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Analysis of Aviation Safety Reporting System Incident Data Associated With the Technical Challenges of the Vehicle Systems Safety Technology Project

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October 2014

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Summary

The Aviation Safety Program (AvSP) Vehicle Systems Safety Technology (VSST) Project asked the AvSP Systems and Portfolio Analysis Team to identify VSST-related trends. VSST has three technical challenges: vehicle health assurance; effective crew-system interactions and decisions in all conditions; and aircraft loss of control prevention, mitigation, and recovery. This report reviews incident data from the NASA Aviation Safety Reporting System (ASRS) for system-component-failure-or-malfunction- (SCFM-) related, human-factor-related, and loss-of-control- (LOC-) 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, LOC category, and human factor category. There were 24 409 SCFM-related incidents and 5096 LOC-related incidents analyzed between January 1993 and January 2011, and 2243 human-factor-related incidents analyzed between May 2009 and January 2011.

1.0 Introduction

This analysis was conducted to support the Vehicle Systems Safety Technology (VSST) Project of the Aviation Safety Program (AVsP) milestone VSST4.2.1.01 (Ref. 1), "Identification of VSST-Related Trends." In particular, this is a review of incident data from the NASA Aviation Safety Reporting System (ASRS) (Ref. 2). The following three VSST-related technical challenges (TCs) were the focus of the incidents searched in the ASRS database:

TC1: Vehicle health assurance
TC2: Effective crew-system interactions and decisions in all conditions
TC3: Aircraft loss of control prevention, mitigation, and recovery

The search criteria used for each TC follow:

TC1: Incidents related to aircraft equipment failure or malfunction (system component failure or malfunction, or SCFM, incidents)
TC2: Incidents related to human factors (human-factor-related incidents)
TC3: Incidents related to loss of aircraft control (loss of control, or LOC, 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 air 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.

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, wing tips, 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, and are not corroborated by the Federal Aviation Administration (FAA) or the National Transportation Safety Board. Voluntary incident reports cannot be considered to be a representative sample of the underlying population of events they describe (Ref. 1). 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.

Three data sets were requested from the ASRS: aircraft component problems, human factors, and loss of control (LOC). The search restricted FAR Parts 121, 135, and 91.

Although the ASRS database contained 159 583 full-form reports as of January 2011, the number of reports used in each analysis varied. The ASRS data has been sorted by FAR part only since January 1993. Therefore, all analyses (except the human factors analysis) started in 1993 and ended in January 2011. Somewhat fewer data were available to search for component problem categories because this information needed to be coded by an ASRS analyst, and only a subset of the entire database had gone through this screening process. The human factors category was not added to the ASRS database until May 2009, so this data set is much smaller. Table 1 presents information about each of the three TC analyses, including the time period for the search, and the number of incident reports found.

TABLE 1.—AVIATION SAFETY REPORTING SYSTEM (ASRS) DATABASE SEARCH INFORMATION

Technical challenge	Analysis focus	Time period	Incident reports
TC1: Vehicle health assurance	System component failure or malfunction (SCFM)	Jan. 1993 to Jan. 2011	24 409
TC2: Effective crew-system interactions and decisions in all conditions	Human factors	May 2009 to Jan. 2011	2 243
TC3: Aircraft loss of control (LOC) prevention, mitigation, and recovery	LOC	Jan. 1993 to Jan. 2011	5 096

The data received from ASRS contained the following information in all three data sets: report number, date of incident, flight phase, make and model of aircraft, FAR part number, and individual component problems. Some of the categories are left blank if it is not known, and some can have more than one option to it. For the human-factor-related data set, it also listed a human factors category. All three data sets were analyzed in three ways: by FAR part, phase of flight, and aircraft SCFM.

There are 10 phase of flight categories in the ASRS data set: taxi, takeoff, initial climb, climb, cruise, descent, initial approach, final approach, landing, and parked. Sometimes an incident report lists more than one phase of flight. This means that when the phase of flight is being analyzed, an incident can be counted under multiple phase of flight categories.

3.0 System Component Failure or Malfunction Incident Analysis

This section discusses the incidents that cited at least one SCFM and the incidents that could possibly be addressed by VSST's TC1, vehicle health assurance. The 508 individual components in the ASRS data set were sorted into the following 18 SCFM categories and are listed in Appendix B.

(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

Some reports contained multiple SCFMs, making it possible for one incident to be counted more than once. For example, for an incident that listed the antiskid system, main gear, and tires, the antiskid system would be in the brakes SCFM category and the main gear and tires would be in the landing gear category. This one incident would be counted three times, twice under landing and once under brakes. There are also some incidents that listed a component problem within ASRS, but did not list the specific component. In this analysis, incidents that do not list a specific component are not counted.

In response to the systems analysis team's request for reports from January 1993 through January 2011 that involved a component problem, the ASRS provided a data set of 24 409 reports for Part 121, 135, and 91 operations. This data set included the incident report number, date, phase of flight, aircraft make and model, and SCFM. A more in-depth analysis of this raw data set was conducted to look at what specific SCFMs occurred during each phase of flight.

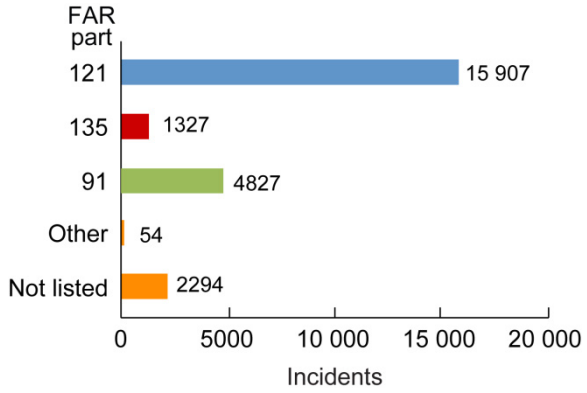


Figure 1.—SCFM-related incidents by FAR part.

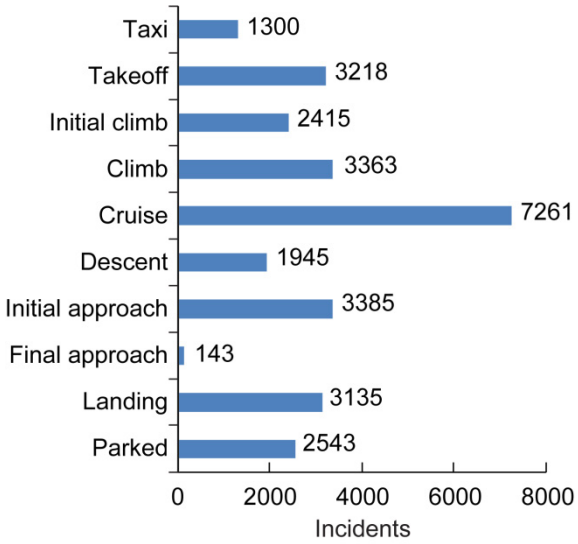


Figure 2.—SCFM-related incidents by phase of flight.

Figure 1 presents SCFM-related incidents by FAR part. The majority of incidents in the data set are for Part 121 with 15 907 incidents (65 percent), followed by Part 91 with 4827 incidents (20 percent), and Part 135 with 1327 incidents (just 5 percent); 9 percent of the incidents did not list a FAR part. Figure 2 shows in which phase of flight most SCFM incidents occurred. Of the total 24 409 SCFM reports, 23 522 listed one or more phases of flight. Of those 23 522 reports, 7261 incidents (31 percent) occurred during cruise, 3385 incidents during initial approach, 3363 during climb, 3218 during takeoff, and 3135 during landing (about 14 percent each). Final approach had the fewest incidents with only 143 (1 percent).

Of the total 24 409 SCFM incidents in the data set, 17 946 (74 percent) listed at least one specific component in the component problem category. Figure 3 shows the SCFM-related incidents by SCFM category. Propulsion system was the top category with 3240 incidents (18 percent), followed by monitoring and management with 2661 incidents (15 percent). Landing gear had 2155 incidents, followed by electrical power with 1933; control surface with 1817; environmental control system with 1619; and navigation with 1511 incidents. The remaining 11 categories had less than 1500 SCFM-related incidents each. Weather system had the fewest incidents—only 55.

3.1 Phase of Flight and FAR Part

In this section, the data are broken down further. Figure 4 shows SCFM-related incidents by phase of flight and FAR part. Part 121 had the greatest number of SCFM incidents that listed a phase of flight with 15 345, Part 91 had 4689 such incidents, and Part 135 had only 1274 such incidents. It is interesting to note that cruise had the largest number of incidents for all three FAR parts. For Part 121, cruise had 4383 incidents followed by climb with 2464 incidents, and takeoff with 2308. For Part 91, cruise had 1748 incidents and landing had 1224 incidents. For Part 135, cruise had 344 incidents and landing had 246 incidents.

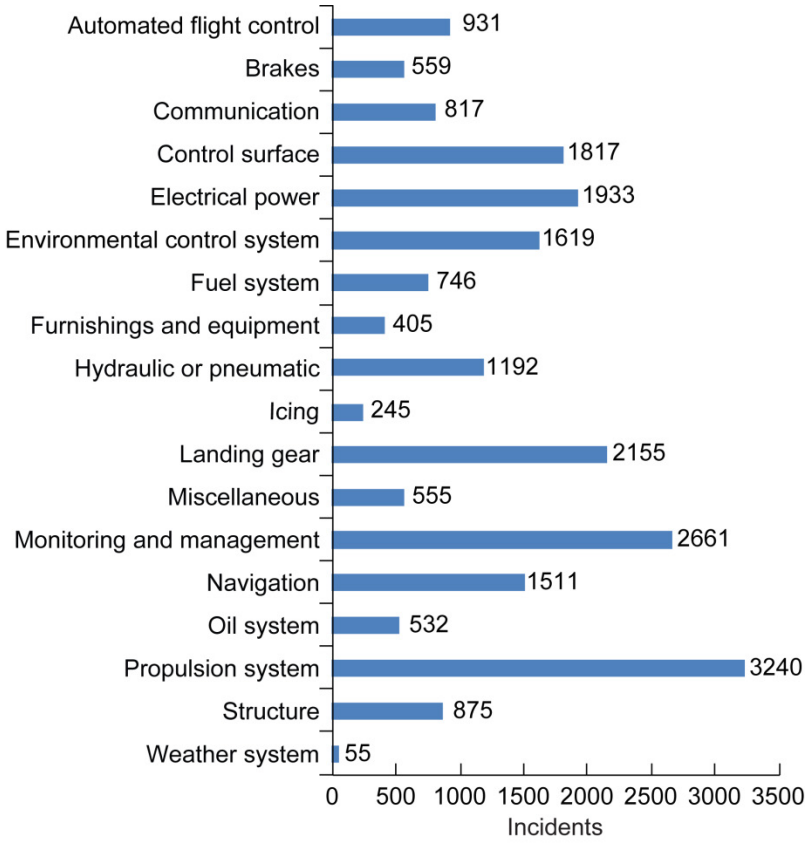


Figure 3.—SCFM-related incidents by SCFM category.

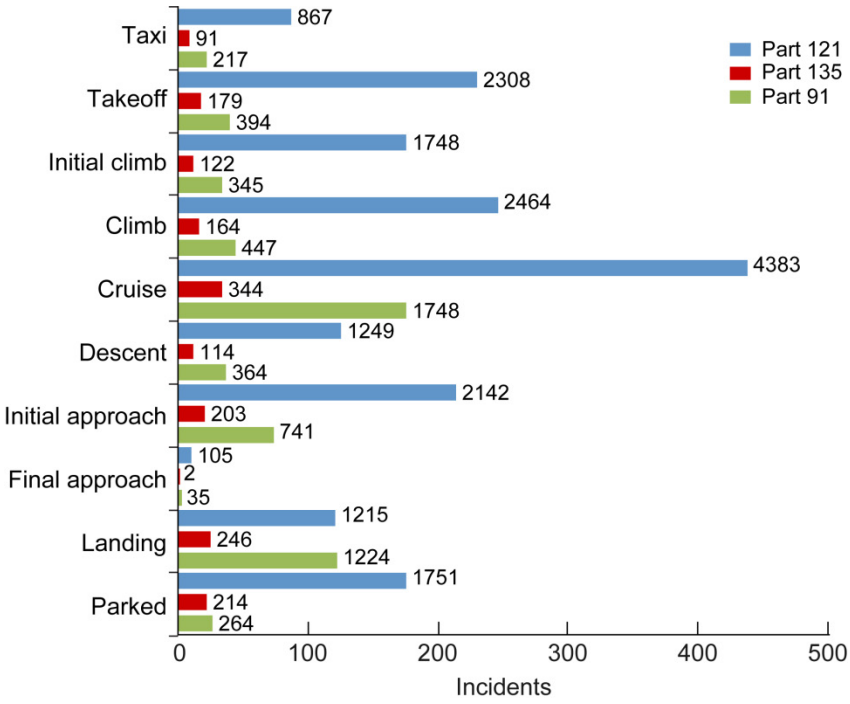


Figure 4.—SCFM-related incidents by phase of flight and FAR part.

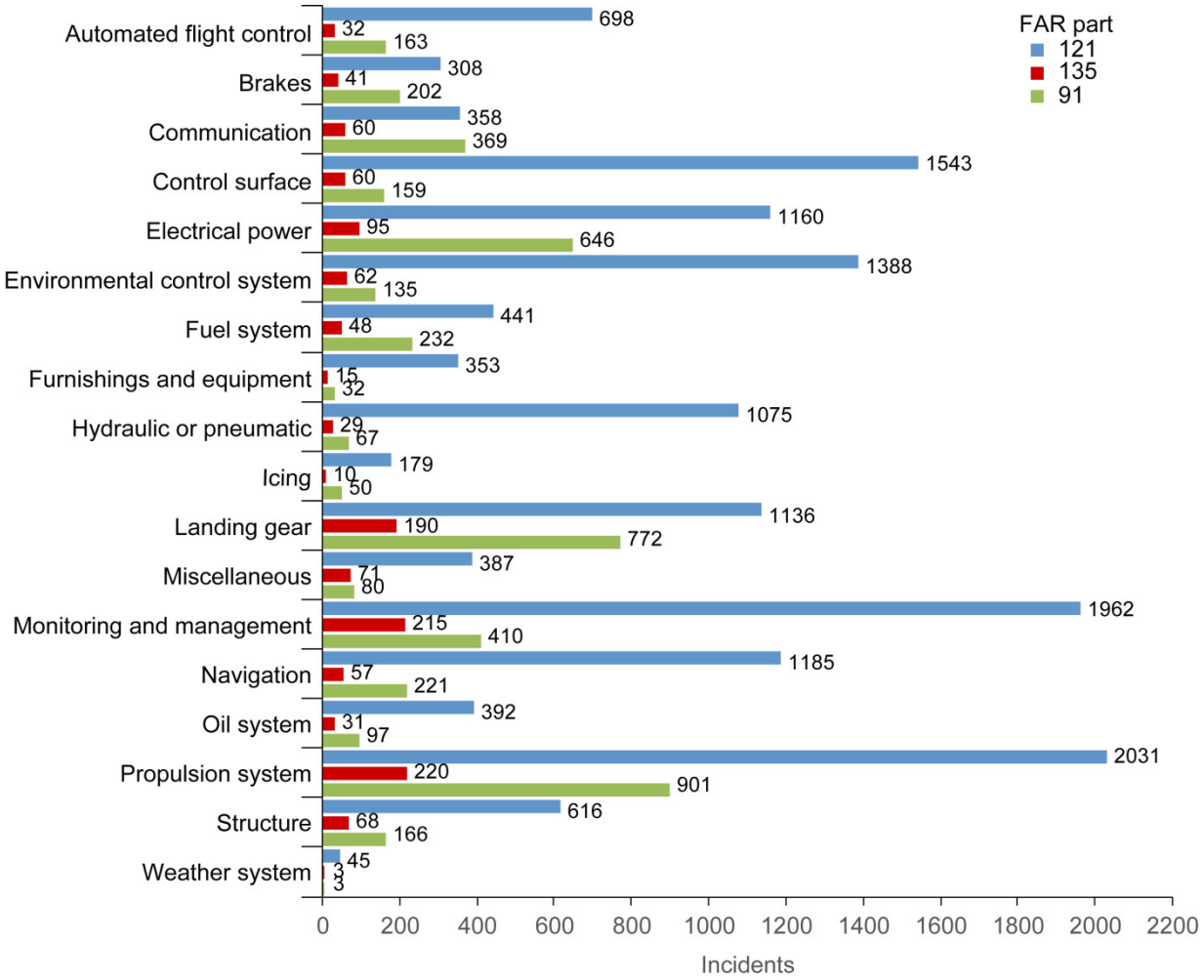


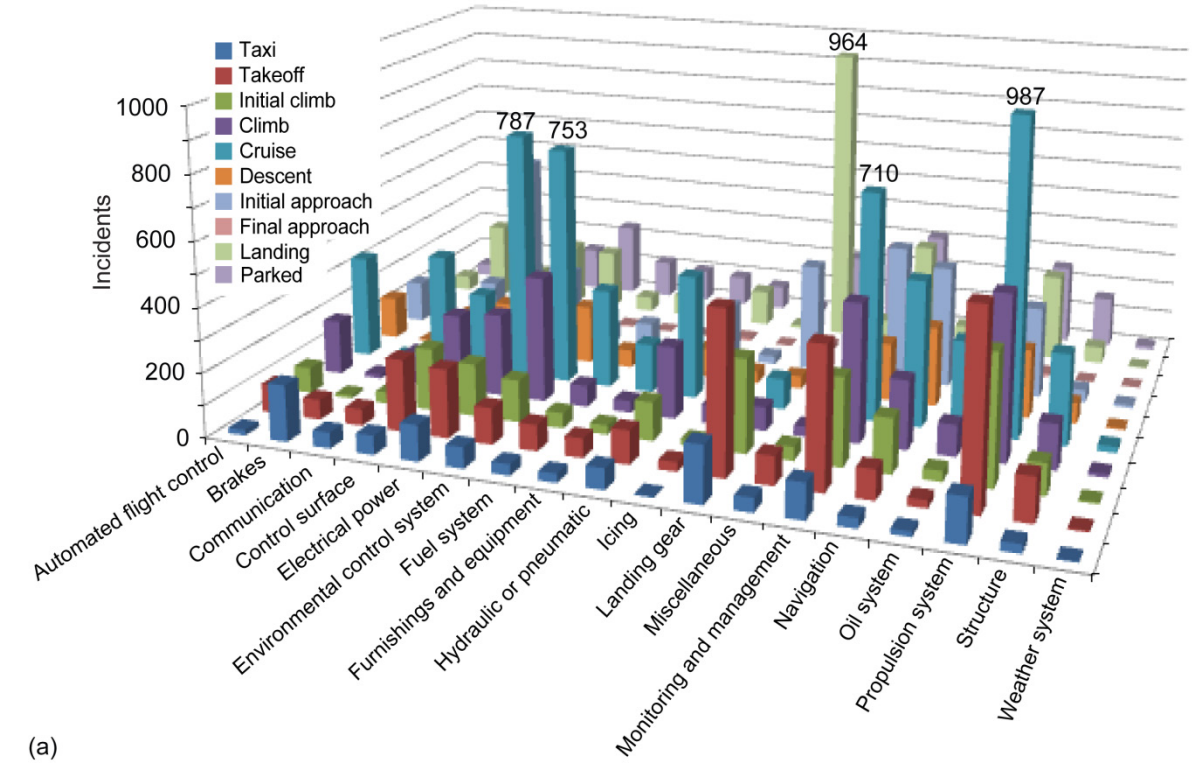
Figure 5.—SCFM-related incidents by SCFM category and FAR part.

3.2 System Component Failure or Malfunction Categories and FAR Part

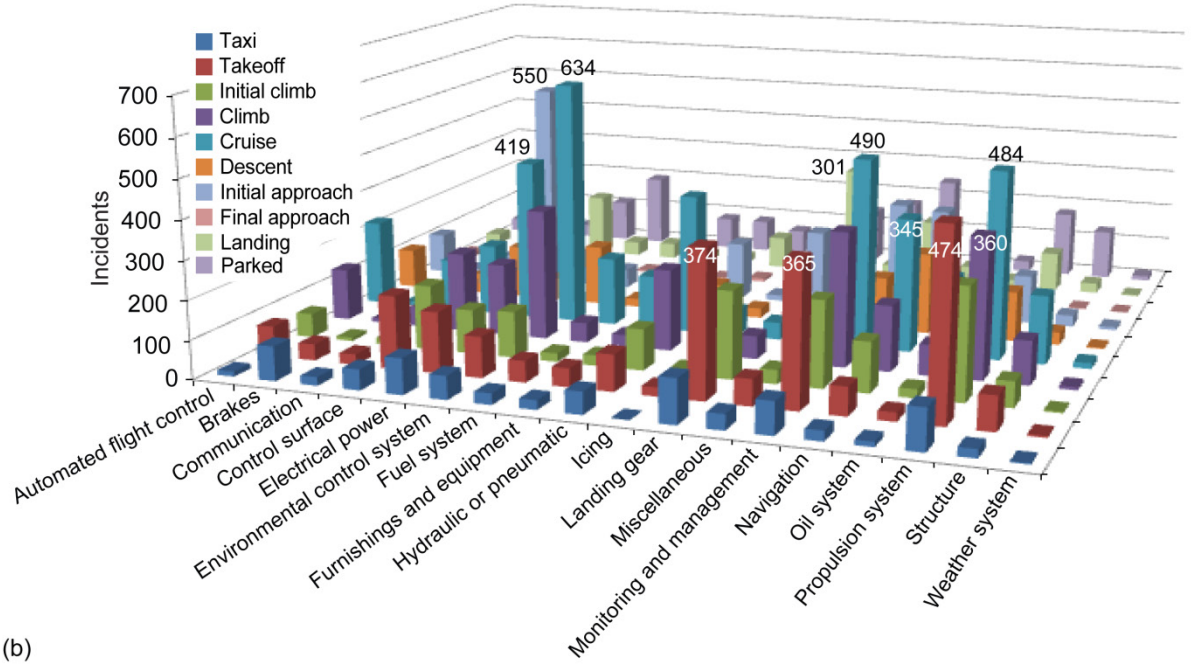
Figure 5 shows SCFM-related incidents by SCFM category and FAR part. Part 121 had the greatest number of SCFM incidents—12 734; Part 135 had 955 incidents, and Part 91 had 3762. Propulsion system was the top SCFM category for all three FAR parts—Part 121 listed 2031 incidents (16 percent), Part 91 listed 901 incidents (24 percent), and Part 135 listed 202 incidents (23 percent). The other top SCFM categories for Part 121 were monitoring and management with 1962 incidents; control surface with 1543; and environmental control system with 1388. Landing gear, electrical power, and monitoring and management were in the top SCFM categories for Parts 135 and 91.

3.3 System Component Failure or Malfunction Category, Phase of Flight, and FAR Part

The final SCFM incident data analysis broke down SCFM-related incidents by SCFM category, phase of flight, and FAR part. Figure 6(a) shows FAR Parts 121, 135, and 91 combined. Figure 6(b) shows only Part 121, Figure 6(c) Part 135, and Figure 6(d) Part 91. More details are shown in Figure C.1(a) to (r) and Table D.1 to Table D.4. Of the 24 409 total aircraft component-related reports, 17 335 (71 percent) listed both a phase of flight and a component problem; Part 121 had 12 326 incidents, Part 135 had 919 incidents, and Part 91 had 3653 incidents.

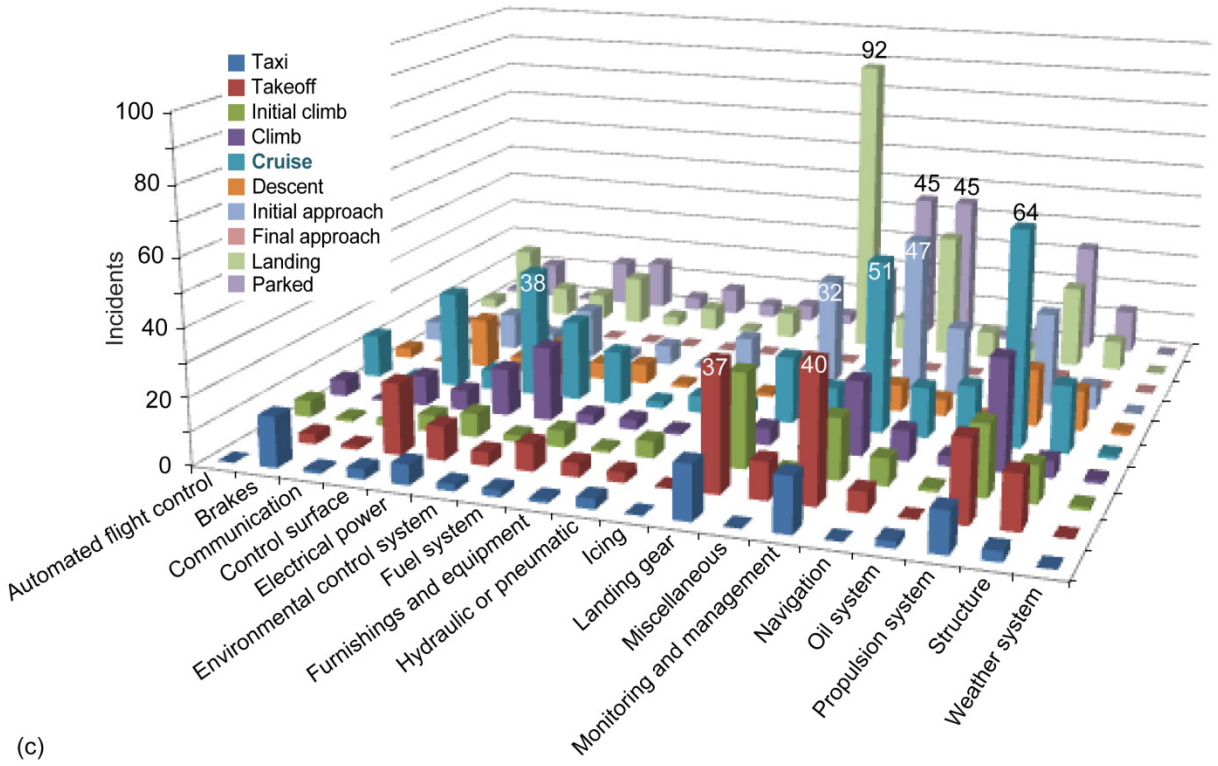


(a)



(b)

Figure 6.—SCFM-related incidents by phase of flight and FAR part: (a) FAR Parts 121, 135, and 91 combined. (b) FAR Part 121. (c) FAR Part 135. (d) FAR Part 91.



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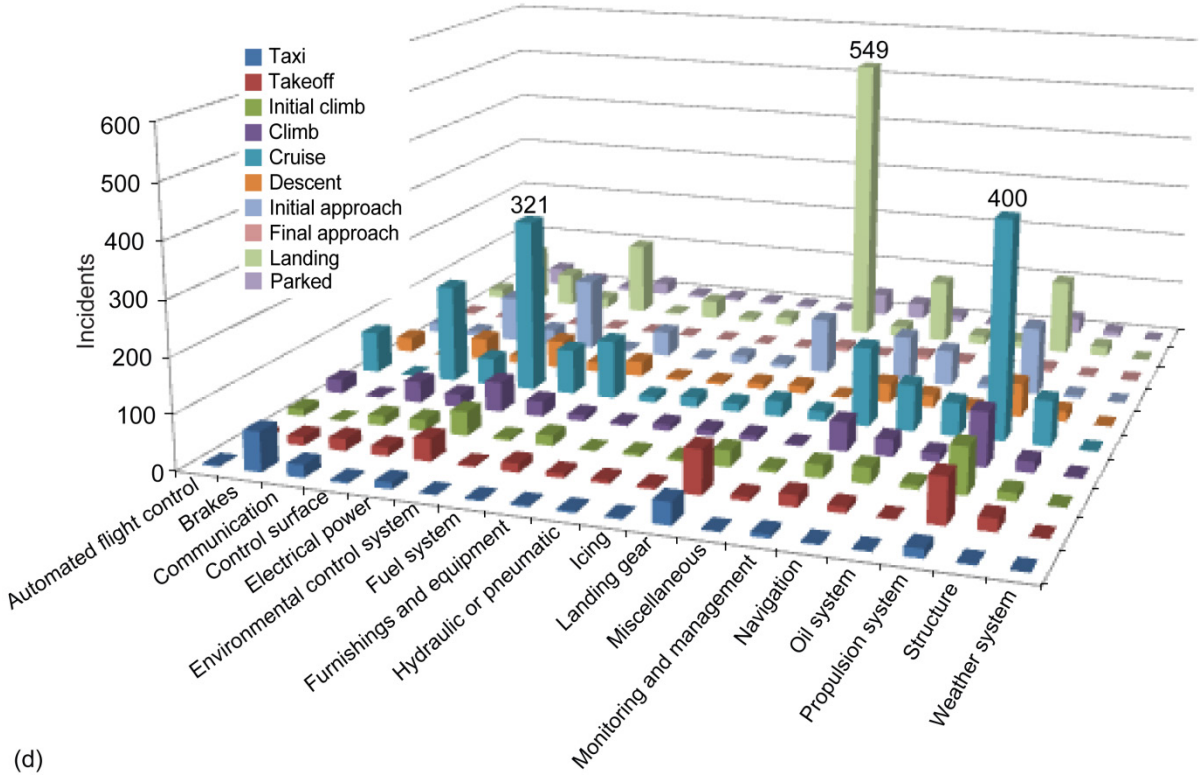


(d)

Figure 6.—Concluded.

The largest SCFM category was propulsion system with 3116 incidents as shown in Figure C.1(p). Cruise and takeoff had the most propulsion system incidents for Part 121 with 484 and 474, respectively. There were almost 4 times as many propulsion incidents for Part 91 as for the other phases for Part 91. If initial climb and climb were combined, there would be 646 Part 121 propulsion incidents—which is a bad phase for a propulsion system to develop a problem.

Monitoring and management was the second largest SCFM category with 2661 incidents as shown in Figure C.1(m). For Parts 121 and 91, cruise was the largest with 490 and 145, respectively, followed by 365 for Part 121 during takeoff.

Table 2 displays the top 10 SCFM categories by phase of flight for each FAR part. Five of the top 10 tall poles under Part 121 occurred during the cruise phase of flight, including the top SCFM category tall pole of environmental control system (634 incidents). Control surface during initial approach was the second largest category (550 incidents). Propulsion system had the most tall poles of the SCFM categories and it also had the most total incidents with 1955.

The tallest pole for Part 135 was landing gear during landing with 92 incidents. The next largest category was propulsion system during cruise with 64 incidents. Monitoring and management had the greatest number of Part 135 tall poles for the SCFM categories, and cruise had the greatest number of tall poles for the phase of flight.

TABLE 2.—TEN MOST FREQUENT SCFM[a] CATEGORIES AND PHASES OF FLIGHT FOR SCFM-RELATED INCIDENTS (TOP 10 TALL POLES) FOR FAR[b] PARTS 121, 135, AND 91

SCFM category	FAR Part	Phase of flight					
		Takeoff	Climb	Cruise	Initial approach	Landing	Parked
Communication	121						
	135						
	91			182			
Control surface	121				550		
	135						
	91						
Electrical power	121			419			
	135			38			
	91			321	135	139	
Environmental control system	121			634			
	135						
	91						
Landing gear	121	374					
	135	37				92	
	91					549	
Monitoring and management	121	365		490			
	135	40		51	47	38	45
	91			145		119	
Navigation	121			345			
	135						
	91						
Propulsion system	121	474	360	484			
	135			64			45
	91			400	126	141	

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

The top tall poles for Part 91 were for landing gear during landing with 549 incidents followed by propulsion system during cruise with 400 incidents. Cruise, initial approach, and landing were the problem phases of flight; and electrical power, landing gear, and propulsion system were the problem SCFM categories.

Table 2 shows that there were persistent problems for monitoring and management, propulsion systems, landing gear, and electrical power. Of interest is that communication, control surface, environmental control, and navigation were only listed in one of the top SCFM categories and that 10 SCFM categories had no tall poles. Cruise had the greatest number of top SCFM problems, followed by landing for phases of flight.

4.0 Loss of Control Incident Analysis

In response to the systems analysis team's request for incident reports involving LOC from January 1993 through January 2011, ASRS analysts provided a data set of 5096 incidents for Part 121, 135, and 91 operations. The information included incident report number, date of incident, phase of flight, aircraft make and model, and any SCFMs. A more in-depth analysis of this raw data set was conducted to look at the conditions present when LOC incidents occurred.

Figure 7 presents LOC incidents by FAR part. The majority of reported incidents were for Part 91 with 2585 incidents (51 percent), followed by Part 121 with 1583 incidents (31 percent), and Part 135 with only 328 incidents. Twelve percent of the incidents did not have a FAR part listed.

4.1 Phase of Flight

There were 4949 LOC incidents that listed one or more phases of flight and the results are shown in Figure 8. Landing was the largest category with 2283 (46 percent) incidents. Cruise had 794 (16 percent) incidents followed by initial approach with 779 (16 percent). A spot check of the LOC incidents reported during taxi and parked phases of flight showed that the incidents were caused by poor runway conditions, jet blast on the ramp, or other issues on the airport grounds. Because of time constraints, the 1056 incidents reported during taxi and park are included in the total number of incidents but are not discussed any further.

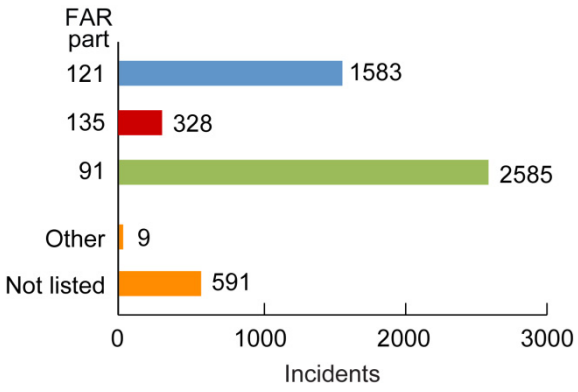


Figure 7.—LOC-related incidents by FAR part.

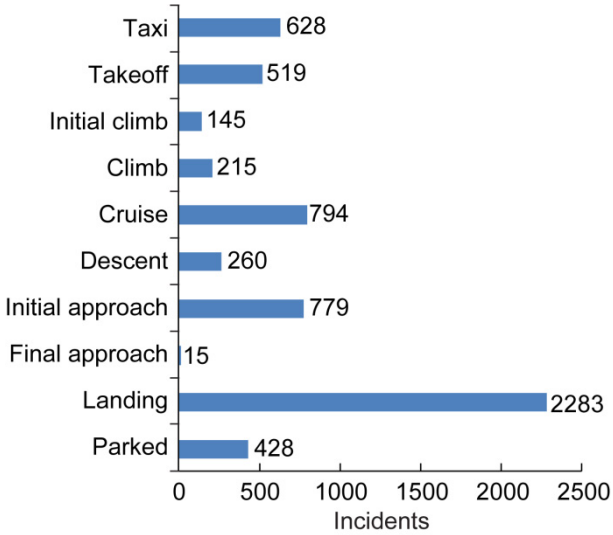


Figure 8.—LOC-related incidents by phase of flight.

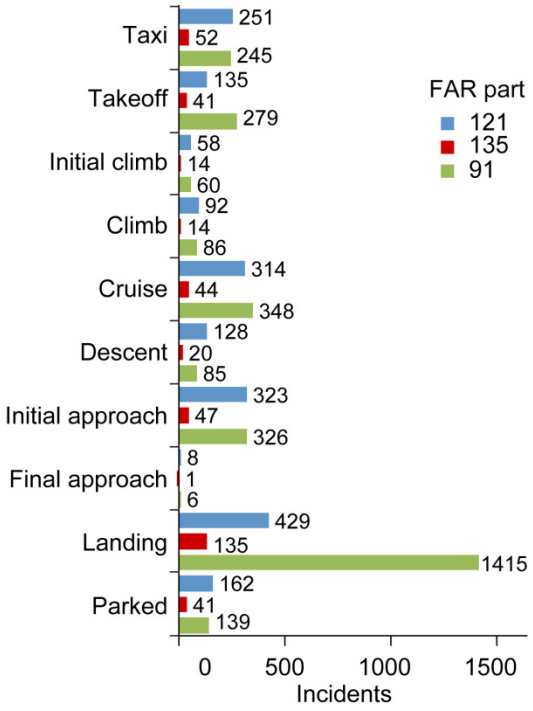


Figure 9.—LOC-related incidents by phase of flight and FAR part.

The FAR part element is added to the phase of flight data as shown in Figure 9. It is interesting to note that the landing phase of flight accounted for the majority of LOC incidents for both Parts 91 and 135. In contrast, incidents occurred in a wider range of flight phases for Part 121 operations: landing accounted for 429 incidents, initial approach accounted for 323 incidents, and cruise accounted for 314 incidents.

4.2 System Component Failure or Malfunction

Many LOC incidents were associated with SCFMs. Figure 10 presents the frequency of SCFMs in the ASRS LOC-related incident data set. Of the 5096 LOC reports in the data set, only 1827 (36 percent) listed one or more SCFM as a primary problem. The top SCFM category was landing gear with 468 incidents (26 percent), followed by brakes with 408 incidents; automated flight control with 325 incidents; control surface with 283 incidents; propulsion system with 230 incidents; and monitoring and management with 142 incidents. The other 12 categories had less than 100 reported LOC incidents with an SCFM.

Figure 11 compares SCFM categories and FAR parts for the LOC-related incidents. For Part 121 operations, 635 reports listed an SCFM. The most frequently listed SCFM category was automated flight control with 180 incidents (29 percent), followed by the control surface with 125 incidents (20 percent); brakes with 112 incidents (18 percent); and landing gear with 105 incidents (18 percent). In contrast, the most frequently cited SCFM category for both Parts 135 and 91 was landing gear, followed by brakes. Propulsion system, control surface, and automated flight control were also significant Part 91 SCFM categories, combining for a total of 39 percent of these incidents.

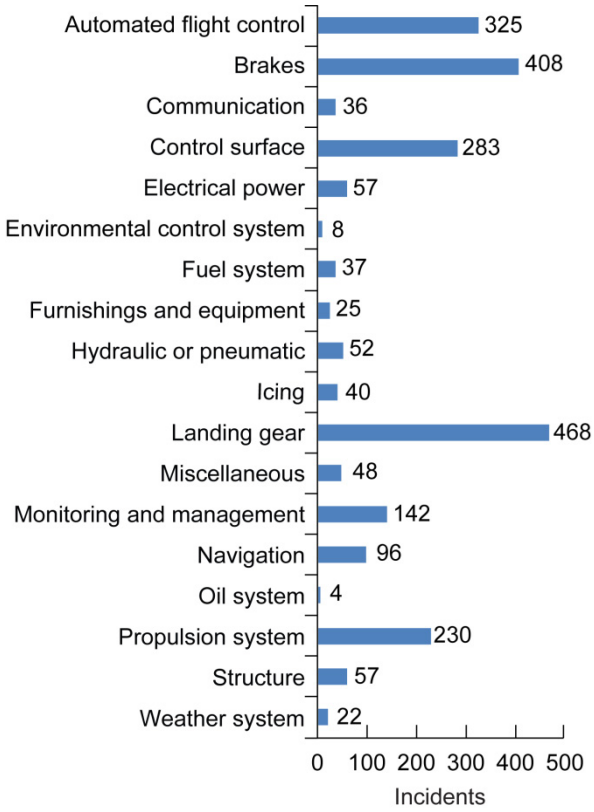


Figure 10.—LOC-related incidents by SCFM category.

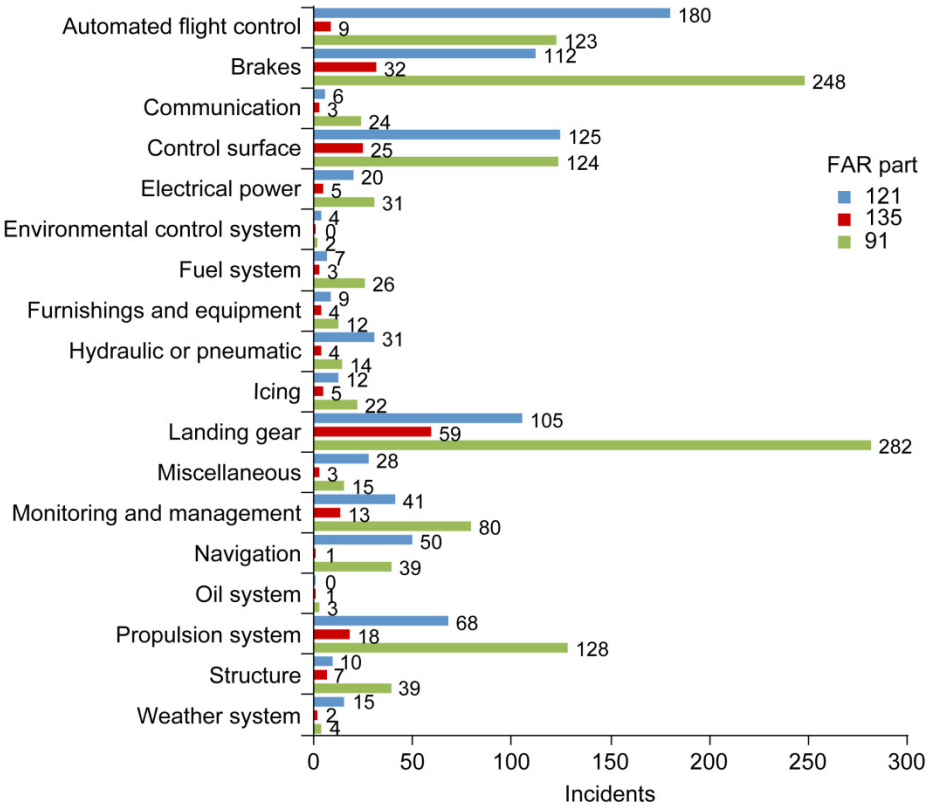


Figure 11.—LOC-related incidents by SCFM category and FAR part.

4.3 Phase of Flight, FAR Part, and System Component Failure or Malfunction Category

The final LOC data analysis broke the incidents down by phase of flight, FAR part, and SCFM category. Figure 12(a) shows FAR Parts 121, 135, and 91 combined, Figure 12(b) shows only Part 121, Figure 12(c) shows Part 135, and Figure 12(d) shows Part 91. More details can be seen in Figure C.2(a) to Figure C.2(r) and Table D.5 to Table D.8. Out of 5096 total LOC incident reports, 1760 (35 percent) had both a phase of flight and an SCFM listed.

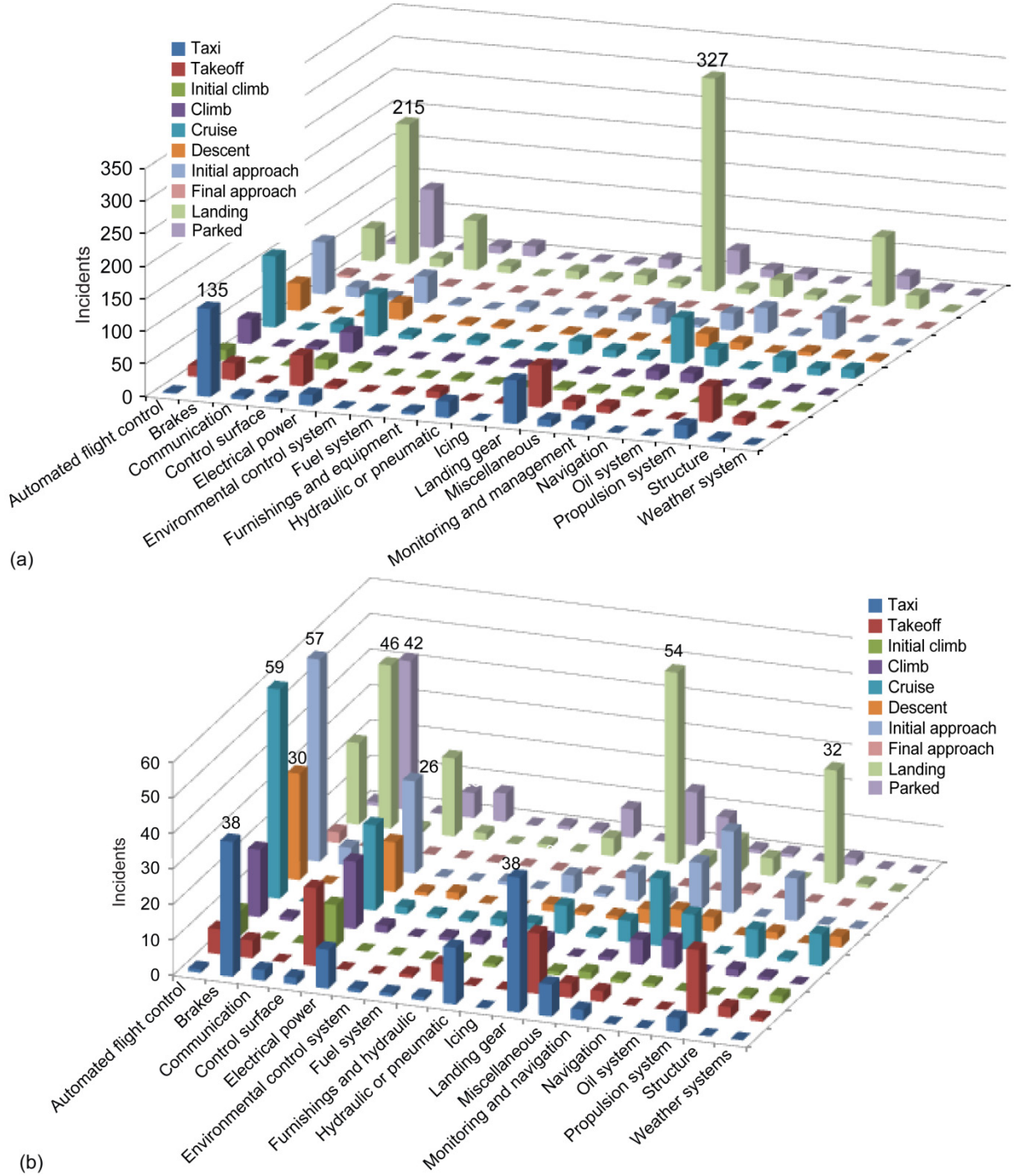
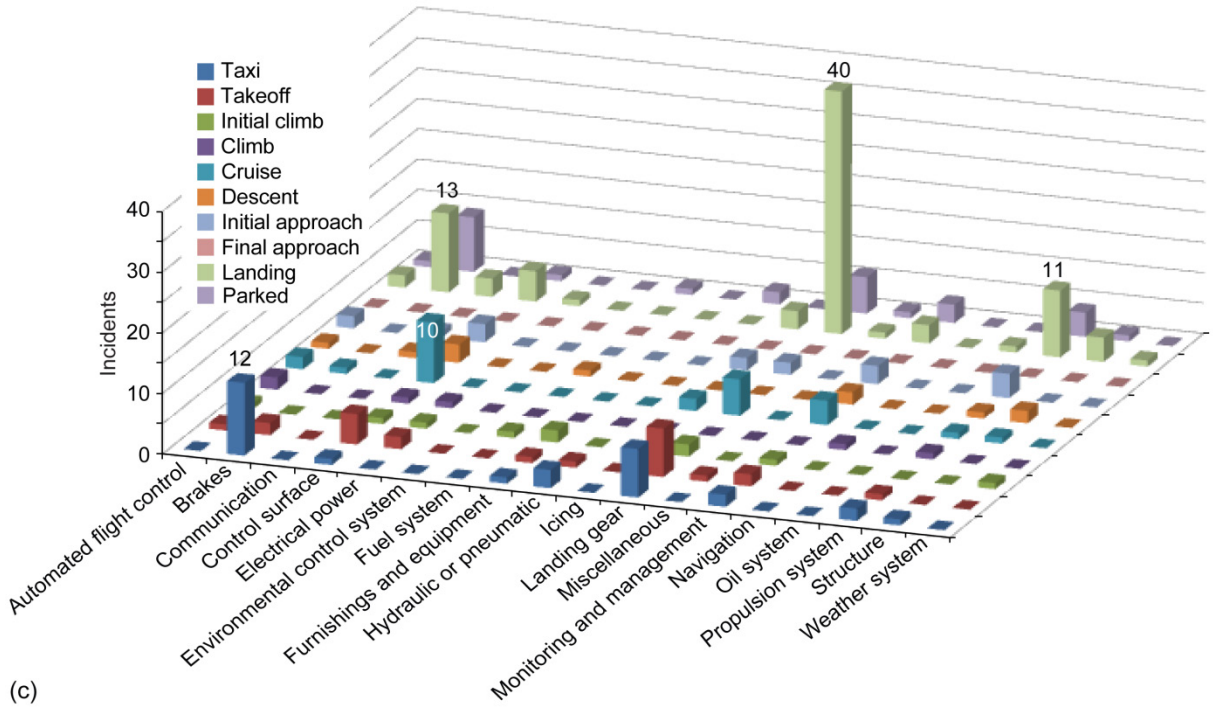


Figure 12.—LOC-related incidents by SCFM category and phase of flight: (a) FAR Parts 121, 135, and 91 combined. (b) FAR Part 121. (c) FAR Part 135. (d) FAR Part 91.



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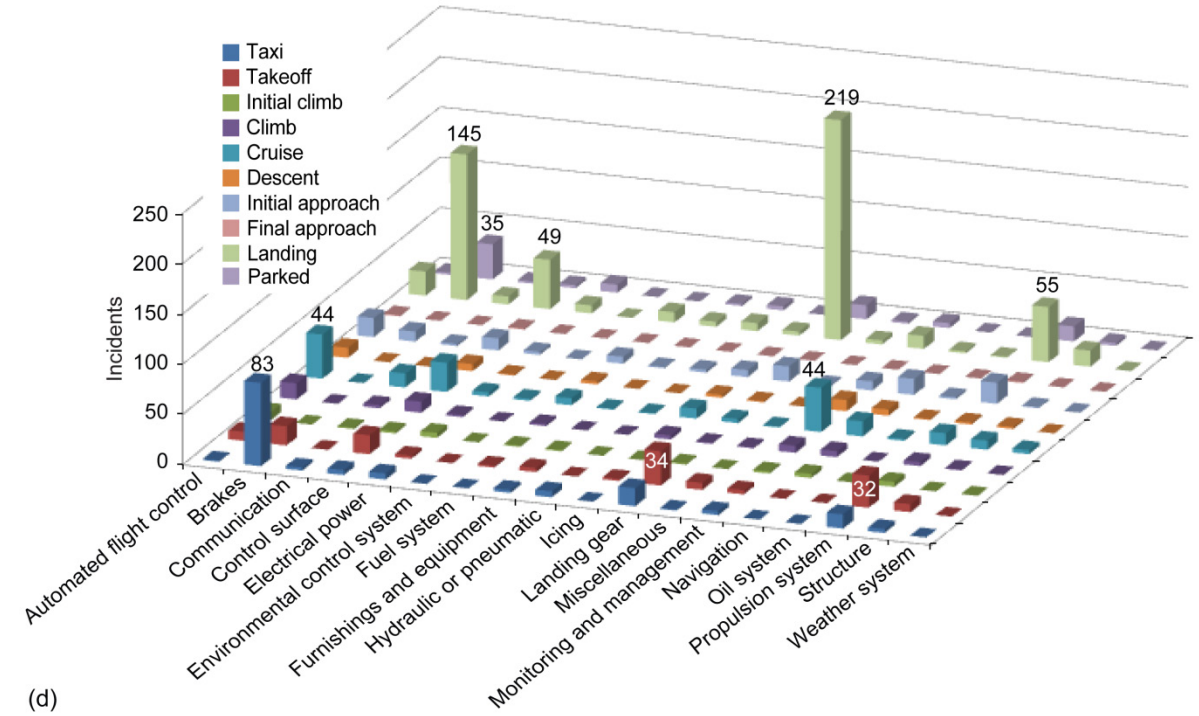


(d)

Figure 12.—Concluded.

For Part 121, the largest SCFM category for the LOC data was automated flight control with 180 total incidents over all phases of flight: cruise had 59 incidents and initial approach had 57 incidents. Control surface was the second largest category with a total of 125, but they were spread out over initial approach (26 incidents), cruise (24), takeoff (22), landing (22), and climb (19). Brakes with 112 incidents and landing gear with 105 incidents came next, but most of these were probably LOCs on the ground and not in the air. Finally propulsion had 68 incidents with 32 during landing, 18 during takeoff, and 12 during initial approach.

Part 135 had 141 incidents listing an SCFM and a phase of flight, with the tallest poles being landing gear during landing (40 incidents), brakes during landing (13), brakes during taxi (12), and propulsion systems during landing (11).

Part 91 had 939 incidents listing an SCFM and a phase of flight. Similar to Part 135, landing gear during landing (219) brakes during landing (145), and brakes during taxi (83) had the most tall poles. This was followed by propulsion systems during landing (55), automated flight control during cruise (44), and monitoring and management during cruise (44).

Table 3 displays the top 10 tall poles for each of the FAR parts for LOC incidents with SCFM categories and a phase of flight. Landing gear and brakes had the most tall poles with 9 each, automated flight control and propulsion system had 4 each, and control surface had 3.

TABLE 3.—TEN MOST FREQUENT SCFM[a] CATEGORY AND PHASES OF FLIGHT FOR LOSS-OF-CONTROL-RELATED INCIDENTS (TOP 10 TALL POLES) FOR FAR[b] PARTS 121, 135, AND 91

SCFM category	FAR Part	Phase of flight						
		Taxi	Takeoff	Cruise	Descent	Initial approach	Landing	Parked
Automated flight control	121			59	30	57		
	135							
	91			44				
Brakes	121	38					46	42
	135	12					13	9
	91	83					145	35
Control surface	121					26		
	135			10				
	91						49	
Landing gear	121	38					54	
	135	8	8	6			40	6
	91		34				219	
Monitoring and management	121							
	135							
	91			44				
Propulsion system	121						32	
	135						11	
	91		32				55	

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

5.0 Human Factor Incident Analysis

The human factor analysis applies to the VSST Project TC2, "Effective crew-system interactions and decisions in all conditions." In response to the systems analysis team's request for human-factor-related incidents from January 1993 to January 2011, ASRS analysts provided a data set of 2243 incidents for Part 121, 135, and 91 operations.

Because the human-factors category was not added to the ASRS search criteria until May 2009, the data set lists incidents from May 2009 through January 2011. Although ASRS data prior to May 2009 also contains human factor data, using a free text search string or reading through each report would be required to obtain the information.

The ASRS information included incident report number, date of incident, phase of flight, aircraft make and model, SCFMs, and human factors. The human factor categories follow:

(1) Communication breakdown
(2) Confusion
(3) Distraction
(4) Fatigue
(5) Human-machine interface
(6) Other-unknown
(7) Physiological-other
(8) Situational awareness
(9) Time pressure
(10) Training/qualification
(11) Troubleshooting
(12) Workload

A more in-depth analysis of this raw data set looked at the conditions present when human factor incidents occurred during the 21 months.

Figure 13 shows the human-factor-related incidents by FAR part. There were 1966 total reports for FAR Parts 121, 135, and 91 combined. The majority of the incidents were for Part 121 with 1393 (71 percent), followed by Part 91 with 504 incidents. There were only 69 incidents for Part 135.

Figure 14 shows human-factor-related incidents by each phase of flight. Of the 2123 reports that listed a phase of flight, the tallest pole was cruise with 404 incidents (19 percent), followed by parked with 282 incidents (13 percent).

Figure 15 shows the human factor data by phase of flight and FAR part. Of the 1922 incidents that listed both a FAR part and a phase of flight, 1354 incidents were for Part 121, 68 for Part 135, and 500 for Part 91. The four tallest poles were all for Part 121—with 261 incidents during the parked phase of flight, 222 during cruise, 154 during climb, and 151 during descent. The largest category for Part 91 was cruise with 107 incidents and the largest category for Part 135 was initial climb with 17 incidents.

Figure 16 shows the results of grouping the data into the human factor categories, with many of the incidents listing multiple human factors. Of the total 2243 reports, 2152 incidents listed a specific human factor, but 5949 human factors were listed in those 2152 reports. Situational awareness was the tallest pole with 1309 followed by communication breakdown with 844 incidents; confusion with 757 incidents; human-machine interface with 510 incidents; and distraction with 506 incidents. Fatigue and physiological-other had the fewest reports with 95 and 84 incidents, respectively.

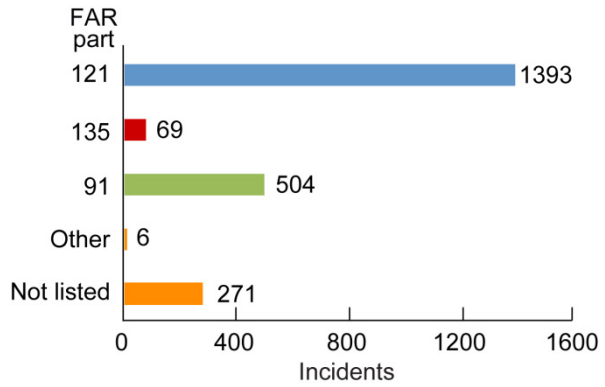


Figure 13.—Human-factor-related incidents by FAR part.

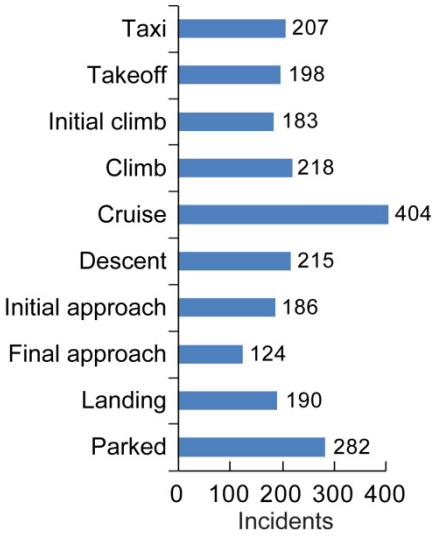


Figure 14.—Human-factor-related incidents by phase of flight.

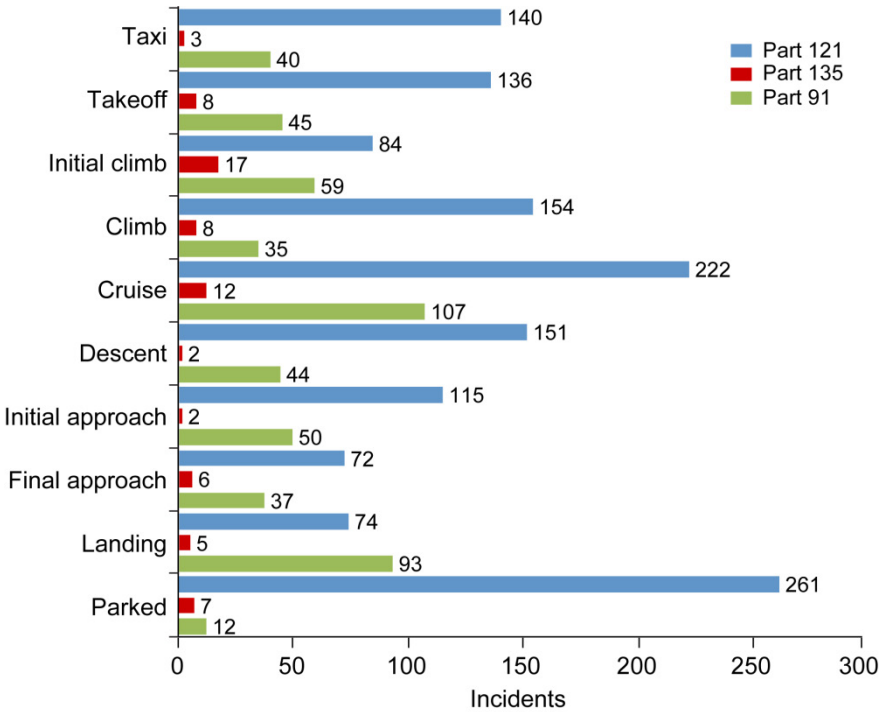


Figure 15.—Human-factor-related incidents by phase of flight and FAR part.

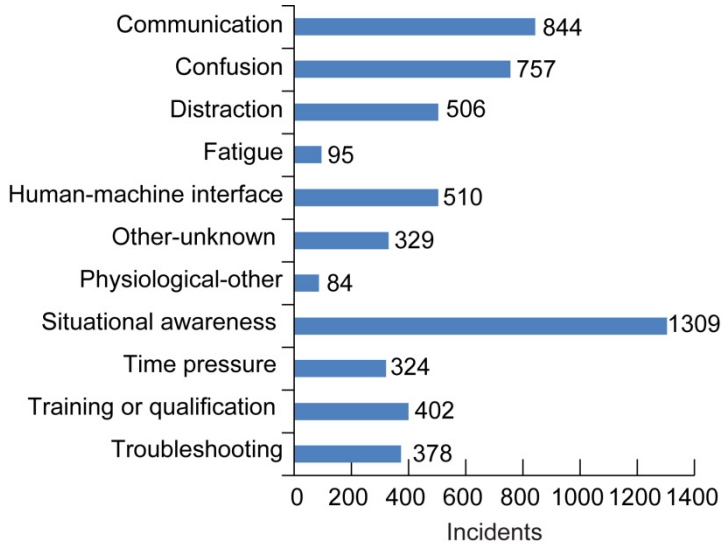


Figure 16.—Human-factor-related incidents by human factor category.

Forty-four percent of the human-factor-related data, or 977 incidents, listed an SCFM. The remaining 1266 human factor incidents did not list an SCFM. Figure 17 shows human-factor-related incidents broken down by SCFM category. The tallest poles were navigation with 155 incidents; propulsion system with 139 incidents; and monitoring and management with 121 incidents.

Figure 18 displays the human factor categories for each FAR part. There were 1345 incidents for Part 121 that listed a human factor, 490 incidents for FAR Part 91, but only 67 incidents for Part 135. Situational awareness had the greatest number of incidents in each phase of flight: 809 in Part 121, 340 in Part 91, and 48 in Part 135. Communication breakdown and confusion were the second and third largest categories, with 538 and 476 human factor incidents—both in Part 121. Physiological-other and fatigue had the fewest incidents in each FAR part.

Figure 19(a) to Figure 19(d) show the human-factor-related incidents by human factor category and phase of flight for FAR Parts 121, 135, and 91 combined and individually. More detailed data is shown in Table D.9 to Table D.12. Figure 20(a) to Figure 20(d) show the human factor categories and SCFMs for FAR Parts 121, 135, and 91 combined and individually. More detailed data is shown in Table D.13 to Table D.16.

The data in Appendix Figure C.3, Figure C.4, and Figure C.5 is displayed in a variety of ways to allow the reader to see the data in the way that is most beneficial to them. Figure C.3(a) to Figure C.3(l) displays two figures for each human factor category in descending incident number order, by phase of flight and FAR part, and by SCFM category and FAR part. Figure C.4(a) to Figure C.4(j) displays the data for each phase of flight by human factor category and FAR part. Finally, Figure C.5(a) to Figure C.5(r) displays the data for each SCFM category by human factor category and FAR part

Each human factor category is discussed in descending incident number order.

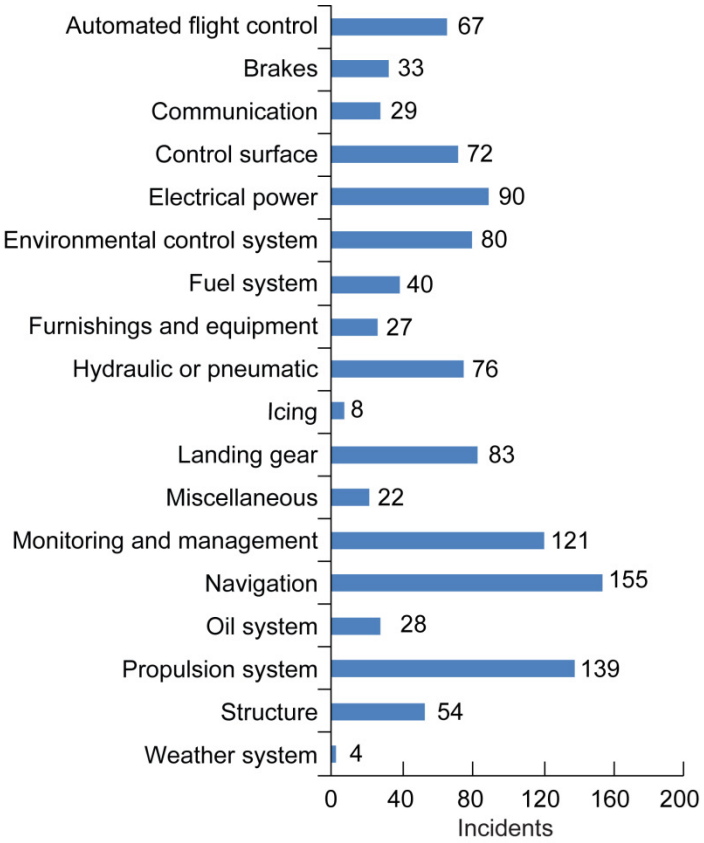


Figure 17.—Human-factor-related incidents by SCFM category.

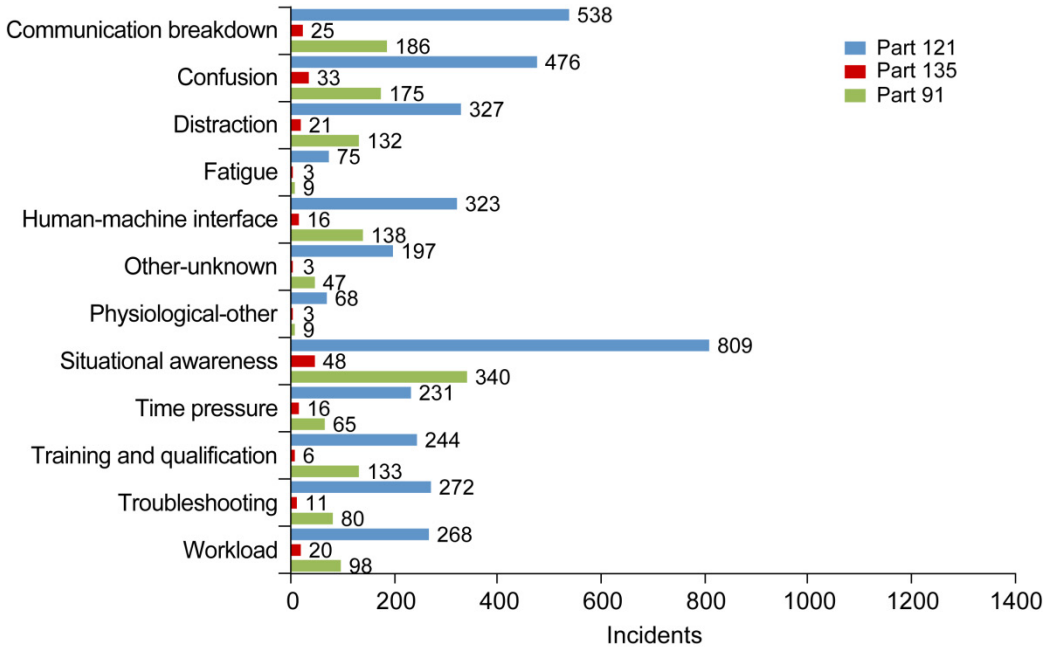
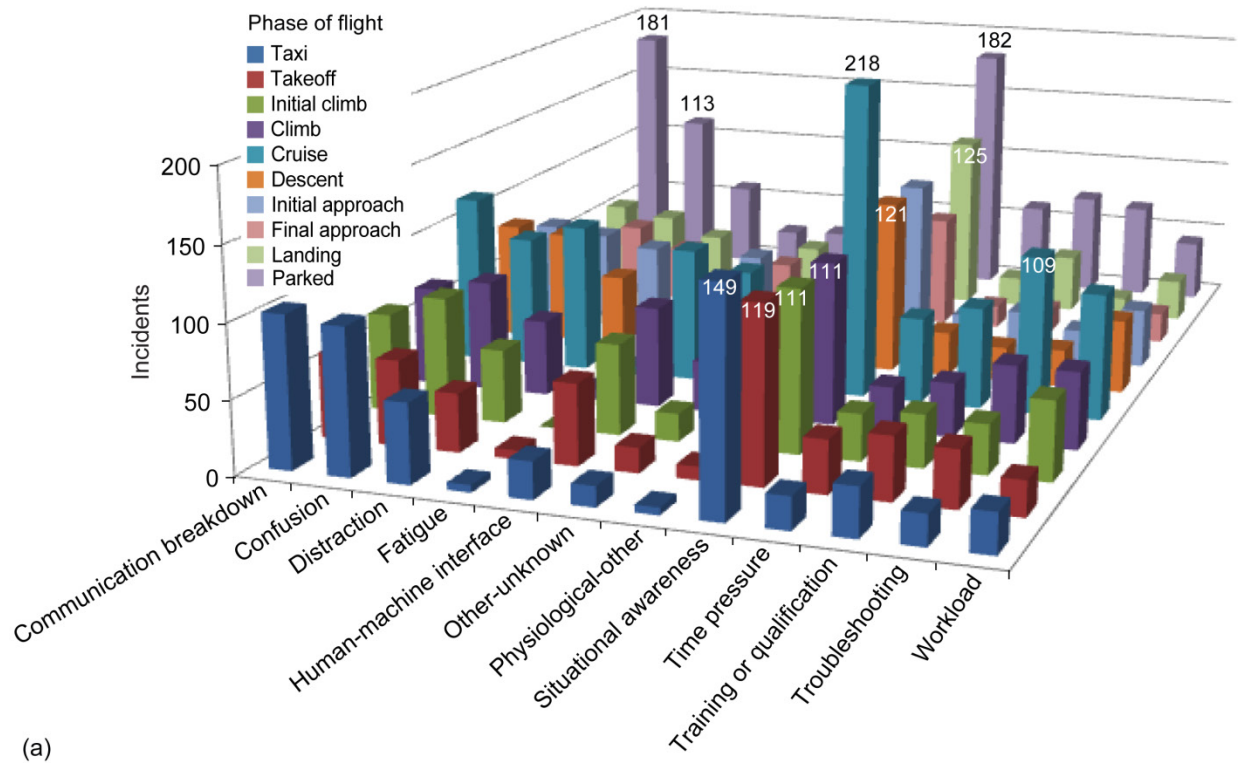
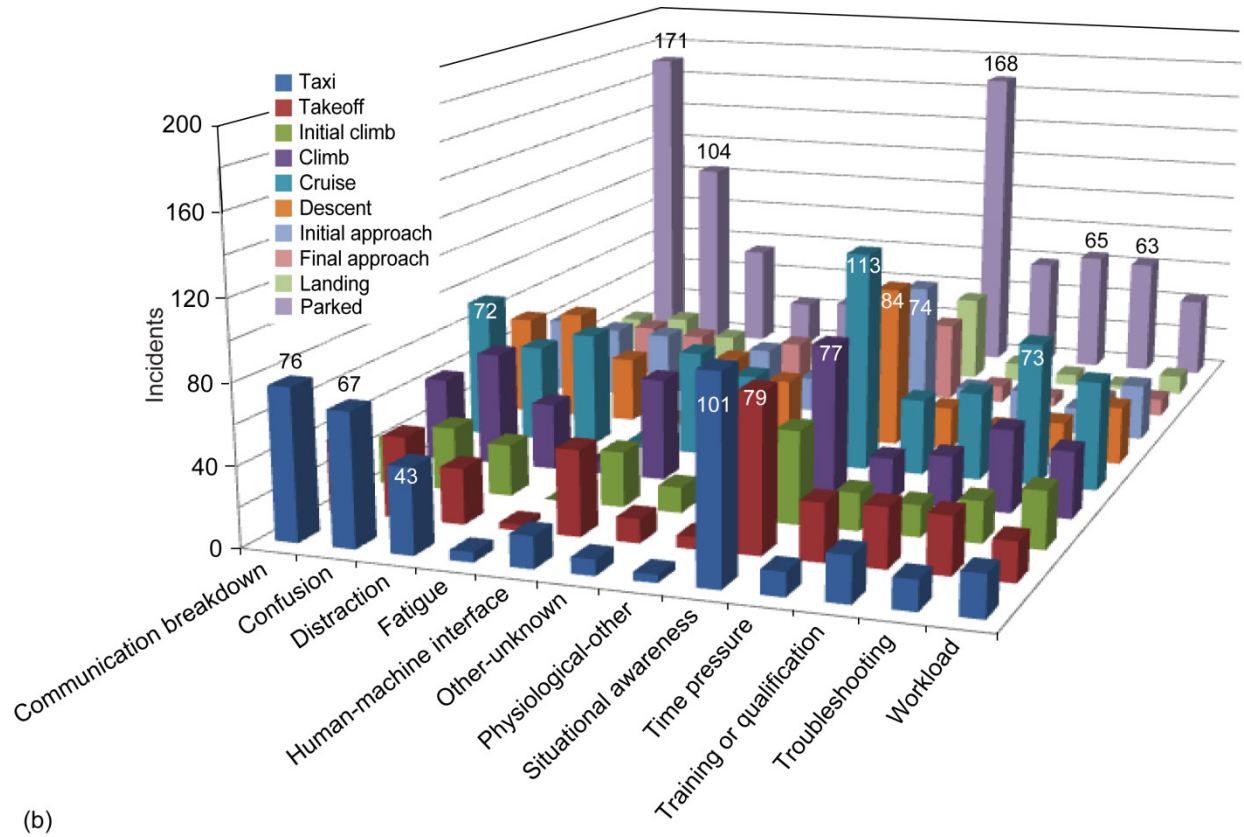


Figure 18.—Human-factor-related incidents by human factor category and FAR part.

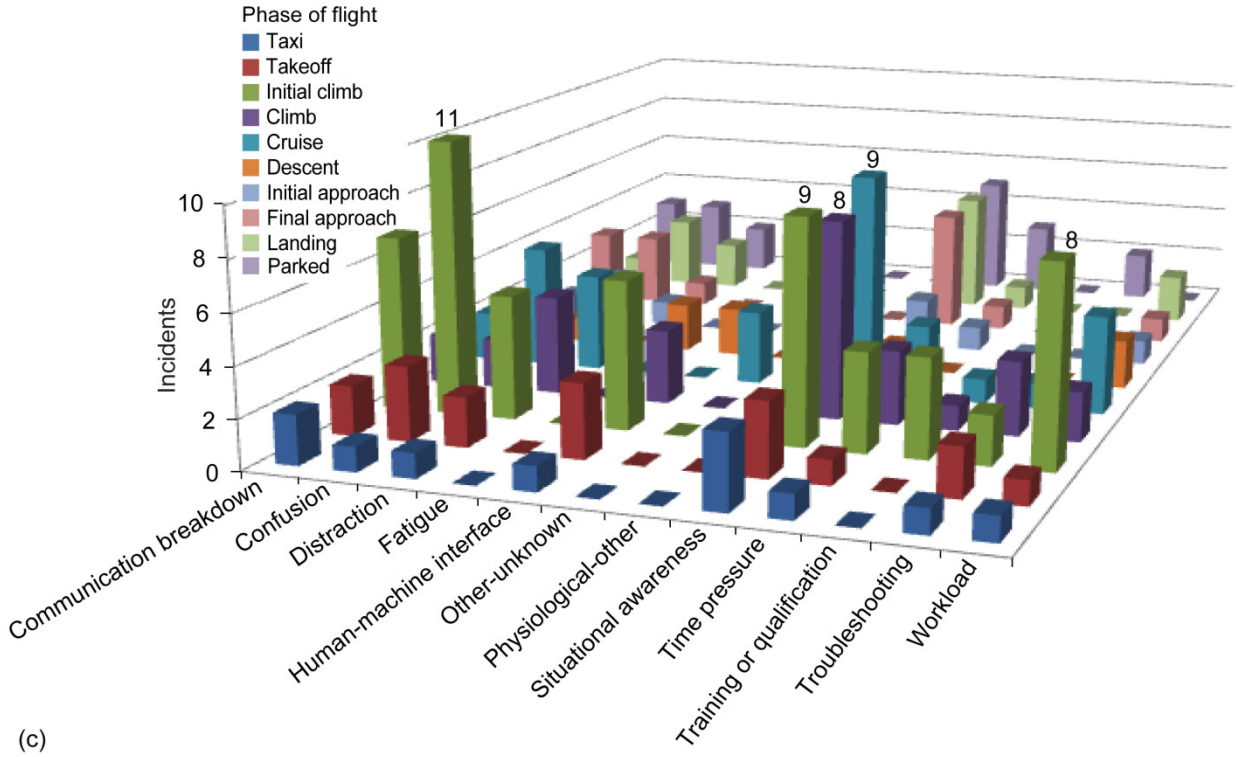


(a)

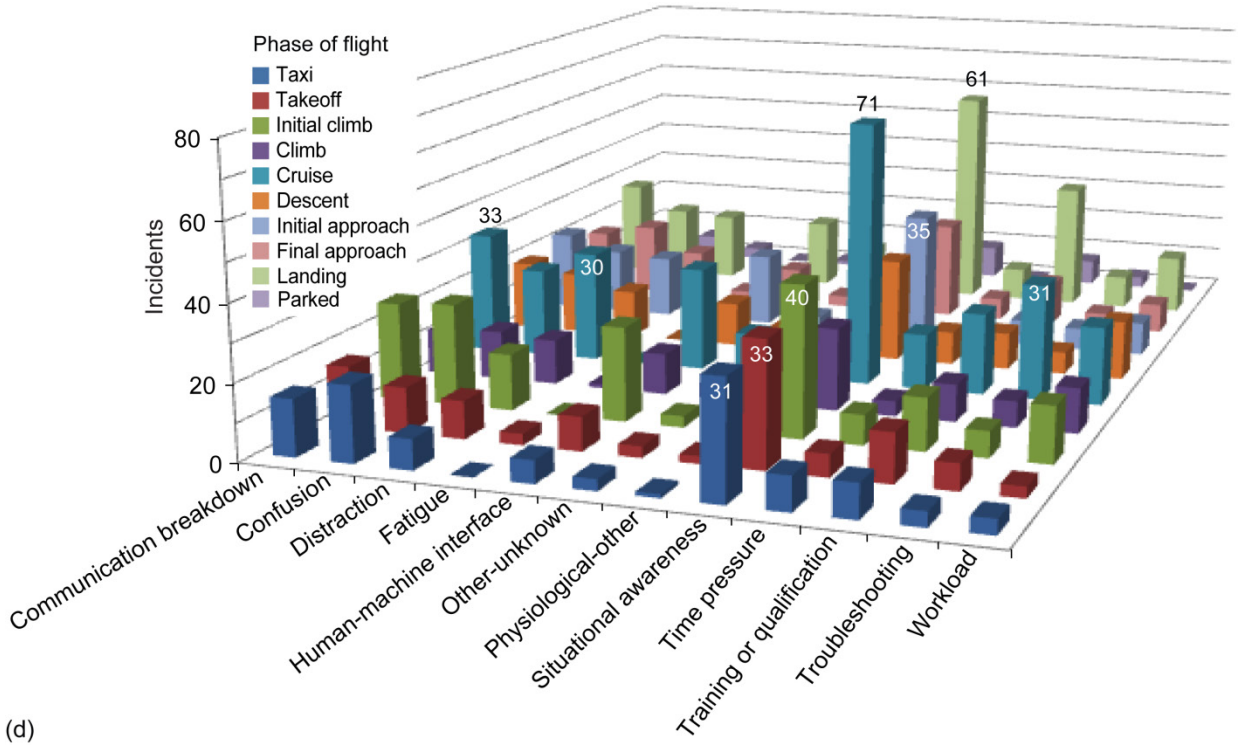


(b)

Figure 19.—Human-factor-related incidents by human factor category and phase of flight: (a) FAR Parts 121, 135, and 91 combined. (b) FAR Part 121. (c) FAR Part 135. (d) FAR Part 91.

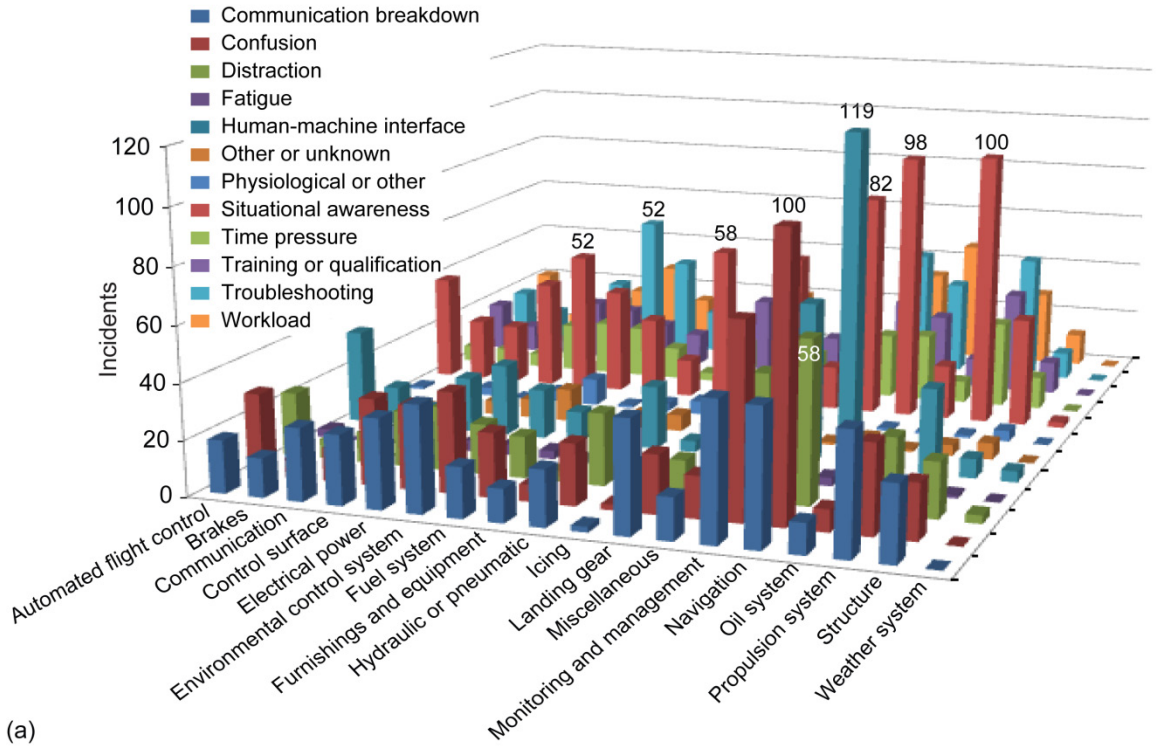


(c)

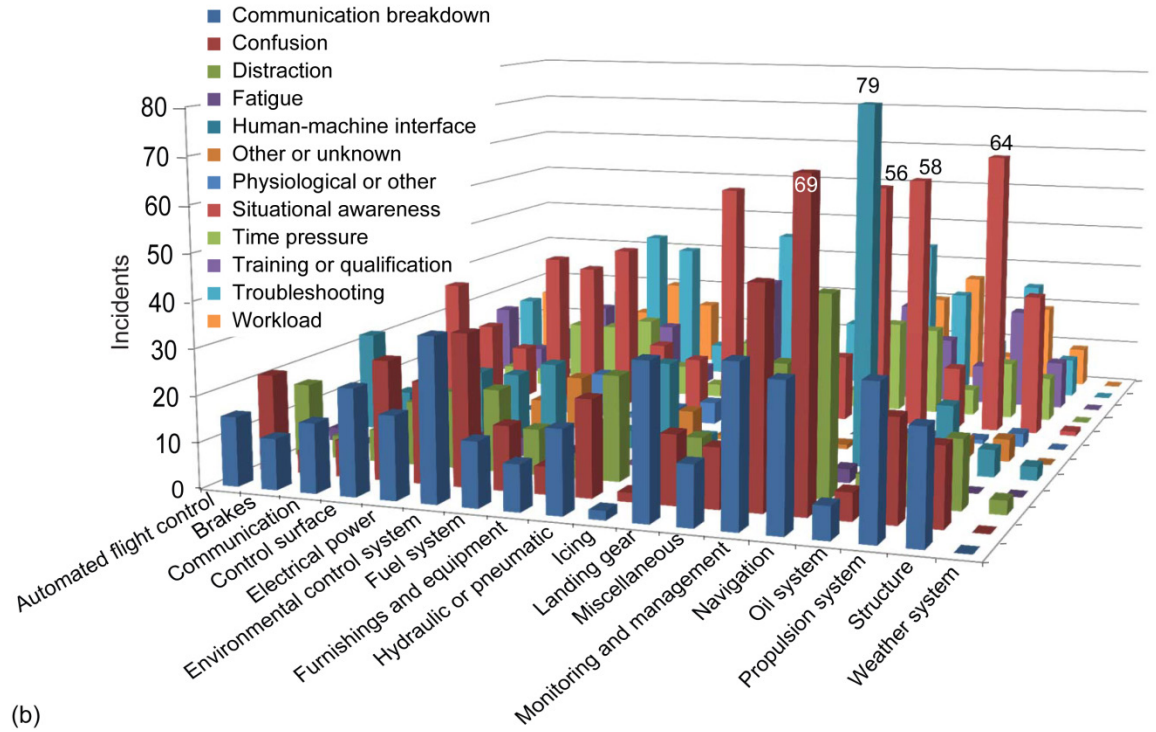


(d)

Figure 19.—Concluded.

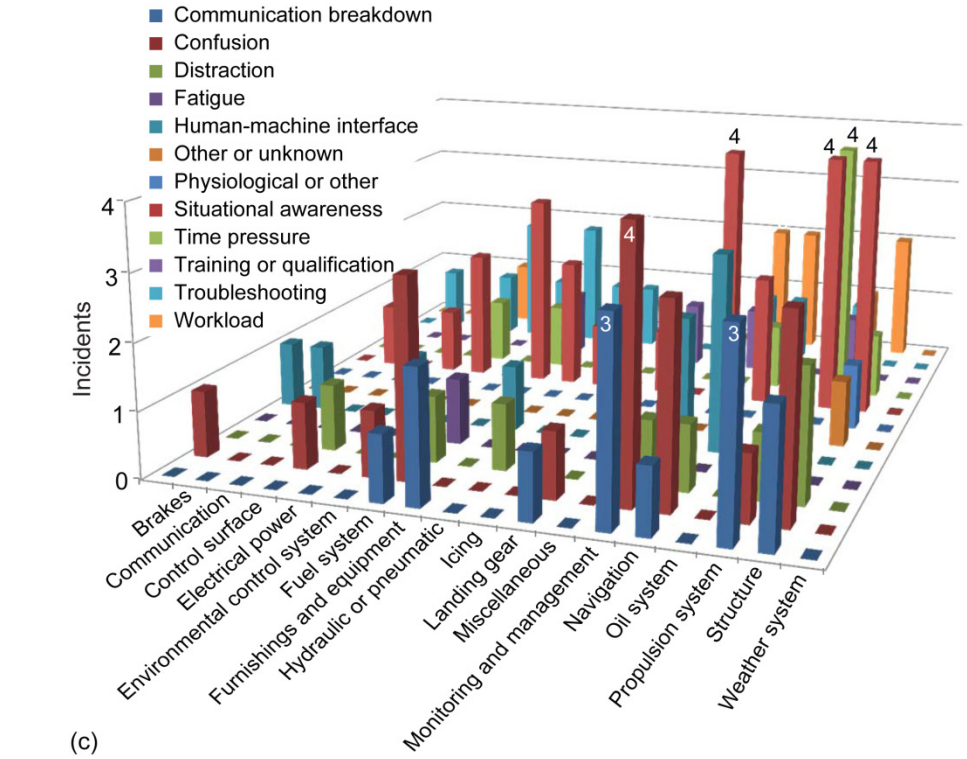


(a)

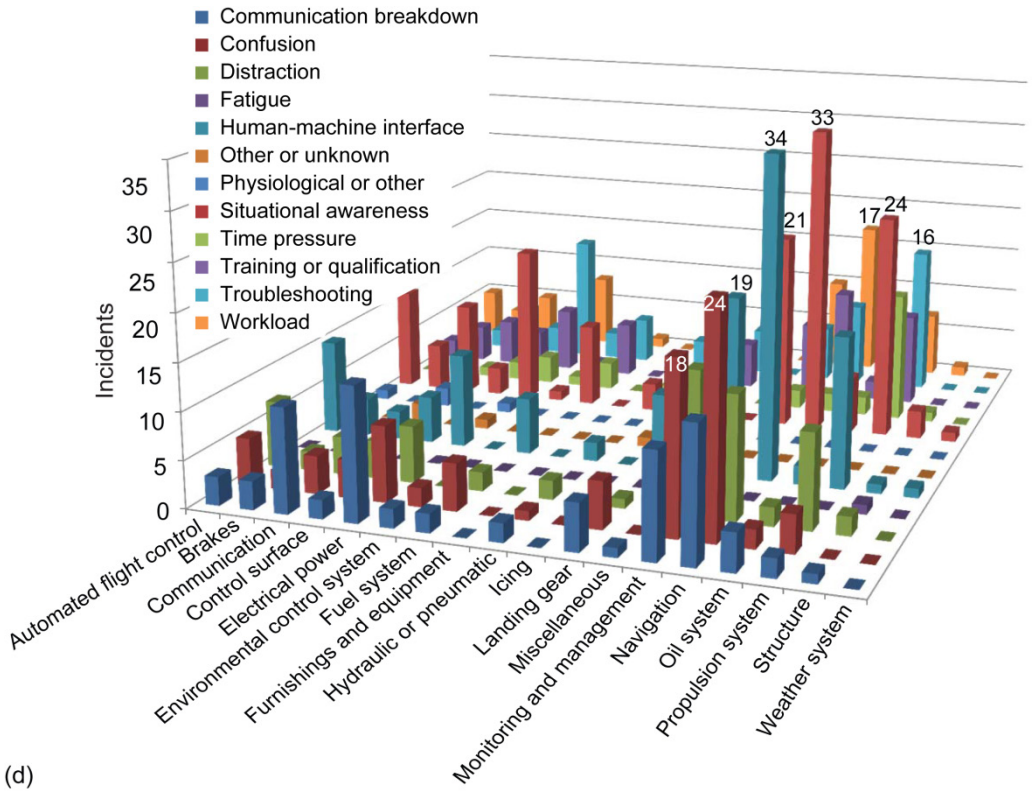


(b)

Figure 20.—Human-factor-related incidents by human factor category and SCFM: (a) FAR Parts 121, 135, and 91 combined. (b) FAR Part 121. (c) FAR Part 135. (d) FAR Part 91.



(c)



(d)

Figure 20.—Concluded.

5.1 Situational Awareness

Situational awareness—knowing all that you need to know about what is going on around you and your task at hand—is of significant importance to both the pilot and air traffic control (ATC). This includes aircraft flight state, flight conditions, other aircraft in the area, and flight terrain. Inadequate situational awareness can lead to loss of control, controlled flight into terrain, loss of separation, and more.

Situational awareness was listed in a total of 1309 incidents in the human factor category: 809 incidents were for Part 121, 48 for Part 135, and 340 for Part 91. Situational awareness was the largest human factor category for all phases of flight for FAR Parts 121 and 91, and 8 out of 10 phases for Part 135.

Figure C.3(a) shows the situational awareness incidents for the phases of flight. Parked was the largest phase of flight for Part 121 with 168 incidents, followed by cruise with 113 incidents, and taxi with 101. The majority of the situational issues that appeared during the parked phase involved work being performed by mechanics. Situational awareness issues during cruise involved items such as deviating around thunderstorms without ATC clearance, emergency procedures due to equipment failure, and chart and clearance issues. Taxi situational awareness issues included unfamiliarity with the taxiways, improper maintenance issues arising during taxi, and charting issues for runways and taxiways.

For human factor and SCFM categories, 6 out of the top 10 most frequent incidents occurred during situational awareness for Part 121. Situational awareness has 4 of the top 10 tall poles for Part 135, and 4 of the top 11 poles for Part 91. The SCFM category breakdown for situational awareness is also shown in Figure C.3(a). Propulsion system had 64 Part 121 incidents, followed by navigation with 58 incidents, and monitoring and management with 56.

5.2 Communication Breakdown

Communication breakdown means there are problems with transmitting, receiving, or interpreting messages. It can involve any combination of flight crew, flight attendant, ATC, maintenance, dispatch, ground personnel, or other. Communication breakdown incidents involve things such as more timely communication of information from ATC, maintenance issues with the work card or aircraft maintenance manual, dissemination of pilot weather reports (PIREP), and the pushback marshaller's signals.

There were 844 incidents that listed communication breakdown as a human factor, with 538 for Part 121; 25 for Part 135; and 186 for Part 91. Figure C.3(b) shows the phase of flight and SCFM category for communication breakdown incidents. Parked was the largest communication breakdown category for Part 121 with 171 incidents, and a large part of this appears to be due to the communication issues during maintenance. Taxi was the next largest phase of flight with 76 incidents and involved a wide variety of issues from similar call numbers to maintenance release issues to communication issues amongst different ground crews. Cruise was the third largest category with 72 incidents; and a spot check varied from loss of separation issues to communication between flight crew and flight attendants to complaints of descriptive wording for procedures.

Communication breakdown issues were listed in a total of 251 incidents for Part 121, 11 incidents for Part 135, and 67 for Part 91. Environmental control system with 35 incidents, monitoring and management with 34 incidents, and landing gear with 33, were the top three SCFMs for Part 121. Part 91 had 14 incidents for both navigation and electrical power SCFM categories.

5.3 Confusion

Confusion—the lack of clearness or distinctness—was listed in 757 incidents as one of the human factors involved. There were 476 confusion incidents listed for Part 121, 33 for Part 135, and 175 for part

91. The parked phase of flight had 104 incidents followed by taxi with 67 for Part 121. The top three phases of flight for confusion were initial climb with 27 incidents, cruise with 24 incidents, and final approach, taxi, and landing all with 20 incidents each for Part 91.

Monitoring and management and navigation were the top SCFM categories for both Parts 121 and Part 91. There were 69 navigation incidents for Part 121 and 24 incidents for Part 91. Monitoring and management had 47 incidents for Part 121 and 18 incidents for Part 91.

5.4 Human-Machine Interface

Human-machine interface incidents involved a variety of issues from equipment malfunctioning, false alerts, and miscoded procedures. There were 510 incidents that reported a human-machine interface incident. There were 323 incidents for Part 121, 16 incidents for Part 135, and 47 for Part 91. There were 54 cruise and 52 climb phase of flight incidents for Part 121. Cruise with 28 incidents and initial climb with 25 incidents were the top two for Part 91. Navigation had the most SCFM category incidents with 79 for Part 121 and 34 for Part 91, followed by monitoring and management with 25 for Part 121 and 19 for Part 91.

5.5 Distraction

Distractions are things that draw away one's attention or concentration from where it needs to be focused. Distraction for aviation human factors can be items such as rushed maintenance to get the aircraft back into service, to mental overload during a missed approach, to mental overload during an emergency. There were 506 distraction incidents in the data set with 327 incidents for Part 121, 21 incidents for Part 135, and 132 for Part 91. Cruise had the most distraction incidents for both Parts 121 and 91 with 59 and 30, respectively. Park was the second largest category for Part 121 with 55 incidents. Navigation was the largest SCFM category for Part 121 with 43 incidents followed by monitoring and management with 28 incidents.

5.6 Workload

Workload is the sixth largest out of the 12 human factor categories. There were 411 incidents that listed workload: 268 incidents were for Part 121, 20 for Part 135, and 98 for Part 91. Cruise was listed in 56 incidents for Part 121, followed by parked with 43 incidents. There were 8 incidents during initial climb for Part 135, and both landing and descent had 16 incidents followed by initial climb with 15 for Part 91. Navigation was the largest category for both Parts 121 and 135 in the SCFM category.

5.7 Training and Qualification

There were 402 incidents that listed training and qualifications: 244 incidents for Part 121, 16 incidents for Part 135, and 133 for Part 91. There were 65 incidents that listed parked as the phase of flight for the training and qualification human factor, followed by 45 incidents for cruise for Part 121. A spot check of the parked incidents shows a variety of issues from deicing problems to maintenance procedures. The top SCFM category was hydraulic or pneumatic with 27 incidents, followed by monitoring and management and propulsion with 23 each for Part 121. Navigation was the largest category for Part 91.

5.8 Troubleshooting

There were 378 incidents that listed troubleshooting as a human factor: 272 incidents for Part 121, 11 incidents for Part 135, and 80 for Part 91. The cruise phase of flight was the largest category and had 73 incidents for Part 121 and 31 for Part 91, followed by 63 incidents during parked for Part 121. The top SCFM categories for Part 121 were hydraulic or pneumatic with 37 incidents, monitoring and management with 36 incidents, electrical power with 35, and environmental control systems with 32 incidents. For Part 91 the top categories were propulsion with 16 incidents and electrical power with 14 incidents.

5.9 Other-Unknown

The other-unknown category is the catchall for human factors. There were 329 incidents that listed other-unknown in the human factor category: 197 incidents for Part 121, 3 incidents for Part 135, and 47 for Part 91. There were 73 cruise phase of flight incidents and 63 parked incidents for Part 121. Thirty-one cruise incidents were for Part 91. There were only 51 incidents for Part 121 that reported an SCFM, with environmental control system being the top category.

5.10 Time Pressure

There were 324 incidents listing time pressure as a human factor: 231 incidents for Part 121, 16 incidents for Part 135, and 65 for Part 91. For all three FAR parts combined, the parked phase of flight had 62 incidents and cruise had 59 incidents. All but three of the parked incidents were for Part 121. Cruise had 39 incidents for Part 121 and 15 for Part 91. Monitoring and management with 21 incidents and navigation with 20 incidents were the top SCFM categories.

5.11 Fatigue

Only 95 incidents that listed fatigue as a human factor: 75 incidents for Part 121, 3 for Part 135, and 9 for Part 91. Of the Part 121 incidents that listed a phase of flight, 24 were during parked and 13 during initial approach. Only 26 incidents that listed fatigue also listed a SCFM, and 23 of them were for Part 121.

5.12 Physiological-Other

There were 84 incidents that listed physiological-other as a human factor: 68 for Part 121, 3 for Part 135, and 47 for Part 91. Cruise was the largest phase of flight category with 18 incidents and 12 during parked for Part 121. Environmental control system was the largest SCFM category with 10 incidents for Part 121.

6.0 Conclusions

6.1 System Component Failure or Malfunction Incidents

A search of a subset of the Aviation Safety Reporting System (ASRS) data set from January 1993 through January 2011 for incidents with system component failures or malfunctions (SCFMs) resulted in 24 409 incident reports. The data were analyzed by Federal Aviation Regulations (FAR) part, phase of flight, and SCFM category. There were 23 522 phase of flight reports, 22 061 reports for FAR Parts 121, 135, and 91, and 17 946 SCFM reports. The FAR part, phase of flight, and SCFM categories were

combined in multiple ways for analysis. When incidents with a phase of flight and an SCFM were combined in one analysis, there were 12 326 incidents for Part 121, 919 incidents for Part 135, and 3653 incidents for Part 91. Most SCFMs occurred during the cruise phase of flight and in the propulsion system SCFM category, followed by the monitoring and management SCFM category. A propulsion system was more likely to fail during takeoff, initial climb, and cruise, whereas monitoring and management SCFMs were more likely to occur during a wider range of flight phases.

6.2 Loss of Control Incidents

A search of the entire NASA ASRS data set (159 583 incident reports) from January 1993 through January 2011 resulted in 5096 loss-of-control (LOC) reports. The data were analyzed in three ways: by FAR Parts 121, 135, and 91 individually, by the 10 phases of flight, and by the 18 SCFM categories. In the data set, 4949 reports listed a phase of flight, 4496 reports listed FAR Parts 121, 135, or 91, and 1827 reports listed an SCFM. Most LOC-related incidents occurred during landing. For all FAR parts, the most commonly reported SCFMs for LOC incidents involved the landing gear, brakes, automated flight control, control surface, and propulsion system.

The three categories—FAR part, phase of flight, and SCFM—were then compared. There were 1693 reports that listed at least one factor in all three categories. The results showed that the SCFM categories of automated flight control, brakes, control surface, and landing gear had the greatest number of incidents for each FAR part. For all three FAR parts, brake system SCFMs occurred most frequently during the taxi, landing, and parked phases of flight; automated flight control SCFMs occurred most frequently during climb; and landing gear SCFMs occurred most frequently during taxi and landing. For FAR Parts 121 and 135, control surface SCFMs occurred most frequently during takeoff, cruise, descent, and initial approach. For FAR Part 91, LOC incidents occurred most frequently during climb and final approach.

6.3 Human-Factor-Related Incidents

Analysis of human-factor-related incidents in the ASRS data set from May 2009 through January 2011 resulted in 2243 reports. It is important to note that human factor categories were only added to the ASRS data set in May 2009. Although ASRS data before this date probably contains human-factor-related incidents, they are not categorized as such. A longer timeframe would be helpful to better understand the causes of human error in the ASRS data.

Of the 2243 human-factor-related incidents, 1966 incidents listed one of the three FAR parts, 2123 listed a phase of flight, 2152 specified a human factor category, and 977 listed an SCFM. The majority of incidents—1393—were for Part 121, followed by 504 incidents for Part 91, and 69 incidents for Part 135. The cruise phase of flight had the most incidents with 404 followed by parked with 282 incidents. Situational awareness was the largest human factor category with 1309 incidents: 809 for Part 121, 48 for Part 135, and 340 for Part 91, followed by communication breakdown with 844 incidents: 538 for Part 121, 25 for Part 135, and 186 for Part 91, and confusion with 757 incidents: 476 for Part 121, 33 for Part 135, and 175 for Part 91. Fatigue and physiological-other had the lowest frequencies.

Appendix A.—Acronyms

ASRS	Aviation Safety Reporting System
ATC	air traffic control
AvSP	Aviation Safety Program
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
ICAO	International Civil Aviation Organization
LOC	loss of control or loss of aircraft control
PIREP	pilot report of actual weather conditions encountered by an aircraft in flight
SCFM	system component failure or malfunction
TC	technical challenge
VSST	Vehicle Systems Safety Technology

Appendix B.—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 C.—Detailed Supplementary Figures

Figure C.1 provides more details about SCFM-related incidents for individual SCFM categories by phase of flight and FAR part.

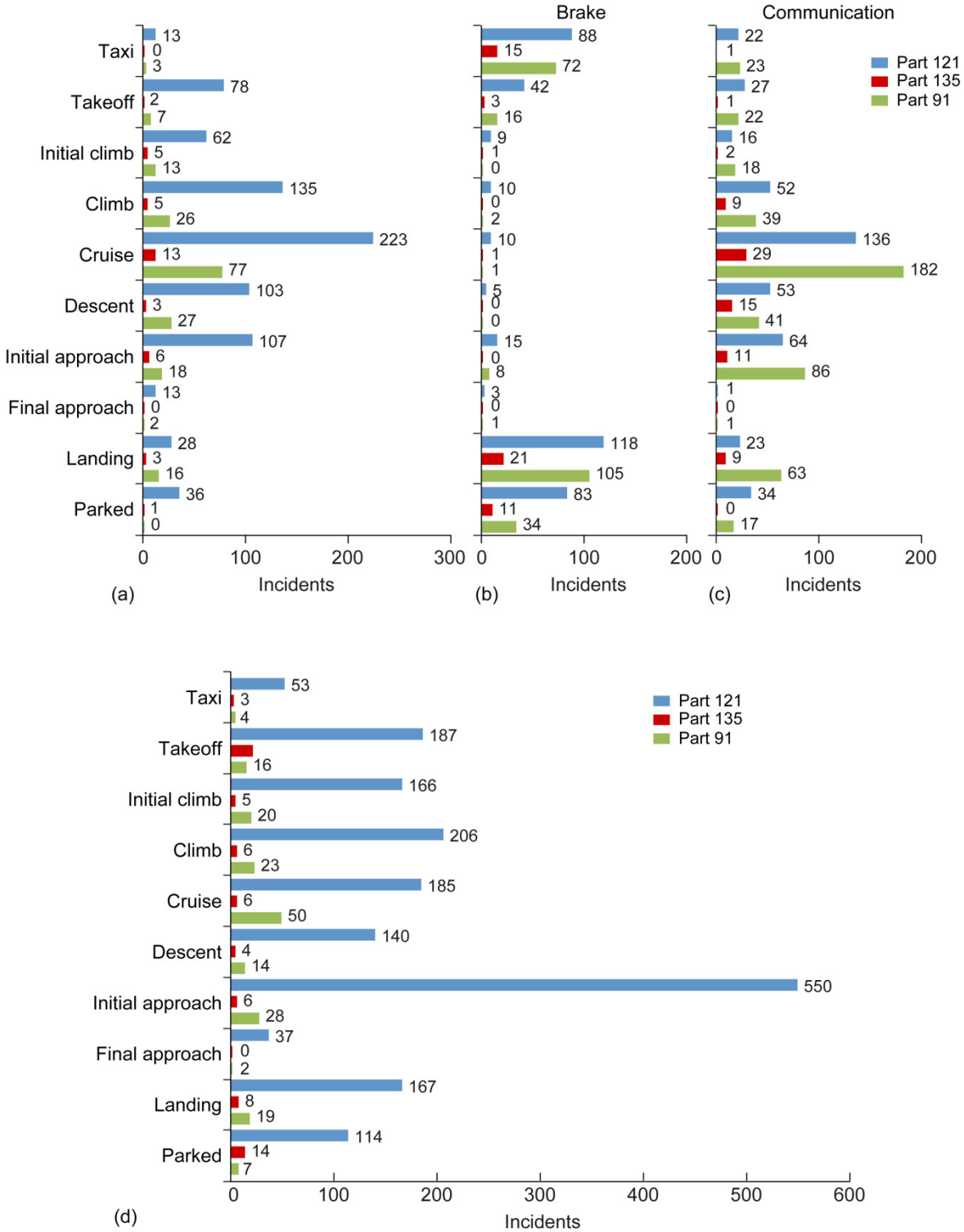


Figure C.1.—SCFM-related incidents for individual SCFM categories by phase of flight and FAR part (a) Automated flight control. (b) Brakes. (c) Communication. (d) Control surface.

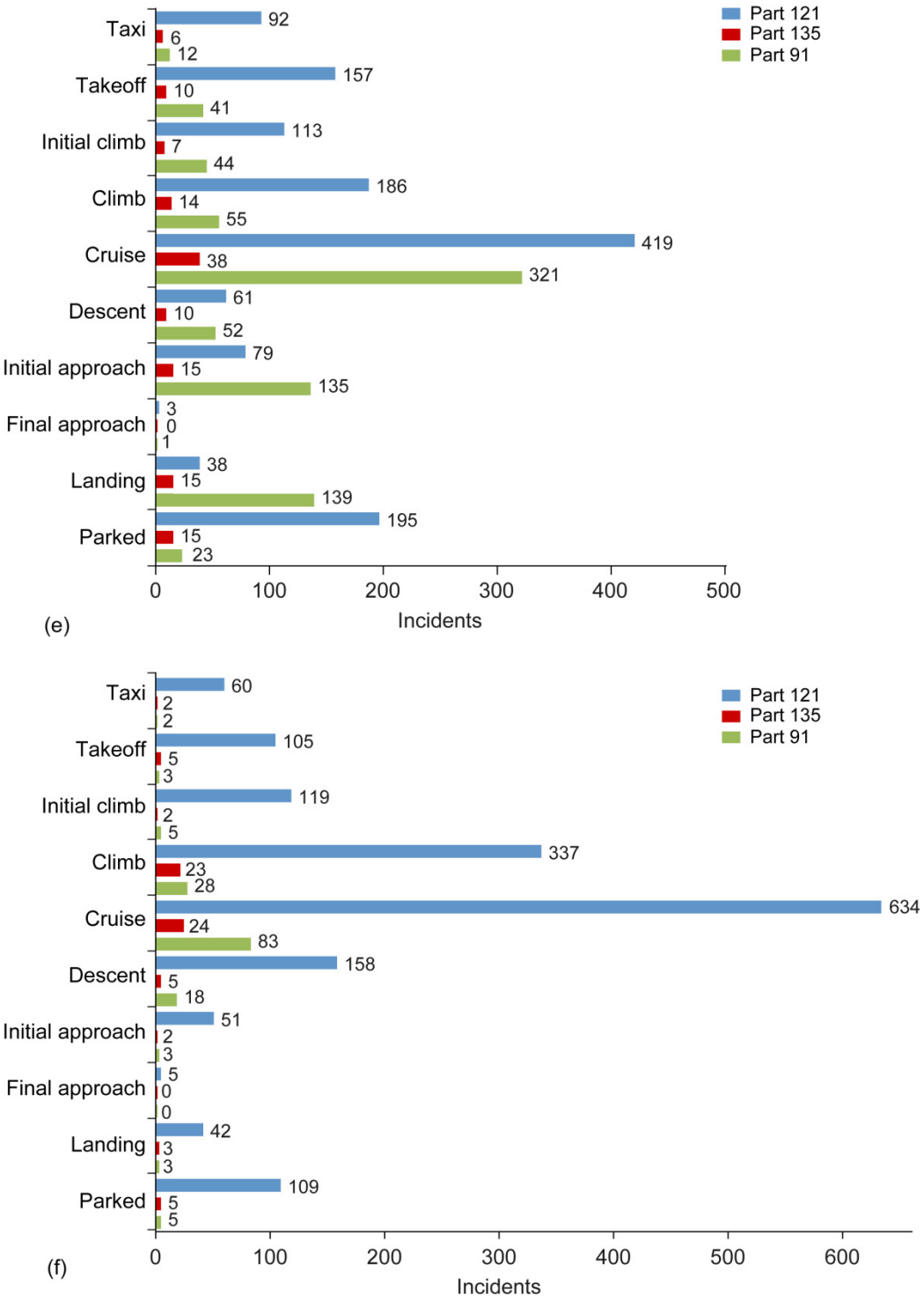


Figure C.1.—Continued. (e) Electrical power. (f) Environmental control system.

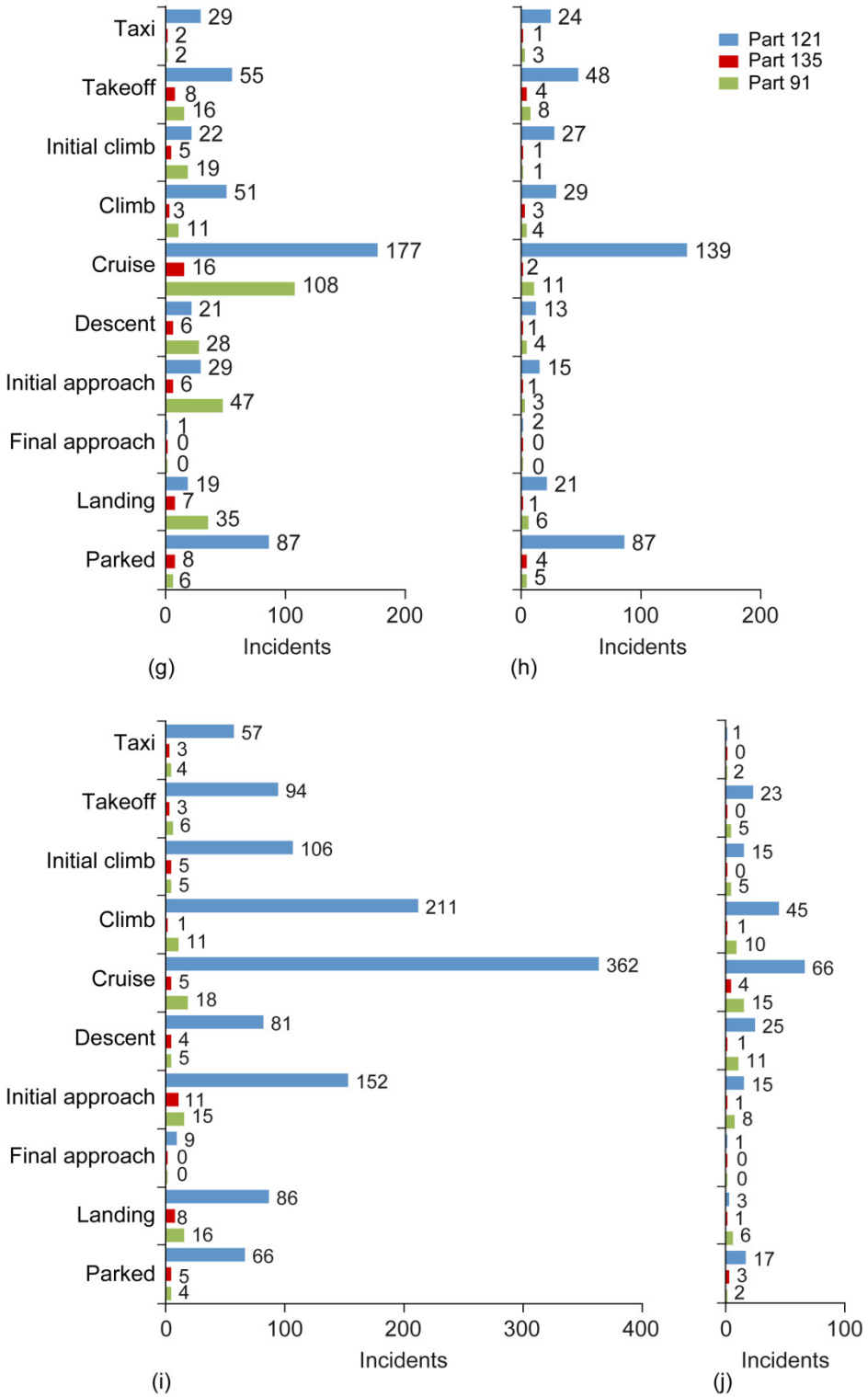


Figure C.1.—Continued. (g) Fuel system. (h) Furnishings and equipment. (i) Hydraulic or pneumatic. (j) Icing.

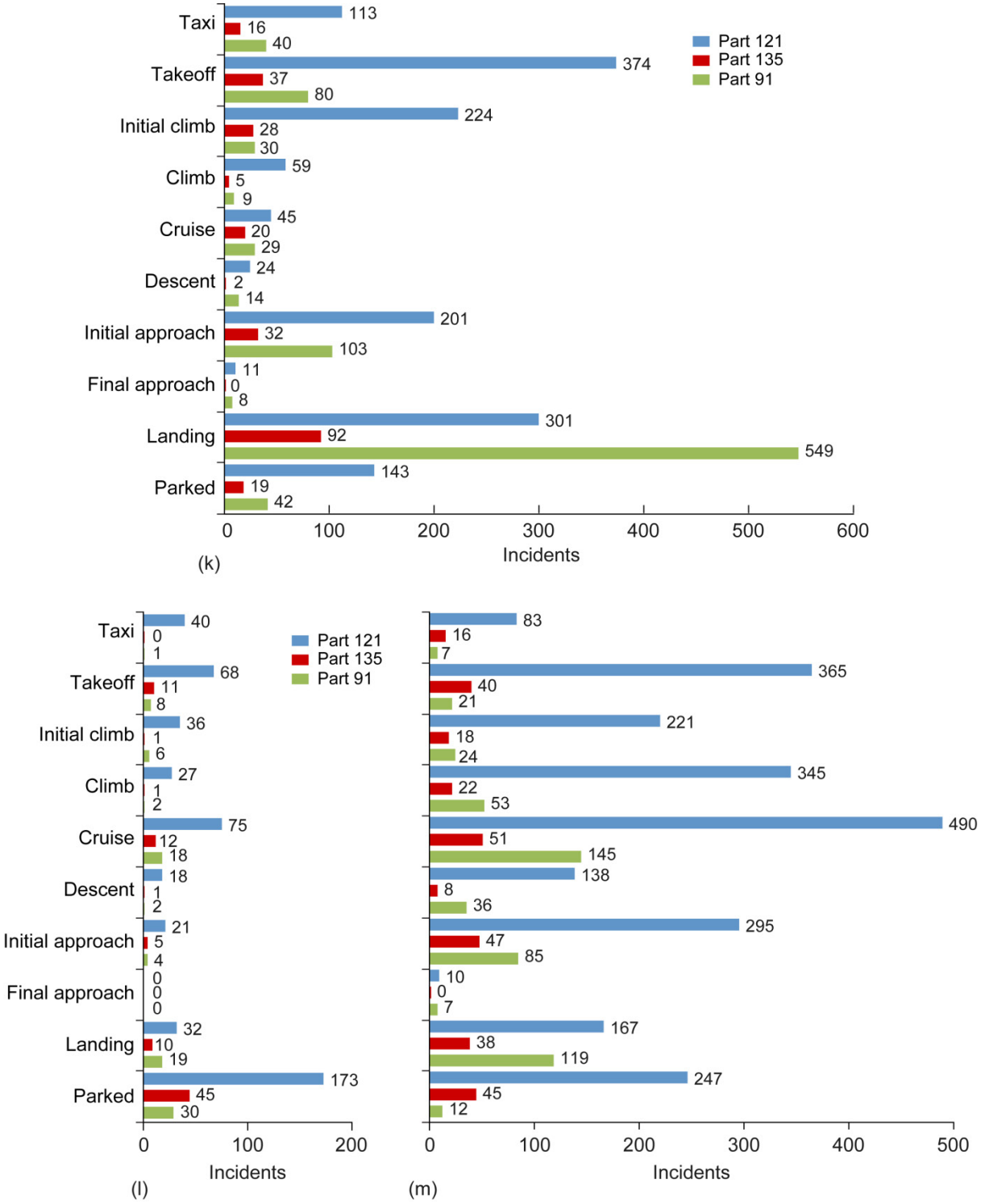


Figure C.1.—Continued. (k) Landing gear. (l) Miscellaneous. (m) Monitoring and management.

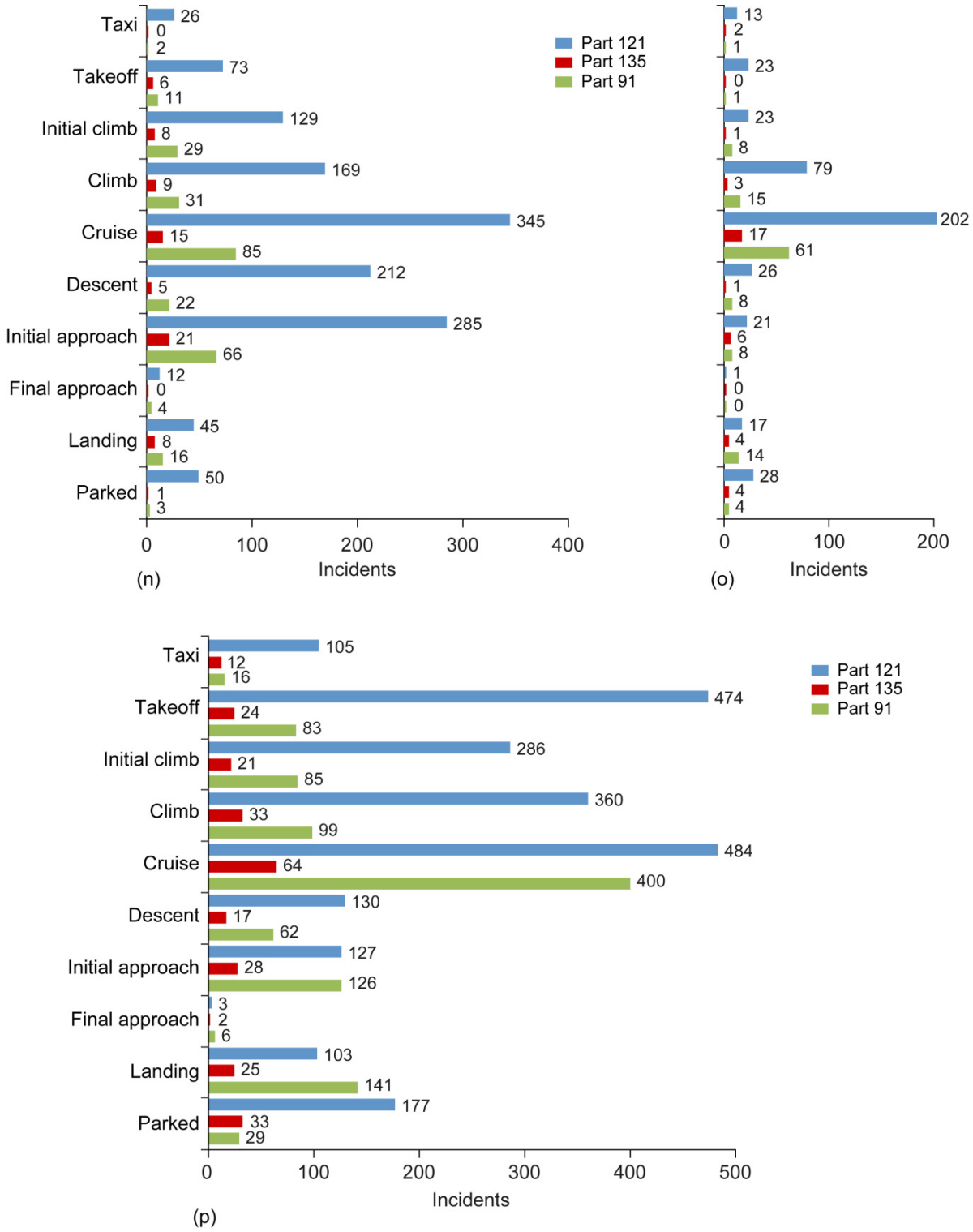


Figure C.1.—Continued. (n) Navigation (o) Oil system. (p) Propulsion system.

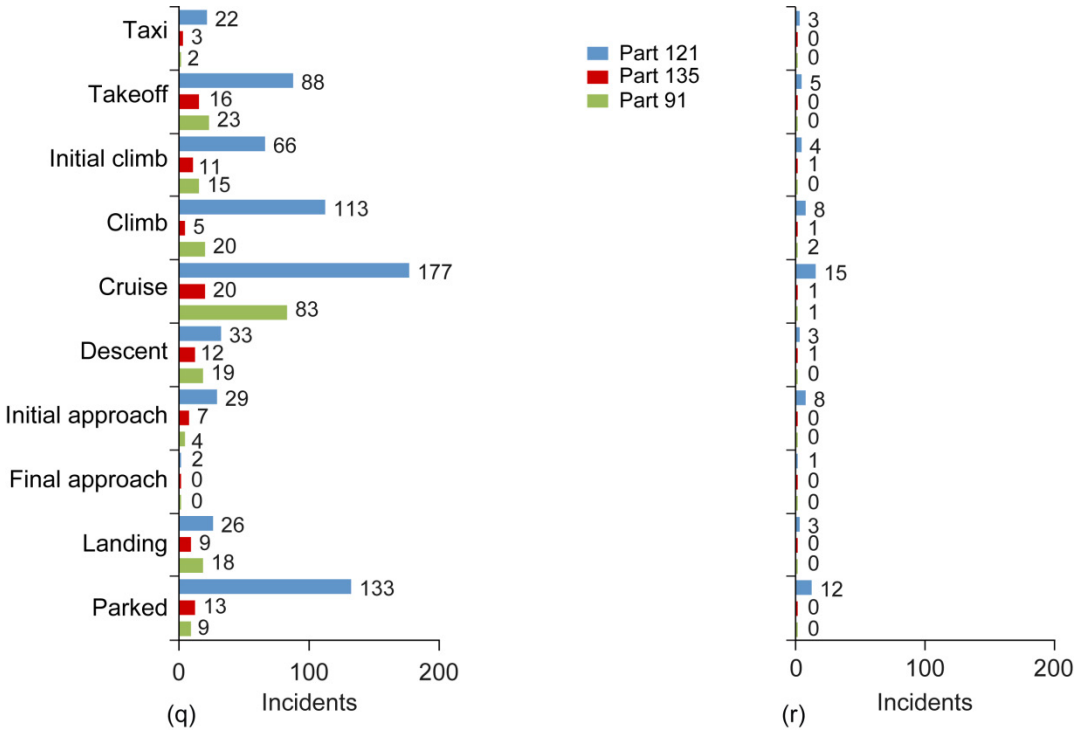


Figure C.1.—Concluded. (q) Structure. (r) Weather system.

Figure C.2 provides more details about LOC-related incidents for individual SCFM categories by phase of flight and FAR part.

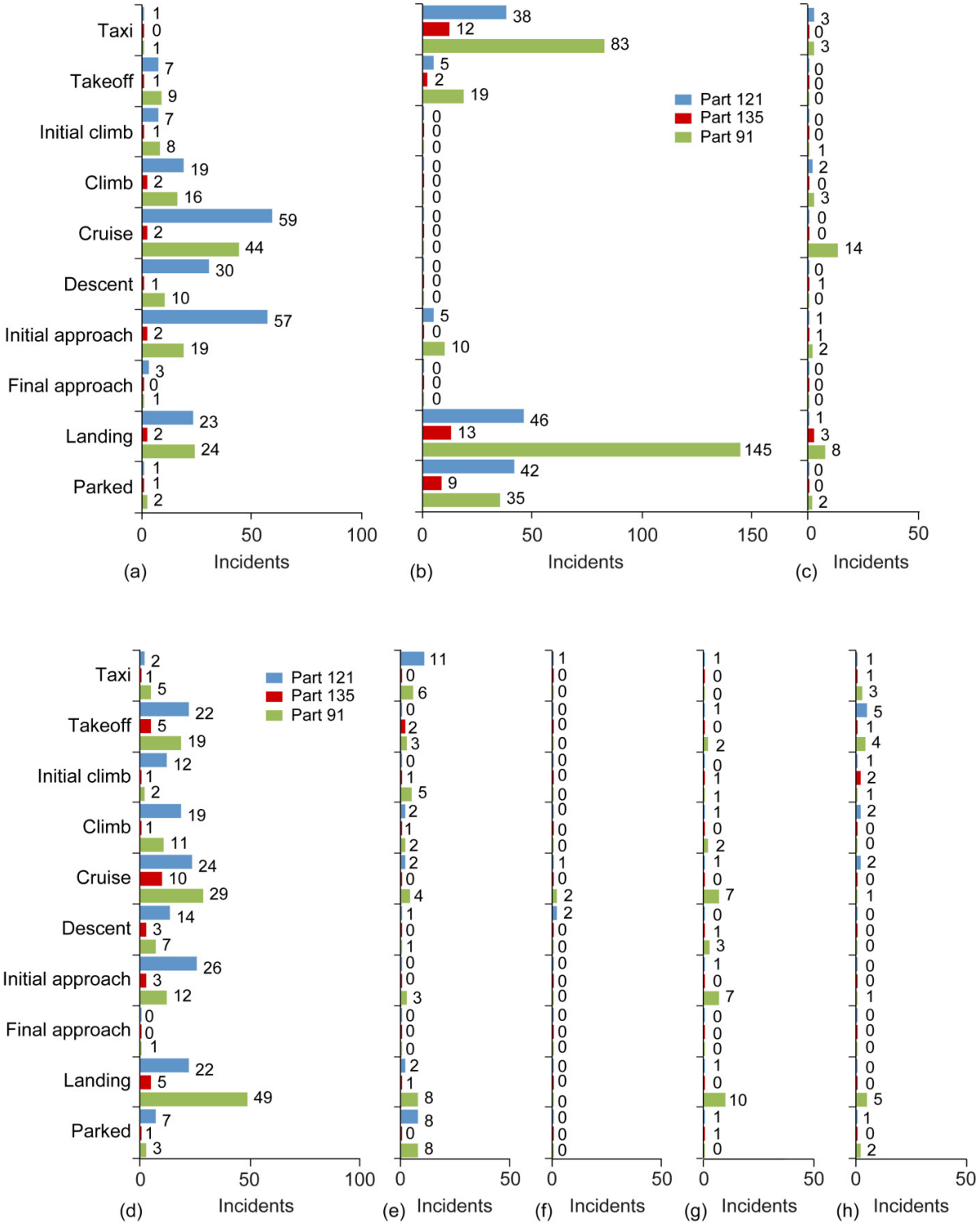


Figure C.2.—LOC-related incidents for individual SCFM categories by phase of flight and FAR part: (a) Automated flight control. (b) Brakes. (c) Communication. (d) Control surface. (e) Electrical power. (f) Environmental control system. (g) Fuel system. (h) Furnishings and equipment.

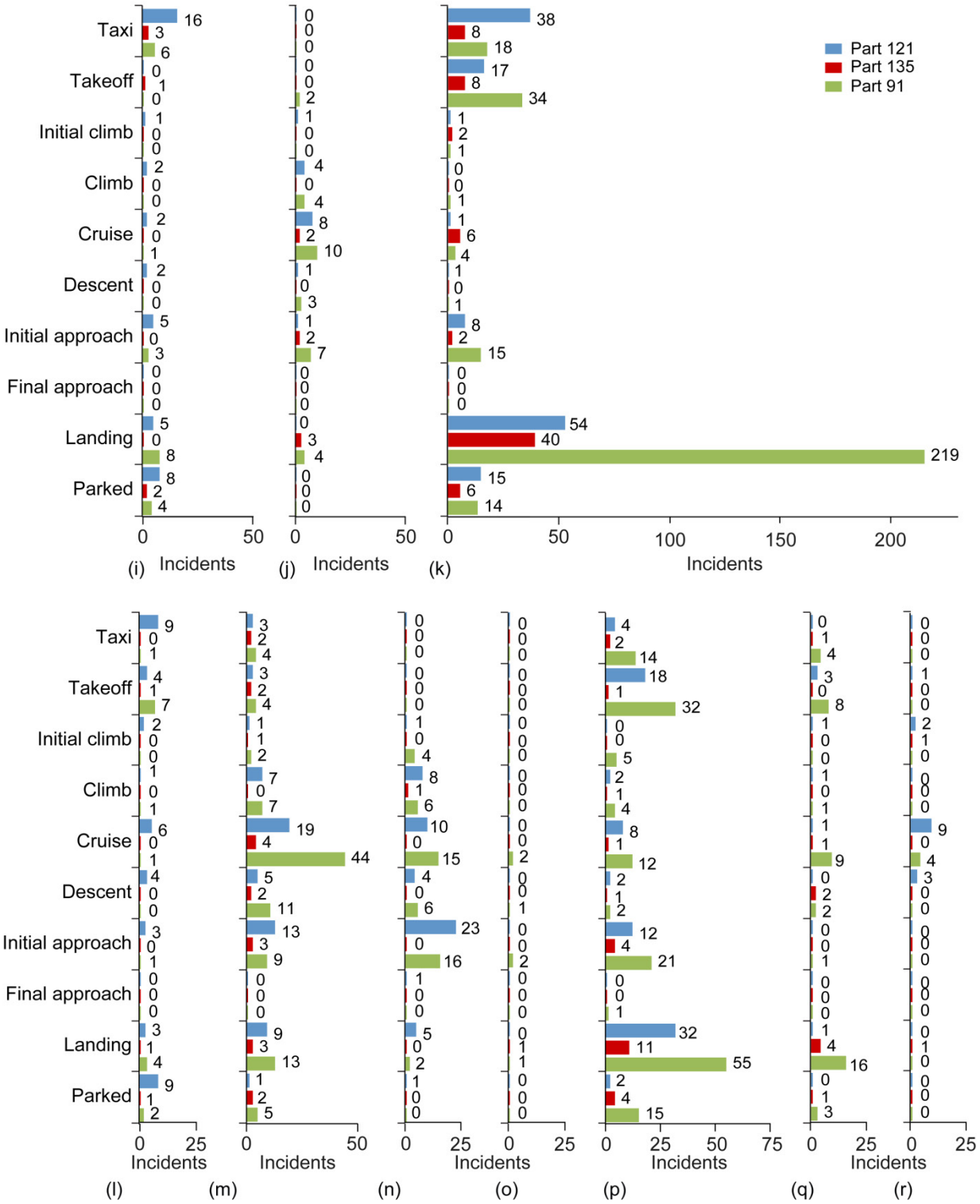


Figure C.2.—Concluded. (i) Hydraulic or pneumatic. (j) Icing. (k) Landing gear. (l) Miscellaneous. (m) Monitoring and management. (n) Navigation system. (o) Oil system. (p) Propulsion system. (q) Structure. (r) Weather system.

Figure C.3 provides more details about human-factor-related incidents for individual human factors by phase of flight and FAR part, and by SCFM and FAR part.

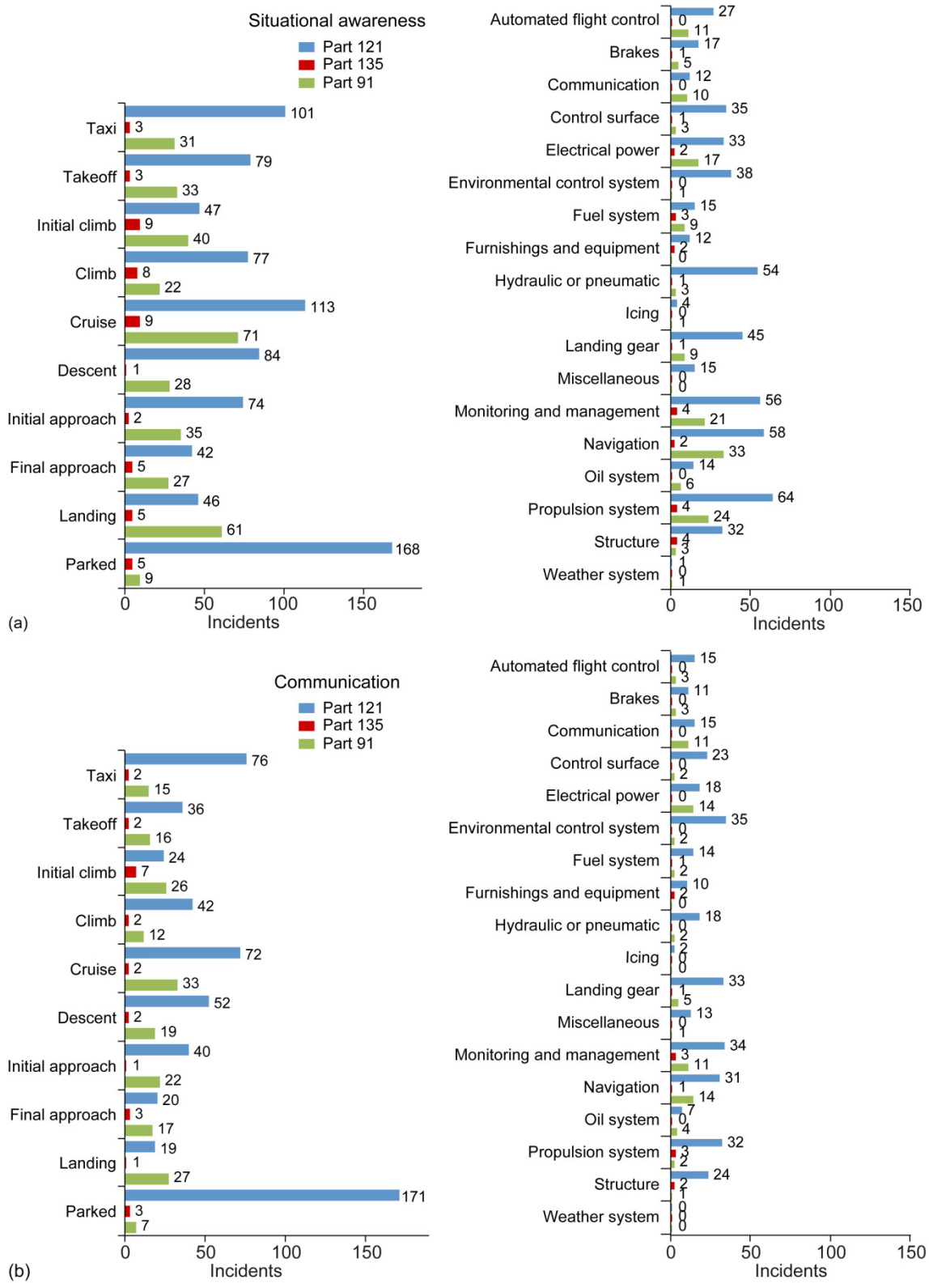


Figure C.3.—Human-factor-related incidents by human factor category, phase of flight, SCFM category, and FAR part: (a) Situational awareness. (b) Communication.

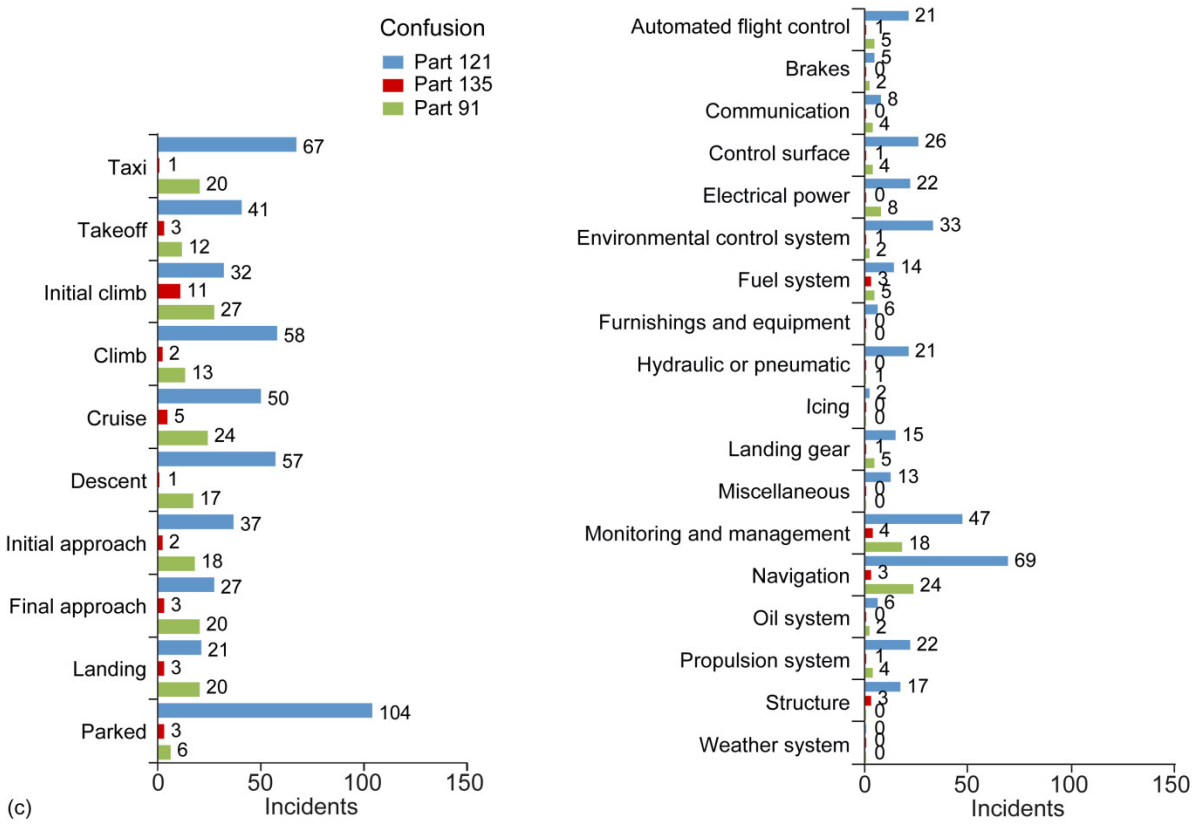
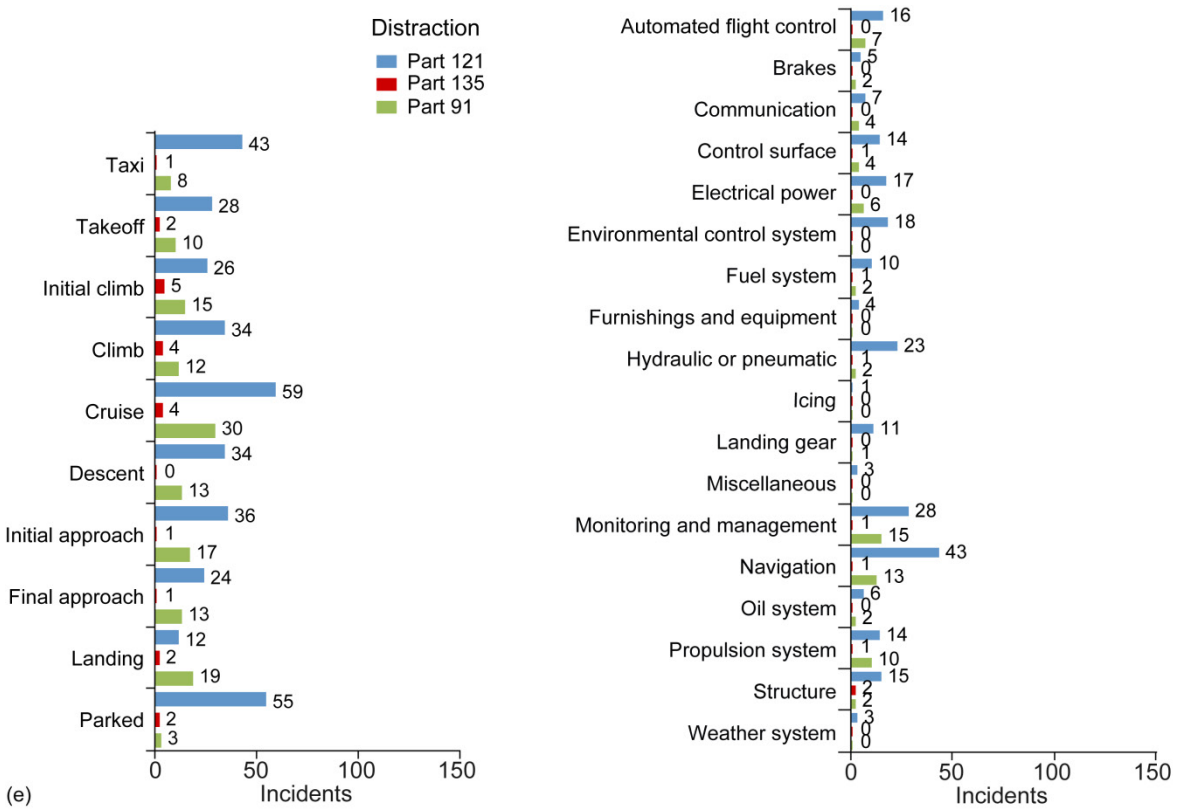


Figure C.3.—Continued. (c) Confusion. (d) Human-machine interface.



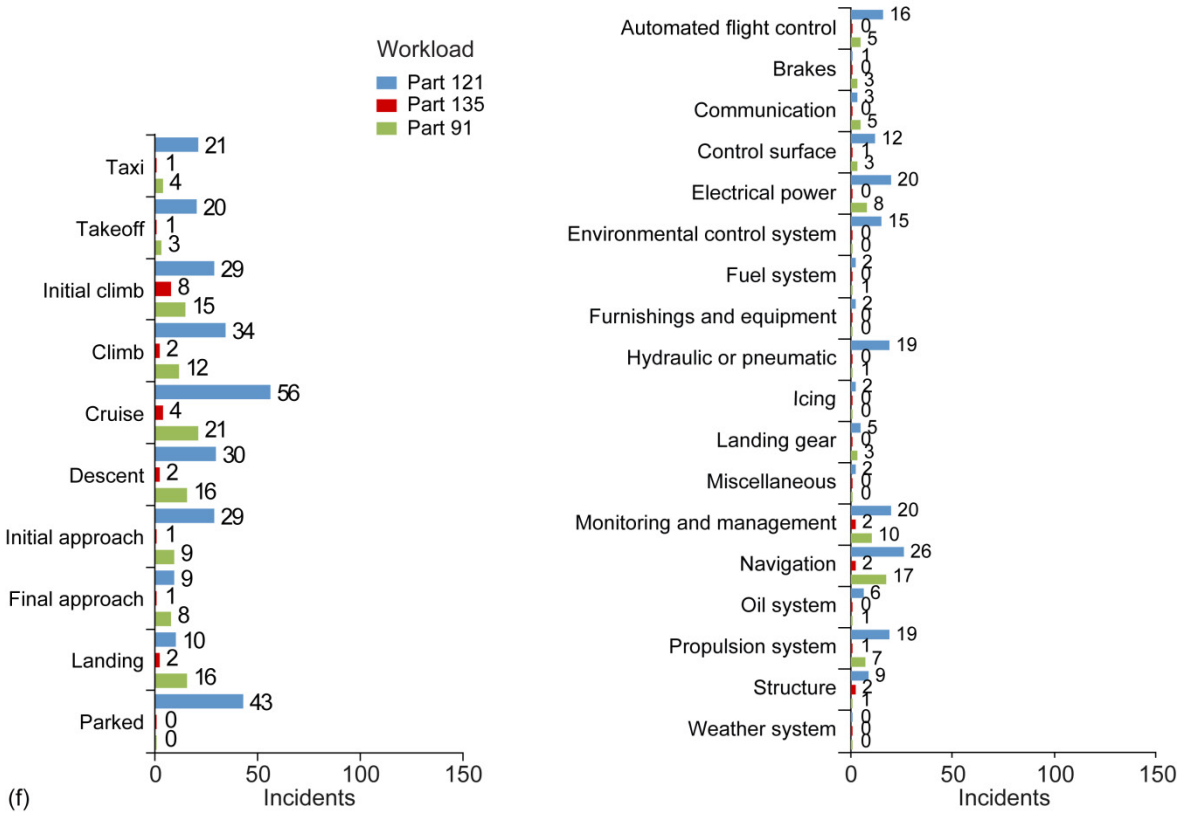
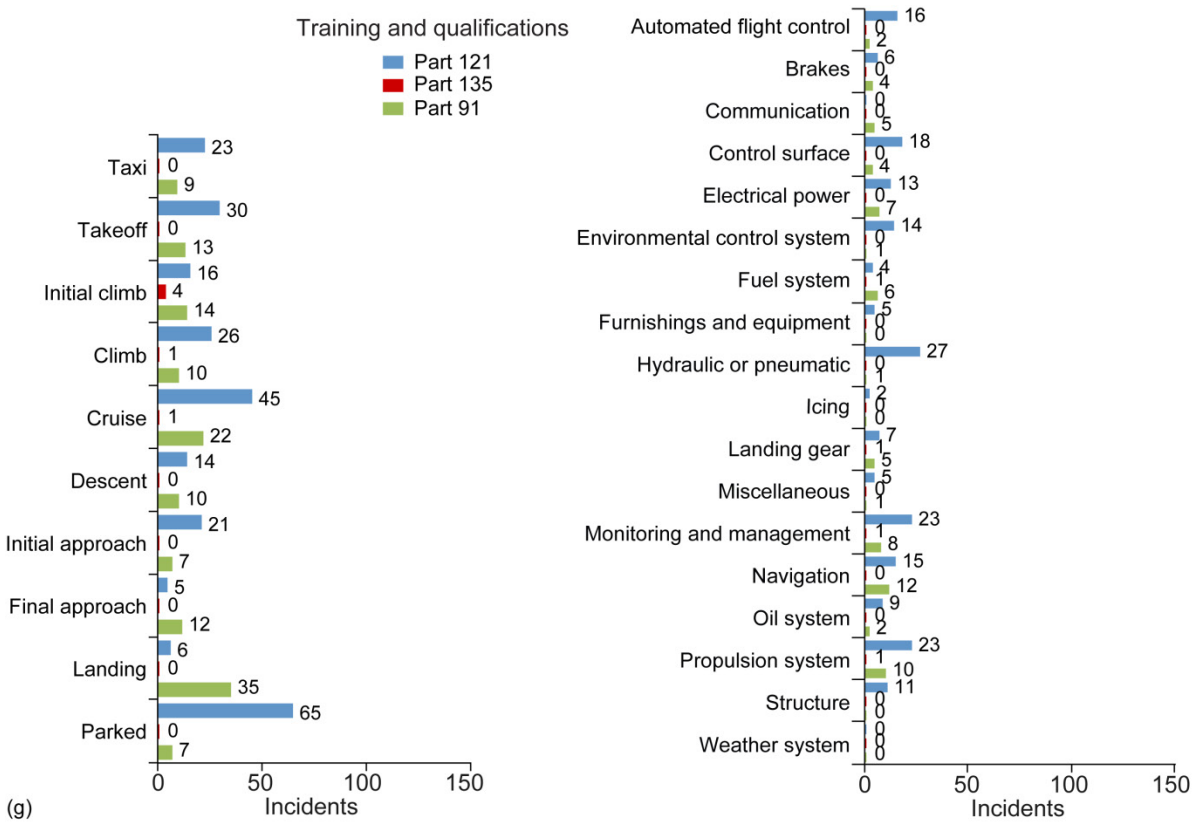


Figure C.3.—Continued. (e) Distraction. (f) Workload.



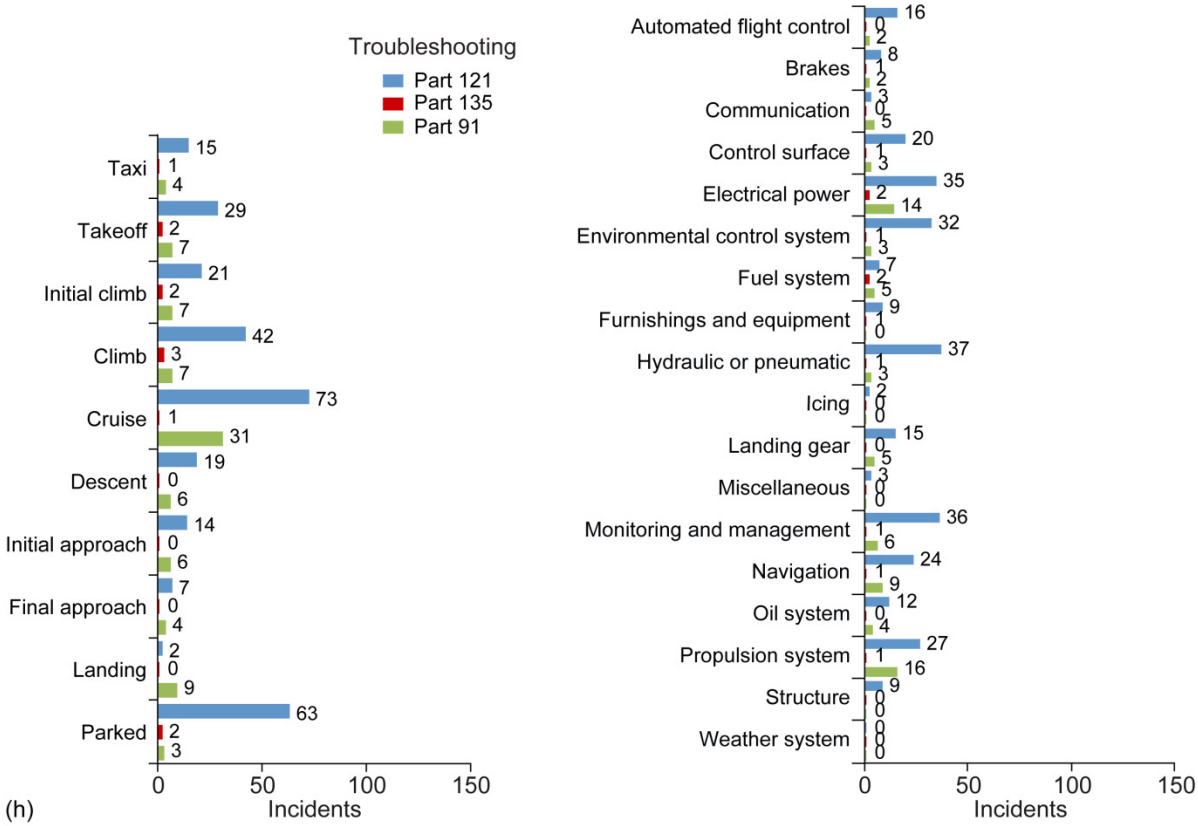
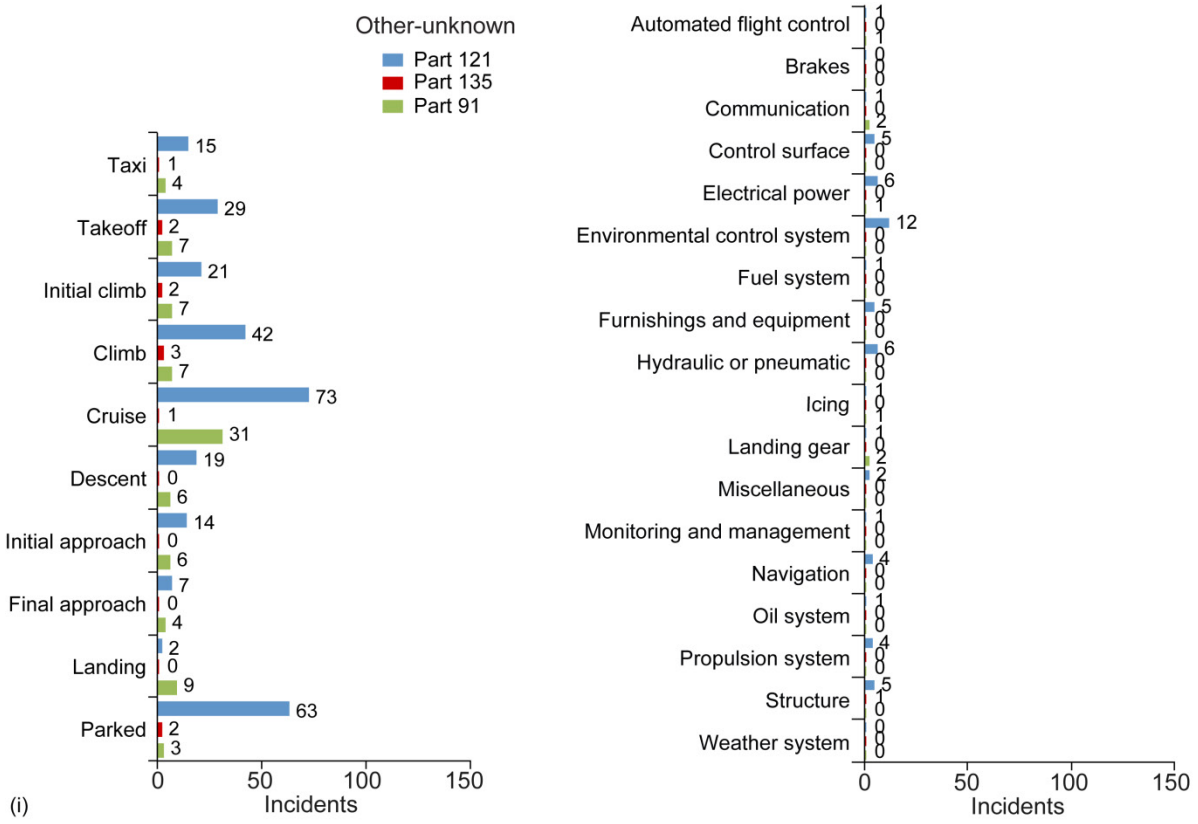


Figure C.3.—Continued. (g) Training and qualifications. (h) Troubleshooting.



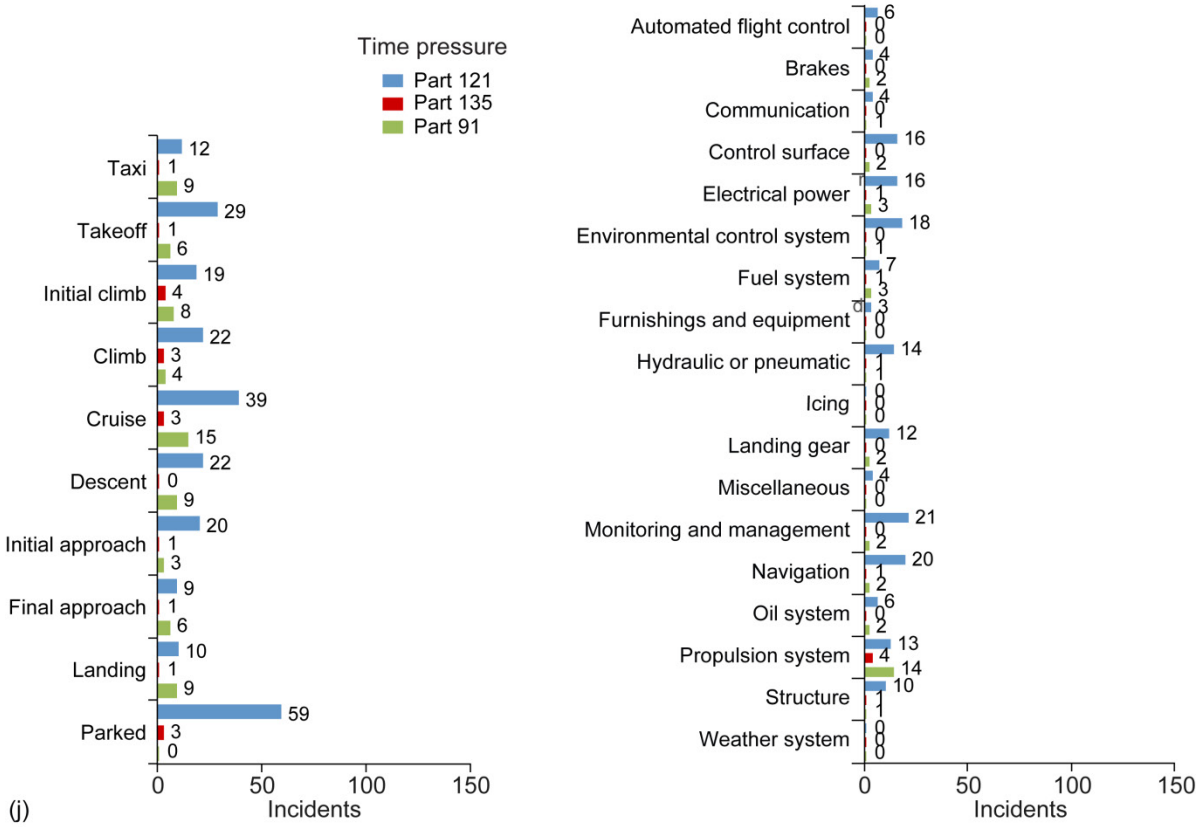
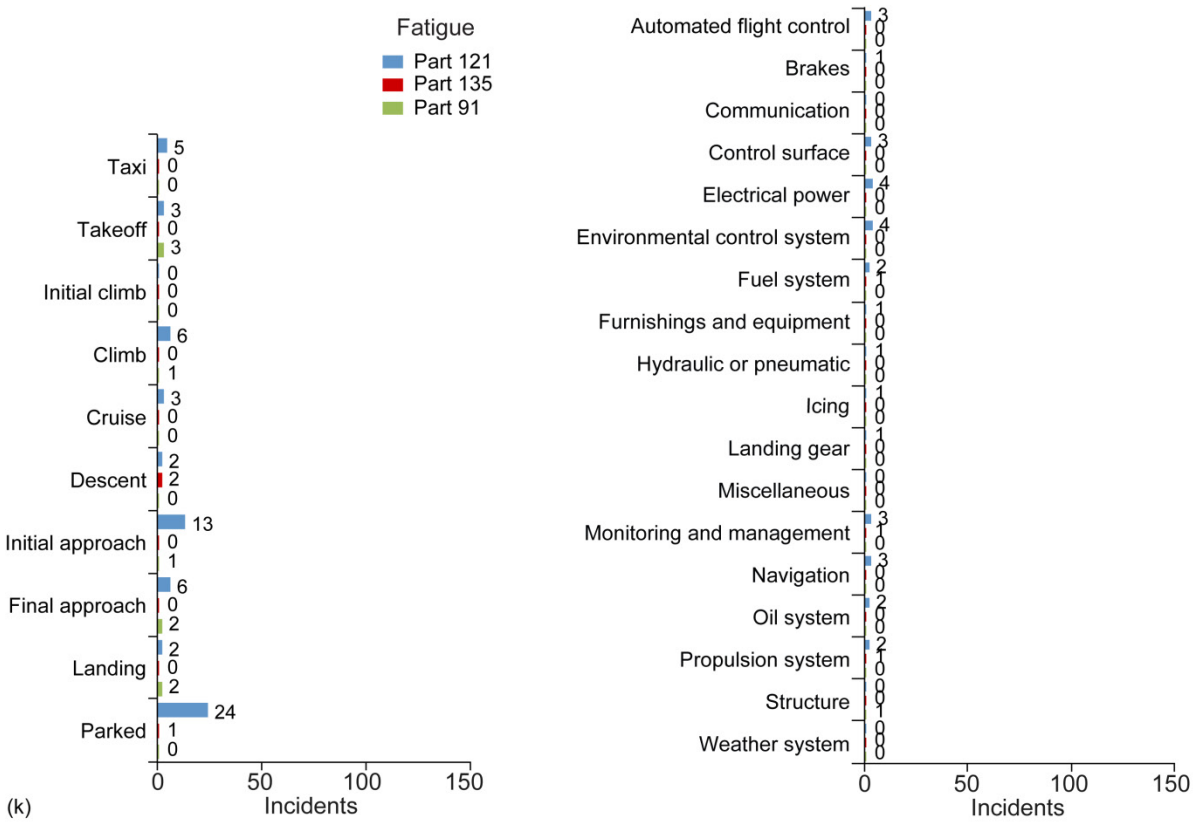


Figure C.3.—Continued. (i) Other-unknown. (j) Time pressure.



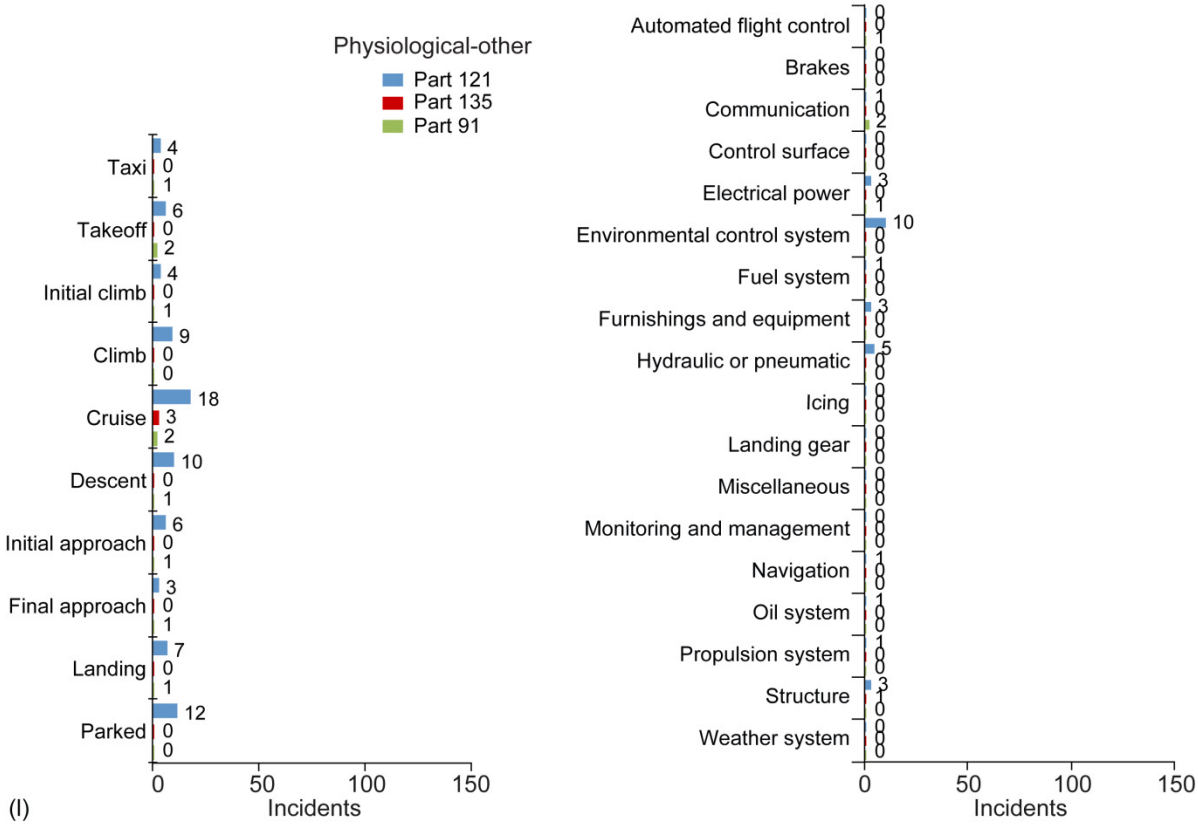


Figure C.3.—Concluded. (k) Fatigue. (l) Physiological-other.

Figure C.4 provides more details about human-factor-related incidents for individual phases of flight by human factor and FAR part.

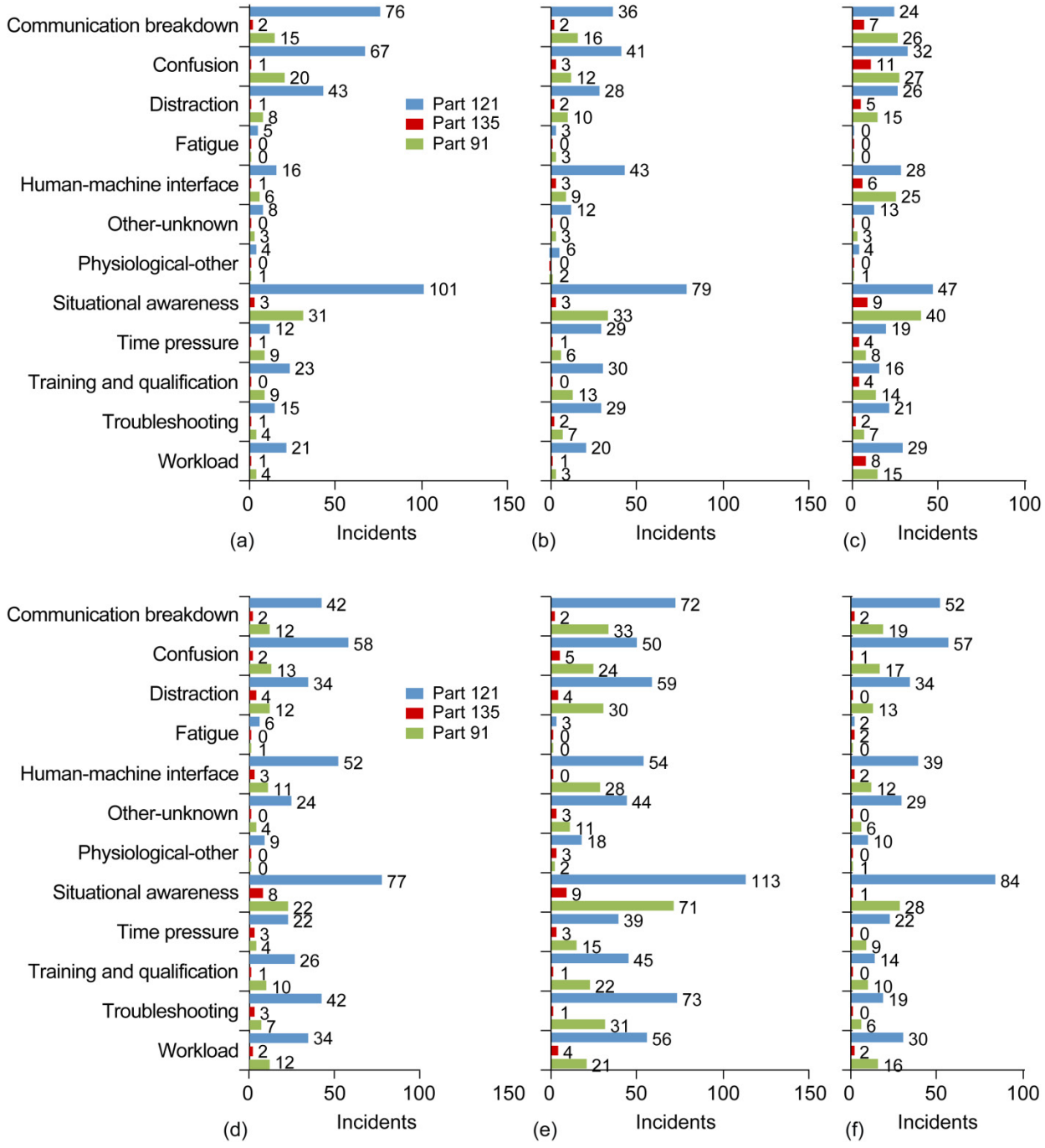


Figure C.4.—Human-factor-related incidents for each phase of flight by human factor category and FAR part. (a) Automated flight control. (b) Brakes. (c) Communication. (d) Control surface. (e) Electrical power. (f) Environmental control system.

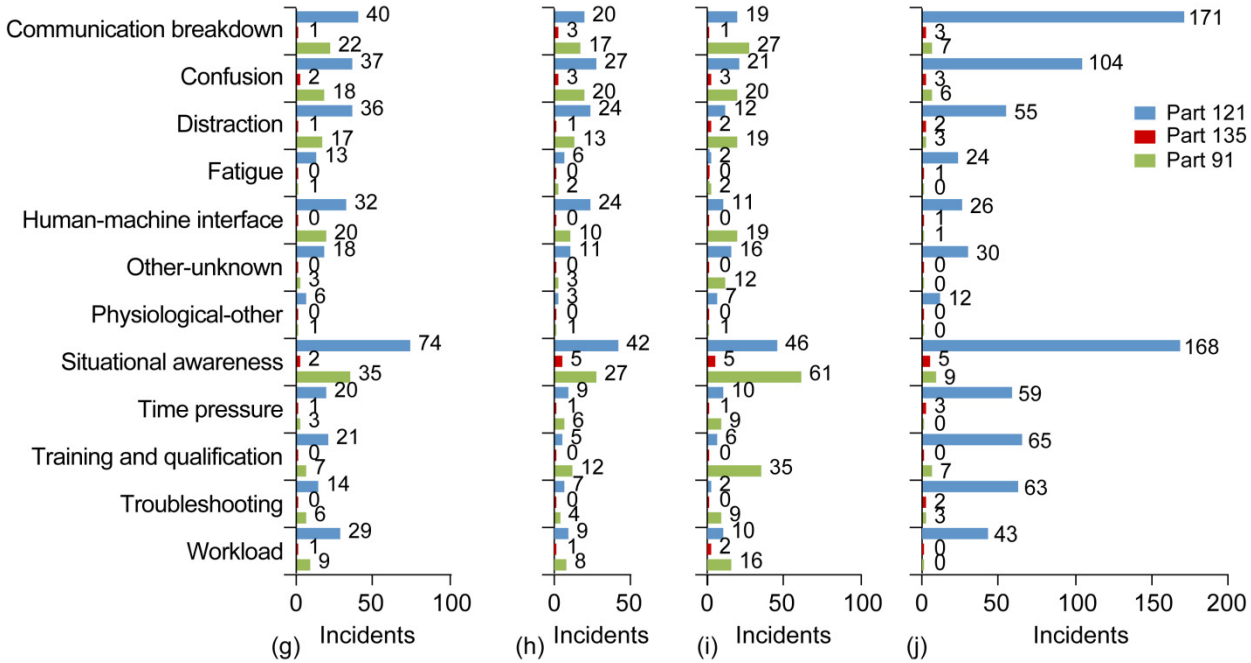


Figure C.4.—Concluded. (g) Fuel system. (h) Furnishings and equipment. (i) Hydraulic or pneumatic. (j) Icing.

Figure C.5 provides more details about human-factor-related incidents for individual SCFM categories by human factor and FAR part.

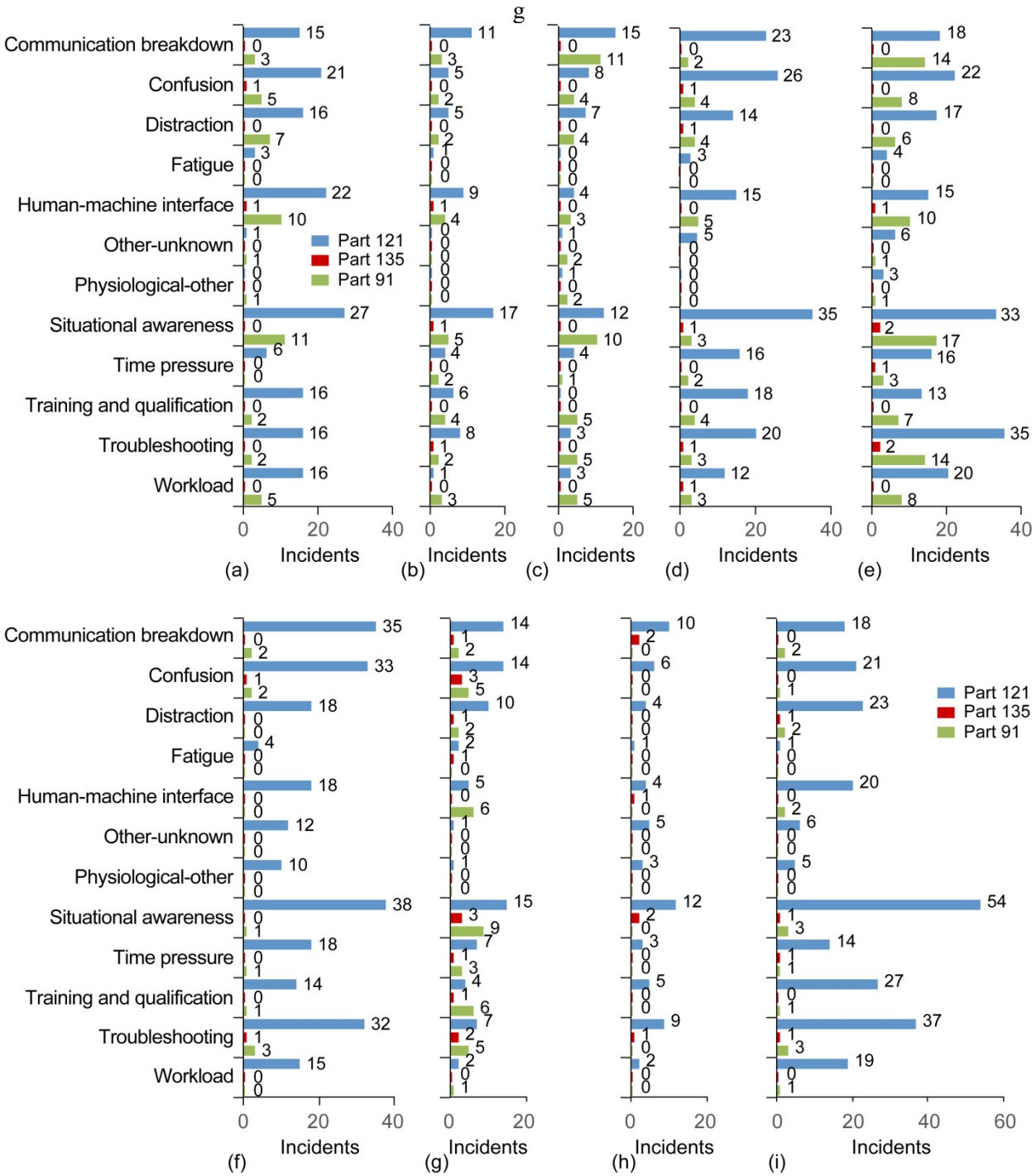


Figure C.5.—Human-factor-related incidents for each SCFM category by human factor and FAR part. (a) Automated flight control. (b) Brakes. (c) Communication. (d) Control surface. (e) Electrical power. (f) Environmental control system. (g) Fuel system. (h) Furnishings and equipment. (i) Hydraulic or pneumatic.

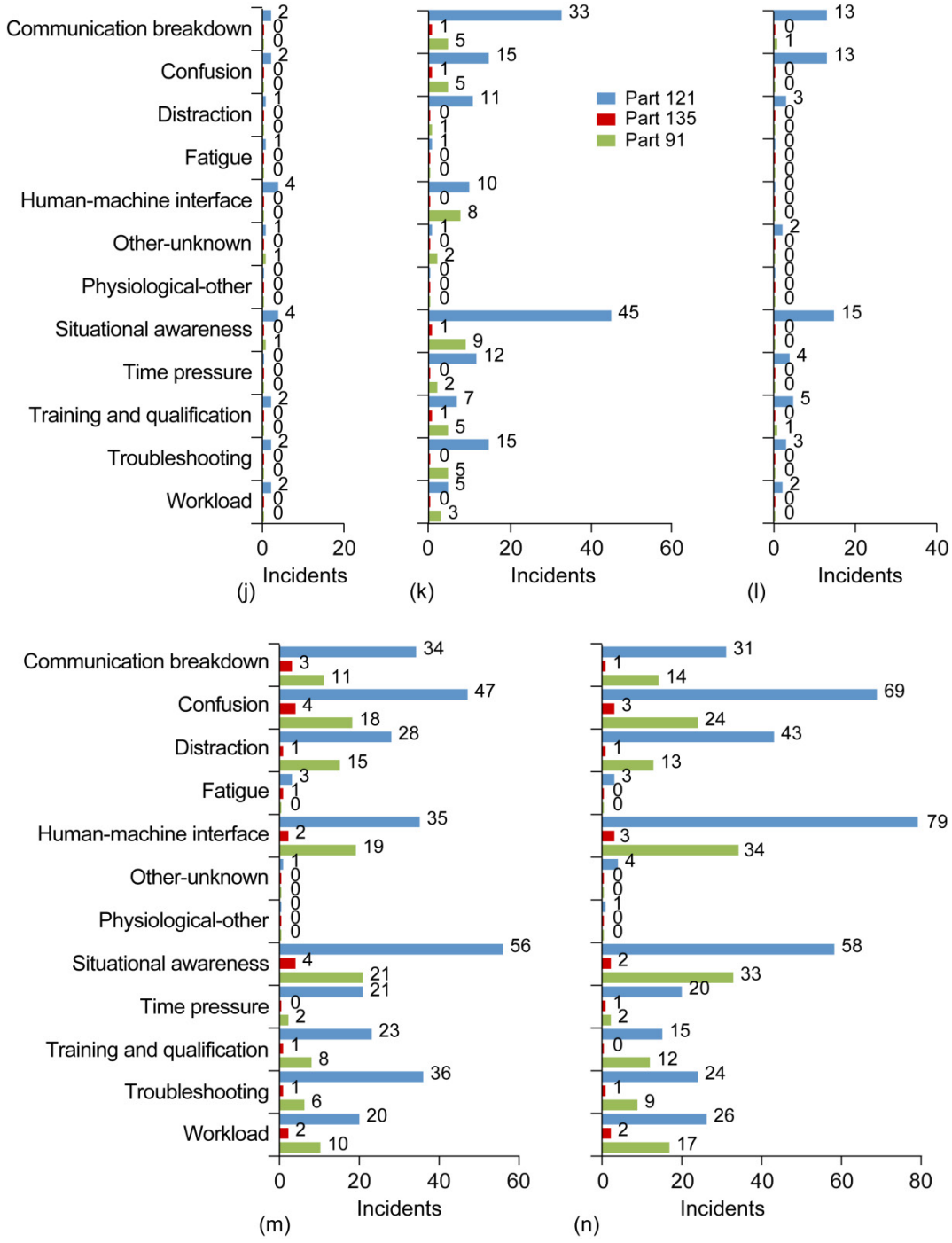


Figure C.5.—Continued. (j) Icing. (k) Landing gear. (l) Miscellaneous. (m) Monitoring and management. (n) Navigation.

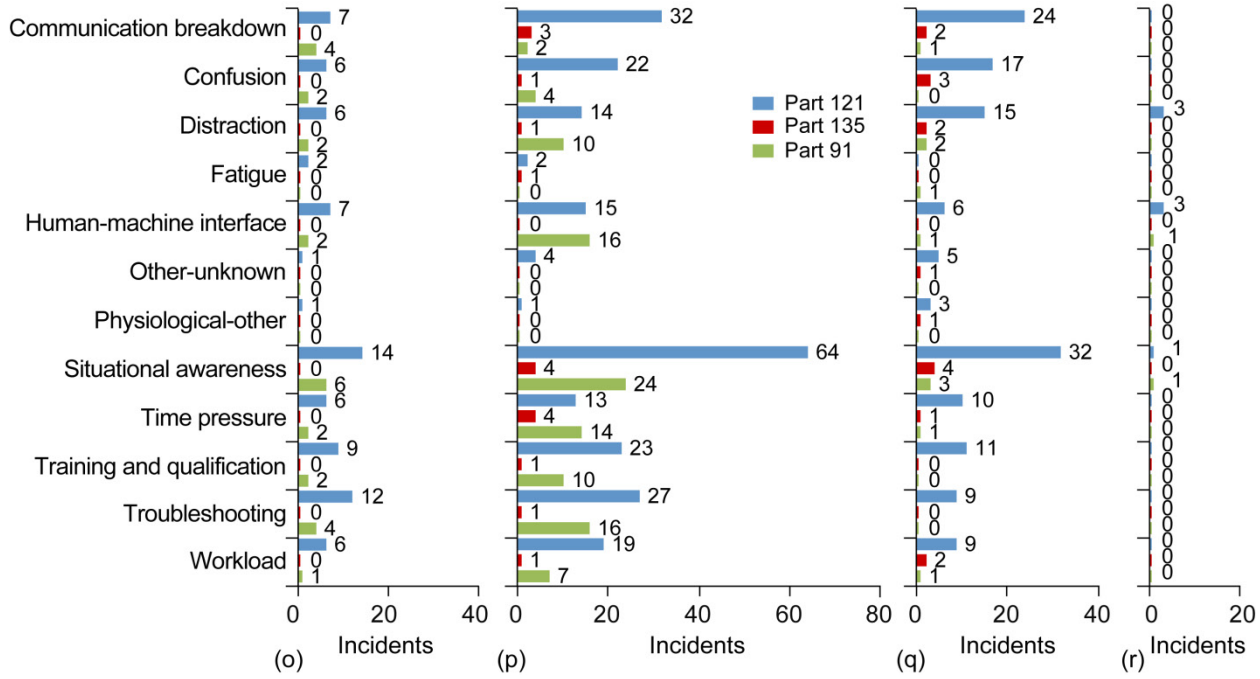


Figure C.5.—Concluded. (o) Oil system. (p) Propulsion system. (q) Structure. (r) Weather system.

Appendix D.—Detailed Supplementary Tables

Table D.1 to Table D.16 provide more details about SCFM-, LOC-, and human-factor-related incidents, respectively.

TABLE D.1.—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 poles)]

SCFM category	Phase of flight										
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Incidents
Automated flight control	17	89	81	173	328	135	134	15	48	40	893
Brakes	175	62	10	13	13	5	23	4	248	129	552
Communication	49	52	36	103	363	112	164	2	97	52	787
Control surface	60	225	195	240	251	164	598	40	205	139	1745
Electrical power	112	213	164	259	787	126	232	4	195	238	1882
Environmental control system	65	113	132	394	753	185	58	4	48	122	1581
Furnishings and equipment	28	60	29	37	154	18	19	2	28	96	384
Fuel system	35	81	48	67	312	56	85	1	68	104	716
Hydraulic or pneumatic	65	104	120	226	390	93	179	9	115	77	1156
Landing gear	175	500	290	74	96	40	344	19	964	212	2093
Icing	4	29	20	58	89	38	25	1	10	22	240
Miscellaneous	44	89	43	31	107	21	30	0	61	259	512
Monitoring and management	109	431	271	430	710	182	434	17	332	314	2579
Navigation	31	92	169	214	456	250	384	16	73	56	1445
Oil system	16	24	33	98	285	35	36	1	35	37	516
Propulsion system	135	593	400	507	978	214	285	11	275	252	3116
Structures	27	135	98	140	283	65	40	2	53	160	837
Weather system	3	5	5	11	19	4	9	1	3	12	51
Incidents	931	2380	1791	2516	5202	1373	2554	137	2137	1702	17335

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.2.—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	Phase of flight										
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Incidents
Automated Flight Control	13	78	62	135	223	103	107	13	28	36	670
Brakes	88	42	9	10	10	5	15	3	118	83	305
Communication	22	27	16	52	136	53	64	1	23	34	345
Control surface	53	187	166	206	185	140	550	37	167	114	1487
Electrical power	92	157	113	186	419	61	79	3	38	195	1128
Environmental control system	60	105	119	337	634	158	51	4	42	109	1359
Furnishings and equipment	24	48	27	29	139	13	15	2	21	87	334
Fuel system	29	55	22	51	177	21	29	1	19	87	429
Hydraulic or pneumatic	57	94	106	211	362	81	152	9	86	66	1043
Icing	1	23	15	45	66	25	15	1	3	17	176
Landing gear	113	374	224	59	45	24	201	11	301	143	1109
Miscellaneous	40	68	36	27	75	18	21	0	32	173	365
Monitoring and management	83	365	221	345	490	138	295	10	167	247	1910
Navigation	26	73	129	169	345	212	285	12	45	50	1134
Oil system	13	23	23	79	202	26	21	1	17	28	381
Propulsion system	105	474	286	360	484	130	127	3	103	177	1955
Structures	22	88	66	113	177	33	29	2	26	133	588
Weather system	3	5	4	8	15	3	8	1	3	12	42
Incidents	681	1896	1374	1992	3475	989	1766	102	963	1323	12 326

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

TABLE D.3.—SCFM[a]-RELATED INCIDENTS BY SCFM CATEGORY AND PHASE OF FLIGHT FOR FAR[b] PART 135
[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	0	2	5	5	13	3	6	0	3	1	31
Brakes	15	3	1	0	1	0	0	0	21	11	40
Communication	1	1	2	9	29	15	11	0	9	0	57
Control surface	3	21	5	6	6	4	6	0	8	14	60
Electrical Power	6	10	7	14	38	10	15	0	15	15	94
Environmental control system	2	4	2	22	24	5	2	0	3	4	59
Furnishings and equipment	1	4	1	3	2	1	1	0	1	4	15
Fuel system	2	8	5	3	16	6	6	0	7	8	45
Hydraulic or pneumatic	3	3	5	1	5	4	11	0	8	5	29
Icing	0	0	0	1	4	1	1	0	1	3	9
Landing gear	16	37	28	5	20	2	32	0	92	19	183
Miscellaneous	0	11	1	1	12	1	5	0	10	45	65
Monitoring and management	16	40	18	22	51	8	47	0	38	45	206
Navigation	0	6	8	9	15	5	21	0	8	1	56
Oil system	2	0	1	3	17	1	6	0	4	4	31
Propulsion system	12	24	21	33	64	17	28	2	25	33	210
Structures	3	16	11	5	20	12	7	0	9	13	62
Weather system	0	0	1	1	1	1	0	0	0	0	3
Incidents	63	134	90	114	248	72	146	2	187	142	919

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.4.—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	Phase of flight										
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Incidents
Automated flight control	3	7	13	26	77	27	18	2	16	0	159
Brakes	72	16	0	2	1	0	8	1	105	34	200
Communication	23	22	18	39	182	41	86	1	63	17	357
Control surface	4	16	20	23	50	14	28	2	19	7	154
Electrical power	12	41	44	55	321	52	135	1	139	23	631
Environmental control system	1	3	5	28	83	18	3	0	3	5	132
Furnishings and equipment	3	8	1	4	11	4	3	0	6	5	32
Fuel system	2	16	19	11	108	28	47	0	35	6	219
Hydraulic or pneumatic	4	6	5	11	18	5	15	0	16	4	65
Icing	2	5	5	10	15	11	8	0	6	2	49
Landing gear	40	80	30	9	29	14	103	8	549	42	753
Miscellaneous	1	8	6	2	18	2	4	0	19	30	67
Monitoring and management	7	21	24	53	145	36	85	7	119	12	397
Navigation	2	11	29	31	85	22	66	4	16	3	211
Oil system	1	1	8	15	61	8	8	0	14	4	96
Propulsion system	16	83	85	99	400	62	126	6	141	29	871
Structures	2	23	15	20	83	19	4	0	18	9	164
Weather system	0	0	0	2	1	0	0	0	0	0	3
Incidents	164	305	281	352	1339	276	590	32	933	175	3653

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.5.—LOSS-OF-CONTROL-RELATED INCIDENTS BY SCFM[a] 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	2	17	16	38	109	42	80	4	50	4	305
Brakes	135	26	0	1	1	0	15	0	215	89	400
Communication	6	1	2	5	14	1	4	0	13	2	36
Control surface	9	47	15	31	64	26	41	1	76	11	270
Electrical power	17	5	6	5	7	2	3	0	11	16	54
Environmental control system	1	0	0	0	3	3	0	0	0	0	7
Furnishings and equipment	5	10	4	2	3	0	1	0	5	3	25
Fuel system	1	3	2	3	8	4	8	0	12	2	34
Hydraulic or pneumatic	25	1	1	3	3	2	9	0	15	14	51
Icing	0	2	1	8	20	4	10	0	8	0	40
Landing gear	67	64	4	1	11	2	25	0	327	37	453
Miscellaneous	11	13	4	2	7	4	4	0	8	12	47
Monitoring and management	12	11	6	14	70	20	26	0	26	10	141
Navigation	0	0	7	15	26	11	39	1	8	1	90
Oil system	0	0	0	0	2	1	2	0	2	0	4
Propulsion system	21	55	8	7	23	6	41	1	106	21	226
Structures	5	11	2	2	11	4	1	0	21	4	51
Weather system	0	1	3	0	14	3	0	0	1	0	20

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.6.—LOSS-OF-CONTROL-RELATED INCIDENTS BY SCFM[a] CATEGORY AND PHASE OF FLIGHT FOR FAR[b] PART 121
[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	1	7	7	19	59	30	57	3	23	1	170
Brakes	38	5	0	1	0	0	5	0	46	42	112
Communication	3	0	0	2	0	0	1	0	1	0	6
Control surface	2	22	12	19	24	14	26	0	22	7	122
Electrical power	11	0	0	2	2	1	0	0	2	8	19
Environmental control system	1	0	0	0	1	2	0	0	0	0	4
Furnishings and equipment	1	5	1	2	2	0	0	0	0	1	9
Fuel system	1	1	0	1	1	0	1	0	1	1	6
Hydraulic or pneumatic	16	0	1	2	2	2	5	0	5	8	30
Icing	0	0	1	4	8	1	1	0	0	0	12
Landing gear	38	17	1	0	1	1	8	0	54	15	105
Miscellaneous	9	4	2	1	6	4	3	0	3	9	28
Monitoring and management	3	3	1	7	19	5	13	0	9	1	41
Navigation	0	0	1	8	10	4	23	1	5	1	45
Oil system	0	0	0	0	0	0	0	0	0	0	0
Propulsion system	4	18	0	2	8	2	12	0	32	2	66
Structures	0	3	1	1	1	0	0	0	1	0	6
Weather System	0	1	2	0	9	3	0	0	0	0	13
Incidents	97	77	26	45	111	52	117	3	157	69	613

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.7.—LOSS-OF-CONTROL-RELATED INCIDENTS BY SCFM[a] CATEGORY AND PHASE OF FLIGHT FOR FAR[b] PART 135
[Shaded entries indicate the most frequent incidents (top 5 tall poles)]

SCFM category	Phase of flight										
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked	Incidents
Automated flight control	0	1	1	2	2	1	2	0	2	1	9
Brakes	12	2	0	0	1	0	0	0	13	9	30
Communication	0	0	0	0	0	1	1	0	3	0	3
Control surface	1	5	1	1	10	3	3	0	5	1	24
Electrical power	0	2	1	1	0	0	0	0	1	0	5
Environmental control system	0	0	0	0	0	0	0	0	0	0	0
Furnishings and equipment	1	1	2	0	0	0	0	0	0	0	4
Fuel system	0	0	1	0	0	1	0	0	0	1	3
Hydraulic or pneumatic	3	1	0	0	0	0	0	0	0	2	4
Icing	0	0	0	0	2	0	2	0	3	0	5
Landing gear	8	8	2	0	6	0	2	0	40	6	58
Miscellaneous	0	1	0	0	0	0	0	0	1	1	3
Monitoring and management	2	2	1	0	4	2	3	0	3	3	13
Navigation	0	0	0	1	0	0	0	0	0	0	1
Oil system	0	0	0	0	0	0	0	0	1	0	1
Propulsion system	2	1	0	1	1	1	4	0	11	4	18
Structures	1	0	0	0	1	2	0	0	4	1	7
Weather system	0	0	1	0	0	0	0	0	1	0	2
Incidents	22	16	8	4	20	8	13	0	68	18	141

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.8.—LOSS-OF-CONTROL-RELATED INCIDENTS BY SCFM[a] CATEGORY AND PHASE OF FLIGHT FOR FAR[b] PART 91
[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	1	9	8	16	44	10	19	1	24	2	116
Brakes	83	19	0	0	0	0	10	0	145	35	244
Communication	3	0	1	3	14	0	2	0	8	2	24
Control surface	5	19	2	11	29	7	12	1	49	3	119
Electrical power	6	3	5	2	4	1	3	0	8	8	29
Environmental control system	0	0	0	0	2	0	0	0	0	0	2
Furnishings and equipment	3	4	1	0	1	0	1	0	5	2	12
Fuel system	0	2	1	2	7	3	7	0	10	0	24
Hydraulic or pneumatic	6	0	0	0	1	0	3	0	8	4	14
Icing	0	2	0	4	10	3	7	0	4	0	22
Landing gear	18	34	1	1	4	1	15	0	219	14	270
Miscellaneous	1	7	0	1	1	0	1	0	4	2	14
Monitoring and management	4	4	2	7	44	11	9	0	13	5	79
Navigation	0	0	4	6	15	6	16	0	2	0	39
Oil system	0	0	0	0	2	1	2	0	1	0	3
Propulsion system	14	32	5	4	12	2	21	1	55	15	127
Structures	4	8	0	1	9	2	1	0	16	3	37
Weather system	0	0	0	0	4	0	0	0	0	0	4
Incidents	117	112	26	42	149	33	106	3	463	64	939

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.9.—HUMAN-FACTOR-RELATED INCIDENTS
BY HUMAN FACTOR CATEGORY AND PHASE OF FLIGHT
[Shaded entries indicate the most frequent incidents (top 10 tall poles)]

Human factor category	Phase of flight									
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked
Communication breakdown	103	58	67	68	117	82	67	43	53	181
Confusion	99	58	82	76	91	79	63	54	47	113
Distraction	54	40	50	52	103	50	56	40	34	60
Fatigue	5	6	0	7	4	4	14	8	4	26
Human-machine interface	25	55	62	69	93	53	56	34	31	28
Other-unknown	14	17	19	35	81	38	27	16	31	30
Physiological-other	5	9	5	10	23	11	7	4	8	12
Situational awareness	149	119	111	111	218	121	119	79	125	182
Time pressure	22	36	32	30	59	31	26	16	21	62
Training/qualification	33	43	36	37	70	24	32	17	41	73
Troubleshooting	21	39	34	53	109	26	22	12	12	68
Workload	27	24	54	53	87	51	41	21	29	43
Incidents	200	189	178	207	382	201	181	121	185	280

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

Human factor category	Phase of flight									
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked
Communication breakdown	76	36	24	42	72	52	40	20	19	171
Confusion	67	41	32	58	50	57	37	27	21	104
Distraction	43	28	26	34	59	34	36	24	12	55
Fatigue	5	3	0	6	3	2	13	6	2	24
Human-machine interface	16	43	28	52	54	39	32	24	11	26
Other-unknown	8	12	13	24	44	29	18	11	16	30
Physiological-other	4	6	4	9	18	10	6	3	7	12
Situational awareness	101	79	47	77	113	84	74	42	46	168
Time pressure	12	29	19	22	39	22	20	9	10	59
Training/qualification	23	30	16	26	45	14	21	5	6	65
Troubleshooting	15	29	21	42	73	19	14	7	2	63
Workload	21	20	29	34	56	30	29	9	10	43
Incidents	136	130	82	148	210	144	112	70	71	259

[a]Federal Aviation Regulations.

TABLE D.11.—HUMAN-FACTOR-RELATED INCIDENTS BY HUMAN FACTOR CATEGORY AND PHASE OF FLIGHT FOR FAR[a] PART 135
[Shaded entries indicate the most frequent human factor incidents (top 7 tall poles)]

Human factor category	Phase of flight									
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked
Communication breakdown	2	2	7	2	2	2	1	3	1	3
Confusion	1	3	11	2	5	1	2	3	3	3
Distraction	1	2	5	4	4	0	1	1	2	2
Fatigue	0	0	0	0	0	2	0	0	0	1
Human-machine interface	1	3	6	3	0	2	0	0	0	1
Other-unknown	0	0	0	0	3	0	0	0	0	0
Physiological-other	0	0	0	0	3	0	0	0	0	0
Situational awareness	3	3	9	8	9	1	2	5	5	5
Time pressure	1	1	4	3	3	0	1	1	1	3
Training/qualification	0	0	4	1	1	0	0	0	0	0
Troubleshooting	1	2	2	3	1	0	0	0	0	2
Workload	1	1	8	2	4	2	1	1	2	0
Incidents	3	7	17	8	12	2	2	6	5	7

[a]Federal Aviation Regulations.

TABLE D.12.—HUMAN-FACTOR-RELATED INCIDENTS BY HUMAN FACTOR CATEGORY AND PHASE OF FLIGHT FOR FAR[a] PART 91
[Shaded entries indicate the most frequent human factor incidents (top 11 tall poles)]

Human factor category	Phase of flight									
	Taxi	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Parked
Communication breakdown	15	16	26	12	33	19	22	17	27	7
Confusion	20	12	27	13	24	17	18	20	20	6
Distraction	8	10	15	12	30	13	17	13	19	3
Fatigue	0	3	0	1	0	0	1	2	2	0
Human-machine interface	6	9	25	11	28	12	20	10	19	1
Other-unknown	3	3	3	4	11	6	3	3	12	0
Physiological-other	1	2	1	0	2	1	1	1	1	0
Situational awareness	31	33	40	22	71	28	35	27	61	9
Time pressure	9	6	8	4	15	9	3	6	9	0
Training/qualification	9	13	14	10	22	10	7	12	35	7
Troubleshooting	4	7	7	7	31	6	6	4	9	3
Workload	4	3	15	12	21	16	9	8	16	0
Incidents	40	44	57	34	102	41	48	37	92	12

Federal Aviation Regulations.

TABLE D.13.—HUMAN-FACTOR-RELATED
INCIDENTS BY SCFM[a] AND HUMAN FACTOR CATEGORIES
[Shaded entries indicate the most frequent incidents (top 10 tall poles)]

Component	Human factor											
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload
Automated flight control	19	29	23	3	34	2	1	39	6	18	18	21
Brakes	14	7	7	1	14	0	0	23	6	10	11	4
Communication	26	12	11	0	7	3	3	22	5	5	8	8
Control surface	25	31	20	3	20	5	0	40	18	22	25	17
Electrical power	32	30	23	4	26	7	4	52	20	20	52	28
Environmental control system	38	36	18	4	18	12	10	39	19	15	36	15
Furnishings and equipment	12	6	4	1	5	5	3	14	3	6	10	2
Fuel system	18	23	15	3	11	1	1	29	12	12	16	3
Hydraulic or pneumatic	20	22	26	1	23	6	5	58	16	28	41	20
Icing	2	2	1	1	4	2	0	5	0	2	2	2
Landing gear	40	21	12	1	20	3	0	57	14	15	24	8
Miscellaneous	15	15	3	0	1	2	0	16	4	8	4	3
Monitoring and management	49	69	45	4	58	1	0	82	24	32	46	33
Navigation	48	100	58	3	119	4	1	98	25	27	35	46
Oil system	11	8	8	2	9	1	1	20	8	11	16	7
Propulsion system	43	32	27	3	31	4	1	100	32	38	47	28
Structures	27	20	20	1	7	6	4	40	12	12	10	12
Weather system	0	0	3	0	4	0	0	2	0	0	0	0
Incidents	340	372	286	26	385	58	33	615	195	242	346	225

[a]System component failure or malfunction.

TABLE D.14.—HUMAN-FACTOR-RELATED INCIDENTS BY SCFM[a] AND HUMAN FACTOR CATEGORIES FOR FAR[b] PART 121
[Shaded entries indicate the most frequent incidents (top 10 tall poles)]

SCFM category	Human factor category											
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload
Automated flight control	15	21	16	3	22	1	0	27	6	16	16	16
Brakes	11	5	5	1	9	0	0	17	4	6	8	1
Communication	15	8	7	0	4	1	1	12	4	0	3	3
Control surface	23	26	14	3	15	5	0	35	16	18	20	12
Electrical power	18	22	17	4	15	6	3	33	16	13	35	20
Environmental control system	35	33	18	4	18	12	10	38	18	14	32	15
Furnishings and equipment	10	6	4	1	4	5	3	12	3	5	9	2
Fuel system	14	14	10	2	5	1	1	15	7	4	7	2
Hydraulic or pneumatic	18	21	23	1	20	6	5	54	14	27	37	19
Icing	2	2	1	1	4	1	0	4	0	2	2	2
Landing gear	33	15	11	1	10	1	0	45	12	7	15	5
Miscellaneous	13	13	3	0	0	2	0	15	4	5	3	2
Monitoring and management	34	47	28	3	35	1	0	56	21	23	36	20
Navigation	31	69	43	3	79	4	1	58	20	15	24	26
Oil system	7	6	6	2	7	1	1	14	6	9	12	6
Propulsion system	32	22	14	2	15	4	1	64	13	23	27	19
Structures	24	17	15	0	6	5	3	32	10	11	9	9
Weather system	0	0	3	0	3	0	0	1	0	0	0	0
Incidents	251	271	208	23	252	51	29	436	148	169	249	156

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.15.—HUMAN-FACTOR-RELATED INCIDENTS BY SCFM[a]
AND HUMAN FACTOR CATEGORIES FOR FAR[b] PART 135
[Shaded entries indicate the most frequent incidents (top 10 tall poles)]

SCFM category	Human factor											
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload
Automated flight control	0	1	0	0	1	0	0	0	0	0	0	0
Brakes	0	0	0	0	1	0	0	1	0	0	1	0
Communication	0	0	0	0	0	0	0	0	0	0	0	0
Control surface	0	1	1	0	0	0	0	1	0	0	1	1
Electrical power	0	0	0	0	1	0	0	2	1	0	2	0
Environmental control system	0	1	0	0	0	0	0	0	0	0	1	0
Furnishings and equipment	2	0	0	0	1	0	0	2	0	0	1	0
Fuel system	1	3	1	1	0	0	0	3	1	1	2	0
Hydraulic or pneumatic	0	0	1	0	0	0	0	1	1	0	1	0
Icing	0	0	0	0	0	0	0	0	0	0	0	0
Landing gear	1	1	0	0	0	0	0	1	0	1	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0	0	0
Monitoring and management	3	4	1	1	2	0	0	4	0	1	1	2
Navigation	1	3	1	0	3	0	0	2	1	0	1	2
Oil system	0	0	0	0	0	0	0	0	0	0	0	0
Propulsion system	3	1	1	1	0	0	0	4	4	1	1	1
Structures	2	3	2	0	0	1	1	4	1	0	0	2
Weather system	0	0	0	0	0	0	0	0	0	0	0	0
Incidents	11	15	7	2	9	1	1	21	7	3	10	8

[a]System component failure or malfunction.
[b]Federal Aviation Regulations.

TABLE D.16.—HUMAN-FACTOR-RELATED INCIDENTS BY SCFM[a] AND HUMAN FACTOR CATEGORIES FOR FAR[b] PART 91

[Shaded entries indicate the most frequent incidents (top 11 tall poles)]

SCFM category	Human factor category											
	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Other-unknown	Physiological-other	Situational awareness	Time pressure	Training/qualification	Troubleshooting	Workload
Automated flight control	3	5	7	0	10	1	1	11	0	2	2	5
Brakes	3	2	2	0	4	0	0	5	2	4	2	3
Communication	11	4	4	0	3	2	2	10	1	5	5	5
Control surface	2	4	4	0	5	0	0	3	2	4	3	3
Electrical power	14	8	6	0	10	1	1	17	3	7	14	8
Environmental control system	2	2	0	0	0	0	0	1	1	1	3	0
Furnishings and equipment	0	0	0	0	0	0	0	0	0	0	0	0
Fuel system	2	5	2	0	6	0	0	9	3	6	5	1
Hydraulic or pneumatic	2	1	2	0	2	0	0	3	1	1	3	1
Icing	0	0	0	0	0	1	0	1	0	0	0	0
Landing gear	5	5	1	0	8	2	0	9	2	5	5	3
Miscellaneous	1	0	0	0	0	0	0	0	0	1	0	0
Monitoring and management	11	18	15	0	19	0	0	21	2	8	6	10
Navigation	14	24	13	0	34	0	0	33	2	12	9	17
Oil system	4	2	2	0	2	0	0	6	2	2	4	1
Propulsion system	2	4	10	0	16	0	0	24	14	10	16	7
Structures	1	0	2	1	1	0	0	3	1	0	0	1
Weather system	0	0	0	0	1	0	0	1	0	0	0	0
Incidents	67	75	65	1	114	6	3	139	35	61	73	56

[a]System component failure or malfunction.

[b]Federal Aviation Regulations.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT
The Aviation Safety Program (AvSP) Vehicle Systems Safety Technology (VSST) Project asked the AvSP Systems and Portfolio Analysis Team to identify VSST-related trends. VSST has three technical challenges: vehicle health assurance; effective crew-system interactions and decisions in all conditions; and aircraft loss of control prevention, mitigation, and recovery. This report reviews incident data from the NASA Aviation Safety Reporting System (ASRS) for system-component-failure-or-malfunction- (SCFM-) related, human-factor-related, and loss-of-control- (LOC-) 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, LOC category, and human factor category. There were 24 409 SCFM-related incidents and 5096 LOC-related incidents analyzed between January 1993 and January 2011, and 2243 human-factor-related incidents analyzed between May 2009 and January 2011.

15. SUBJECT TERMS
Health; Prevention; Aircraft safety

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