflict, which may be equal to, or less than legal standard separation, or incidents where the reporter claims a potential conflict. This also includes a conflict that requires an evasive maneuver initiated by a controller, a pilot, or by cockpit equipment.
- Ground conflict, critical: Two or more aircraft (one may be airborne) in conflict, or an aircraft in conflict with a vehicle/aircraft/person/object in which the reporter or other involved took some evasive action to avoid a collision, or a collision that almost occurred in cases where evasive action was not taken or was not possible.
- Ground conflict, less severe: Two or more aircraft (one may be airborne) in conflict, or an aircraft in conflict with a vehicle/aircraft/person/object in which the reporter or other involved may, or may not, have taken some precautionary avoidance action, and in which a collision hazard was *not* imminent.

Flight crew results (17 options or subcategories)

- Became reoriented: Overcame disorientation.
- Diverted: Diverted to a filed alternate or any airport that is not a filed alternate. Does not include returning to departure airport.
- Executed go around or missed approach: A pilot or controller-initiated action, typically to avoid a potentially hazardous situation/condition on a movement surface, that does not require adherence to a published missed approach procedure. A missed approach is a procedure that is formulated for each published instrument approach and it is initiated by either the pilot or the controller due to weather, unstable approach, “fouled” runway, etc. It allows the pilot to enter a new approach while remaining clear of obstacles.
- Exited penetrated airspace: Airborne maneuver to exit erroneously penetrated airspace.

- Flight crew complied with automation or advisory: Flight crew followed what was recommended by what computer.
- Flight crew overrode automation: Pilot or flight crew took action and overrode any aircraft programmed system.
- In-flight shutdown: Pilot or flight crew shut down one or more engines.
- Landed as precaution: May or may not be caused by an emergency event.
- Landed in emergency conditions.
- Overcame equipment problem: Pilot or flight crew restored function of malfunctioning equipment, or developed a successful "work-around" to deal with loss of equipment.
- Regained aircraft control: Pilot or flight crew became aware of and took successful action to resolve an LOC.
- Rejected takeoff: Pilot- or ATC-initiated takeoff abort.
- Requested ATC assistance or clarification: Pilot or flight crew asked ATC for vectors or other assistance including filing an en route IFR clearance.
- Returned to clearance.
- Returned to departure airport: Diverted or returned to departure airport.
- Returned to gate: While on ground, aircraft returned to gate.
- Took evasive action: Evasive, typically an abrupt action taken, whether on the ground or airborne, to avoid another aircraft, object, terrain, weather, or environmental conditions (such as wake turbulence). Also includes precautionary avoidance action.

Ground event or encounter (9 options)

Note: an aircraft is considered to be on the ground when any of the aircraft's main gear, nosewheel, tailwheel, or all skids are on the ground at both takeoff and landing.

- Aircraft: Actual physical contact with another aircraft when aircraft is on the ground.
- Foreign object damage (FOD): Hazard to an aircraft caused by unavoidable or unseen plant, animal, or object.
- Gear-up landing: Aircraft is landed without landing gear extended (does not include gear collapse).
- Ground strike-aircraft: Physical contact by a portion of the aircraft such as a wingtip, prop, or tail strike to the ground.
- Loss of aircraft control: Pilot is unable to effectively maintain control of the aircraft due to pilot error, environment, aircraft, or other reasons.
- Object: Physical contact with any object (not alive) other than what is covered in the other categories when the aircraft is on the ground (runway lights, airport signs, fencing, etc.).
- Person/animal/bird: Actual physical contact or near miss with a person, animal, bird, or any "live object" when aircraft is on the ground. Includes encounters with birds or live objects during the takeoff roll.
- Vehicle: Actual physical contact with a vehicle (not aircraft) when aircraft is on the ground. A jetway, bridge, or baggage cart is considered an object, not a vehicle. A vehicle is defined as being equipped with an engine, is self-propelled, and can be driven, legally or illegally, to the store.
- Other-unknown: Everything not covered elsewhere in this section.

Ground excursion (3 options)

- Ramp: An undesirable or unwanted departure or excursion from a confined, marked standard ramp movement area.
- Runway: An undesirable or unwanted departure or excursion from a designated runway surface, whether from the runway edge (side) or (departure) end. This does not include events where a landing aircraft touches down short of the runway's approach end.
- Taxiway: An undesirable or unwanted departure or excursion from a designated taxiway surface.

Ground incursion (2 options)

Ground incursion is an undesirable or unwanted entry into a confined, marked, or identified standard movement area

- Runway: Uncoordinated, unauthorized, or improper entry to any active runway by an aircraft, vehicle, or person, but *does* include landing on a closed runway. Actual collision hazard or conflict does not need to not occur.
- Taxiway: Uncoordinated, unauthorized, or improper entry to a taxiway by an aircraft, vehicle, or person.

Human factor (12 options)

- Communication breakdown
- Confusion
- Distraction
- Fatigue
- Human-machine interface
- Other-unknown
- Physiological-other
- Situational awareness
- Time pressure
- Training/qualification
- Troubleshooting
- Workload

In-flight event or encounter (10 options)

- CFTT or CFIT: Pilot or crew has control of an airworthy, mechanically normal aircraft, but is unaware of in-flight proximity to dangerous or unsafe terrain or obstacles. An example is an aircraft in instrument meteorological conditions (IMC) vectored unacceptably close to terrain.
- Fuel issue: Event related to a fuel concern that occurred during flight.
- LOC: Pilot is unable to effectively maintain control of the aircraft in flight, due to pilot error, environment, aircraft, or other reasons.
- Object: Physical contact with any object during aircraft flight other than what is covered in the other categories.
- Person/animal/bird: Actual physical contact or near miss to a bird, animal, or skydiver when aircraft is in flight.
- Unstabilized approach: Failure to establish and maintain a constant attitude, airspeed, or descent rate on approach; or making aircraft configuration changes at or below 500-ft height above terrain (HAT) (above ground level) on approach when conducting a precision approach in visual meteorological conditions (VMC); or at or below 1000-ft HAT on approach when conducting a precision approach in IMC. A nonprecision approach may also be considered unstabilized if there is a significant variance from appropriate speed, rate of descent, attitude, or configuration profiles.

- Visual flight rules (VFR) in IMC: Flight in IMC without an ATC clearance is usually reported by a general aviation pilot without IFR qualifications or not on an IFR clearance. Note: if a pilot is not instrument-qualified but enters IMC with ATC clearance, the event is a violation of Federal Aviation Regulations, and not considered VFR in IMC.
- Wake vortex encounter: Any encounter with another aircraft's wake vortices in the terminal environment or en route (does not include jet or propeller blast events).
- Weather or turbulence: An encounter with weather or turbulence including clear air turbulence that is commented on by the reporter in the narrative.
- Other/unknown: No other fields in this section are appropriate.

Phase of flight (10 options)

- Taxi
- Takeoff
- Initial climb
- Climb
- Cruise
- Descent
- Initial approach
- Final approach
- Landing
- Parked

Appendix D.—System Component Failure or Malfunction Categories

Automated flight control—20 components
Aeroplane flight control
AHRS/ND [altitude heading reference systems]
Altitude hold/capture
Auto flare
Autoflight system
Autoflight system, autopilot, elevator trim system
Autoflight yaw damper
Autoland
Autopilot
Autothrottle/speed control
Cyclic control
Damper
Engine control
FAC (flight augmentation computer)
FADEC/TCC [full-authority digital engine or electronic control/turbine case cooling]
FCC (flight control computer)
FCU (flight control unit)
Fuel control computer
MCP [mode control panel]
Yaw control

Brakes—6 components
Antiskid system
Antiskid system, main gear tire
Brake system
Emergency brake system
Normal brake system
Parking brake

Communication—14 components
ACARS [aircraft communication and response system]
ACARS printer
Air/ground communication
Cabin address system
Cockpit/cabin communication
Communication systems
ELB/ELT [emergency locator beacon/emergency locator transmitter]
HF SSB [high frequency-single sideband radio]
Integrated audio system
Interphone system
Microphone
SELCAL [selective-calling radio system]
Transponder
VHF [very high frequency]

Control surface—35 components
Aileron
Aileron control column
Aileron control system
Aileron tab
Aileron trim system
Elevator
Elevator control column
Elevator control system
Elevator feel system
Elevator tab
Elevator trim system
Flap control (trailing and leading edge)
Flap vane
Flap/slat control system
Ground spoiler
Gust lock
Horizontal stabilizer
Horizontal stabilizer control
Horizontal stabilizer trim
Horizontal stabilizer trim motor
Leading edge flap
Leading edge slat
Mach trim
Rudder
Rudder control system
Rudder feel system
Rudder pedal
Rudder trim system
Speedbrake/spoiler
Spoiler system
Stabilizer
Trailing edge flap
Trailing edge flap control
Vertical stabilizer/fin
Wing flight control surface

Electrical power—44 components
AC [alternating-current] generation
AC generator/alternator
Aircraft logo light
Anticollision light
APU [auxiliary power unit] APU controls
APU electrical
Cabin lighting
Circuit breaker/fuse/thermocouple
Cockpit lighting
DC [direct-current] battery
DC generation

DC generator
DC ram air turbine
DC rectifier
DC regulator
Electrical distribution
Electrical distribution busbar
Electrical distribution relay
Electrical power
Electrical wiring
Electrical wiring and connectors
Electrical/electronic panel and parts
Emergency exit lighting
Emergency floor lighting
Emergency light
Engine electric starter
External power
Generator drive
Ice inspection light
Igniter plug
Ignition distribution
Ignition electrical supply
Ignition switching
Ignition system
Ignition/magneto switch
Inverter
Landing light
Lighting
Magneto/distributor
Navigation light
Power drive system
Spark plug
Switch
Taxiing light

Environmental control system—22 components
Air conditioning and pressurization pack
Air conditioning compressor
Air conditioning distribution ducting, clamps, connectors
Air conditioning distribution system
Aircraft auto temperature system
Aircraft cooling system
Aircraft heating system
APU fire extinguishing
Fire extinguishing
Fire extinguishing indication system
Fire protection system
Other fire extinguishing system
Other fire protection system
Oxygen system/crew
Oxygen system/general
Oxygen system/pax [passenger]
Oxygen system/portable
Portable extinguisher
Pressurization control system
Pressurization outflow valve
Pressurization system
Smoke hood

Furnishings and equipment—22 components
Aircraft furnishing
Cabin crew seat
Cabin entertainment
Cabin furnishing
Cargo equipment
Cargo restraint/tie down
Cargohook/strap
Cockpit door
Cockpit furnishing
Crash axe
Door
Emergency equipment
First aid equipment
Galley furnishing
Interior door
Life raft
Life vest/jacket
Other flight crew seat
Pax [passenger] seat/pilot seat
Seat belt sign
Seatbelt
Toilet furnishing

Fuel system—22 components
APU fuel system
Engine fuel filter
Fuel
Fuel booster pump
Fuel crossfeed
Fuel distribution system
Fuel drain
Fuel line, fittings, and connectors
Fuel nozzle
Fuel selector
Fuel storage system
Fuel system
Fuel tank
Fuel tank cap
Fuel trim pump
Fuel trim system
Mixing unit
Powerplant fuel control

Powerplant fuel control unit
Powerplant fuel distribution
Powerplant fuel system
Powerplant fuel valve

Hydraulic or pneumatic—20 components
APU pneumatic system
Engine air pneumatic ducting
Hydraulic actuator
Hydraulic aux [auxiliary] syst[em] ram air turbine
Hydraulic aux system
Hydraulic fluid
Hydraulic lines, connectors, fittings
Hydraulic main system
Hydraulic main system—regulator
Hydraulic system
Hydraulic syst[em] engine-driven pump
Hydraulic system lines, connectors, fittings
Hydraulic system pump
Hydraulic syst[em] reservoir tank
Hydraulic syst[em] valve
Pneumatic control valves
Pneumatic ducting
Pneumatic system
Pneumatic system control
Pneumatic valve/bleed valve

Icing—9 components
Aerofoil ice system
Deicing fluid
Engine air anti-ice
Fuel system anti-ice additive
Ice/rain protection system
Intake ice system
Pitot/static ice system
Propeller ice system
Window ice/rain system

Landing gear—23 components
Emergency extension system
Gear down lock
Gear extend/retract mechanism
Gear float
Gear lever/selector
Gear ski
Gear skid
Gear up lock
Landing gear
Main gear
Main gear door
Main gear tire
Main gear wheel
Nose gear
Nose gear door
Nose gear tire
Nose gear wheel
Nosewheel steering
Supplemental landing gear
Tail wheel
Tires
Wheel assemblies
Wheels/tires/brakes

Miscellaneous—20 components
Aircraft documentation
Aircraft logbook(s)
Cargo/baggage
Checklists
Company operations manual
Cooling fan, any cooling fan
CVR (cockpit voice recording)
Data processing
Drinkable/waste water syst[em]
Electronic library (other than navigation database)
Escape slide
FDR (flight data recorder)
Filter
Flight crew harness
High tension wiring/harness
Injector
Minimum equipment list (MEL)
Other documentation
Safety instrumentation and information
Waste water disposal system

Monitoring and management—82 components
Air data computer
AC generation indicating and warning system
Airspeed indicator
Altimeter
Altitude
Altitude alert
Angle-of-attack vane
APU fire/overheat warning
Attitude
Attitude indicator (gyro/horizon/ADI [attitude direction indicator])
Cargo compartment fire/overheat warning
Central computer
Central warning/master caution
Chip detector indicator
DC generation indicating and warning system

Door warning system
EICAS/EAD [engine indicating and crew alerting system/engine alert display]
EICAS/EAD/ECAM [electronic centralized aircraft monitor]
Electronic Flt Bag (EFB)
Engine air indications
Engine analysers
Engine indications
Engine pressure ratio indicat[or]
Engine temperature indication
Engine torque indication
Engine vibration indication
Exhaust gas temperature indicat[or]
Fire/overheat warning
Flap/slat indication
Fuel contents indication
Fuel flow indication
Fuel pressure indication
Fuel quantity-pressure indication
Fuel temp indication
Galley fire/overheat warning
Generator drive indicators and warning system
Heads-up display
Heater fire/overheat warning
Hydraulic syst[em] pressure/temp[erature] indication
Ice detection system
Ice/rain protection system indicating and warning
Ignition indication
Indicating and warning—air conditioning and press
Indicating and warning—APU
Indicating and warning—flight and navigation systems
Indicating and warning—fuel system
Indicating and warning—hydraulics
Indicating and warning—landing gear
Indicating and warning—lighting systems
Indicating and warning—oxygen systems
Indication
Instrument and control panels
Landing gear indicating system
Main rotor vibration monitor indicator
Manifold pressure indication
Monitoring system
Nacelle fire/overheat warning
Oil contents indication
Oil indicating system
Oil pressure indication
Oil temperature indication
PFD [personal flotation device]
Pitot-static system
PMC [performance management computer]
PMC, performance/thrust management computer
Pneumatic duct fire/overheat warning
Pneumatic system—indicating and warning
Potable water storage, control, indication
Powerpl[ant] fuel indication
Powerplant fire/overheat warning
Radio altimeter
Reverser position indication
RPM [revolutions per minute]/N1/N2/etc. indication
Speed (rate sensing)
Stall barrier system
Stall protection system
Stall warning system
System monitor: indicating and warning
Toilet fire/overheat warning
Turbine inlet temperature indicat[or]
Turn/bank indicator
Vertical speed system

Navigation—23 components
ADF (automatic direction finder)
Approach coupler
Compass (HSI [horizontal situation indicator]/ETC [earth terminal complex])
DME (distance measuring equipment)
Flight director
Flight dynamics
Flight dynamics navigation and safety
FMS/FMC [flight management system/computer]
GPS [Global Positioning System] and other satellite navigation
GPWS [ground proximity warning system]
ILS/VOR [instrument landing system/VFR omni-directional radio range]
ILS/VOR, positional/directional sensing, trailing edge flap control
INS/IRS/IRU [instrument landing system/inertial reference system/unit]
Navigation database
Navigational equipment and processing
Position computing system
Positional/directional sensing
TCAS [traffic collision avoidance system] equipment
TCAS software
Traffic Collision Avoidance System (TCAS)

Traffic Collision Avoidance System (TCAS), transponder
Vacuum pump
VLF [very low frequency]/Omega navigation

Oil system—14 components
Lubrication
Lubrication oil
Oil chip detector
Oil cooler
Oil distribution
Oil filler cap
Oil filter
Oil line
Oil pump
Oil storage
Oil tank
Powerpl[ant] lubrication system
Powerplant lubrication system
Valve/oil system

Propulsion system—85 components
Accessory drive section
Aux engine turbine
Carburetor
Carburetor heat control
Combustor assembly
Compressor
Compressor bearing
Compressor blade
Compressor bleed valve
Compressor disc
Compressor hub
Compressor stator/vane
Cowling
Cowling/nacelle fasteners, latches
Crankshaft
Cylinder
Cylinder head
Cylinder head temperature
Engine
Engine air
Engine air starter
Engine cranking
Engine driven pump
Engine exhaust system
Engine starting system
Exhaust manifold
Exhaust pipe
Exhaust turbo charger
Fan
Fan bearing
Fan blade
Fan case
Fan disc
Fan reverser
Fan variable blade mechanism
Gearbox
Intake assembly
Jet pipe
Main rotor
Main rotor blade
Main rotor hub
Nacelle/pylon
Nacelle/pylon attachment
Nacelle/pylon fairing
Nacelle/pylon main structure
Nacelle/pylon skin
Nozzle
Piston
Power high pressure cock
Powerpl[ant] accessory driveshaft
Powerpl[ant] accessory gearbox
Powerplant accessory driveshaft
Powerplant accessory gearbox
Powerplant fire extinguishing
Powerplant fire seals
Powerplant installation
Powerplant mounting
Propeller
Propeller assembly
Propeller autofeather system
Propeller blade
Propeller brake
Propeller control
Propeller pitch change mechanism
Propeller reversing
Propeller spinner
Propeller synchronization
Reciprocating engine assembly
Reverser actuator
Reverser cascade
Reverser clamshell door
Reverser translating sleeve
Rotating guide vane
Supercharger (turbocharger is 81.1)
Tail rotor drive shaft
Throttle/power level
Thrust reverser control
Turbine assembly
Turbine assemb[ly] blade
Turbine assemb[ly] disc

Turbine assemb[ly] shaft
Turbine assembly stator/vane
Turbine engine
Turbine engine thrust reverser
Turbine reverser

Structure—34 components
Airframe
Airframe composite structure
Cabin window
Cargo door
Cockpit canopy window
Cockpit window
Door window
Emergency exit
Exterior pax [passenger]/crew door
Fuselage
Fuselage attachment
Fuselage bulkhead
Fuselage door frame
Fuselage fairings
Fuselage floor beam
Fuselage main frame
Fuselage nose cone
Fuselage panel
Fuselage skin
Fuselage tail cone
Inspection window
Pax [passenger]/crew door
Service/access door
Tail boom
Window
Wing
Wing attachment
Wing fairing
Wing leading edge
Wing main frame
Wing skin
Wing spar
Wing trailing edge
Wingtip

Weather system—4 components
Rain repellent system
Static wick
Weather radar
Windshield wiper system

Appendix E.—Examples of Human Factor Analysis and Classification System

TABLE E.1.—EXAMPLES OF HUMAN FACTOR ANALYSIS AND CLASSIFICATION SYSTEM (REF. 6)

Unsafe acts	
Errors	Violations
Skill-based Breakdown in visual scan Failed to prioritize attention Inadvertent use of flight controls Omitted step in procedure Omitted checklist item Poor technique Over-controlled the aircraft	Failed to adhere to brief Failed to use the radar altimeter Flew an unauthorized approach Violated training rules Flew an overaggressive maneuver Failed to properly prepare for the flight Briefed unauthorized flight Not current or qualified for the mission Intentionally exceeded the limits of the aircraft
Decision Improper procedure Misdiagnosed emergency Wrong response to emergency Exceeded ability Inappropriate maneuver Poor decision	Continued low-altitude flight in VMC Unauthorized low-altitude canyon running
Perceptual (due to) Misjudged distance, altitude, or airspeed Spatial disorientation Visual illusion	
Unsafe aircrew conditions	
Substandard conditions of operators	Substandard practice of operators
Adverse mental state Channelized attention Complacency Distraction Mental fatigue Get-home-itis Haste Loss of situational awareness Misplaced motivation Task saturation	Crew resource management Failed to back-up Failed to communicate or coordinate Failed to conduct adequate brief Failed to use all available resources Failure of leadership Misinterpretation of traffic calls
Adverse physiological state Impaired physiological state Medical illness Physiological incapacitation Physical fatigue	Personal readiness Excessive physical training Self-medicating Violation of bottle-to-throttle requirement Violation of crew rest requirement
Physical or mental limitation Insufficient reaction time Visual limitation Incompatible intelligence or aptitude Incompatible physical capability	

TABLE E.1.—CONCLUDED.

Unsafe supervision	
Inadequate supervision Failed to provide guidance Failed to provide operational doctrine Failed to provide oversight Failed to provide training Failed to track qualifications Failed to track performance Planned inappropriate operations Failed to provide correct data Failed to provide adequate brief time Improper manning Mission not in accordance with rules or regulations Provided inadequate opportunity for crew rest	Failed to correct a known problem Failed to correct document in error Failed to identify an at-risk aviator Failed to initiate corrective action Failed to report unsafe tendencies Supervisory violations Authorized unnecessary hazard Failed to enforce rules and regulations Authorized unqualified crew for flight

Organizational influences		
Resource management Resource/acquisition management Equipment or facility resources Excessive cost cutting Human resources Lack of funding Monetary/budget resources Poor design Purchasing of unsuitable equipment Selection Staffing/manning Training	Organizational climate Chain of command Communication Culture Delegation of authority Drugs and alcohol Formal accountability for actions Hiring and firing Policies Promotion Norms and rules Organizational justice Structure Values and beliefs	Organizational process Clearly defined objectives Deficient planning Documentation Operations Incentives Instructions Measurement or appraisal Time pressure Production quotas Operational tempo Oversight Procedures Risk management Safety programs Schedules Standards

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14. ABSTRACT
The Aviation Safety Program (AvSP) System-Wide Safety and Assurance Technologies (SSAT) Project asked the AvSP Systems and Portfolio Analysis Team to identify SSAT-related trends. SSAT had four technical challenges: advance safety assurance to enable deployment of NextGen systems; automated discovery of precursors to aviation safety incidents; increasing safety of human-automation interaction by incorporating human performance, and prognostic algorithm design for safety assurance. This report reviews incident data from the NASA Aviation Safety Reporting System (ASRS) for system-component-failure-or-malfunction- (SCFM-) related and human-factor-related incidents for commercial or cargo air carriers (Part 121), commuter airlines (Part 135), and general aviation (Part 91). The data was analyzed by Federal Aviation Regulations (FAR) part, phase of flight, SCFM category, human factor category, and a variety of anomalies and results. There were 38 894 SCFM-related incidents and 83 478 human-factor-related incidents analyzed between January 1993 and April 2011.

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