Accident Event Type

Glass cockpit aircraft were involved in higher percentages of loss-of-control in flight and collision-with-terrain events, and conventional aircraft were involved in more loss-of-control on ground and hard-landing events. This is consistent with the results of the previous comparison showing more glass cockpit accidents during in-flight phases and more takeoff and landing accidents for the conventional cohort. A summary comparison of accident event types is presented in figure 18.

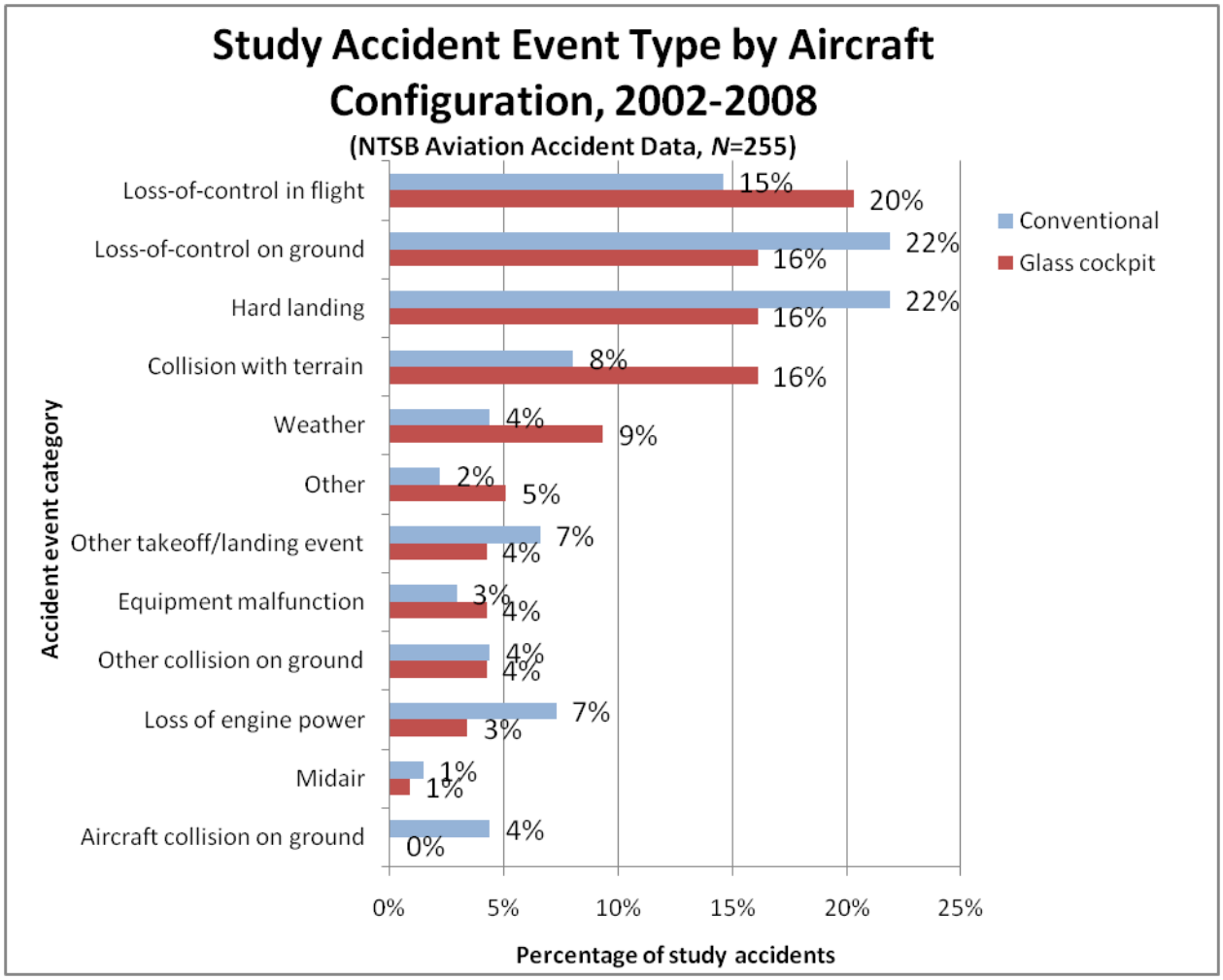

Figure 18. Comparison of study accidents by event type and aircraft configuration. [58]

The higher percentage of collisions with terrain versus all other events for the glass cockpit cohort was the only statistically significant difference between the two cohorts in accident events: χ^2 (1, N = 255) = 3.980, p = 0.046.

[58] Totals do not sum to 100 percent due to rounding.

Accident Pilot Information

Information regarding accident pilots was compared to identify differences that might have affected the safety record of study aircraft. For example, if one cohort was more likely to be flown by less experienced pilots, the accident record would likely be worse for those aircraft.

Number of Pilots

As illustrated in figure 19, aircraft with conventional cockpits were more likely to have two flight crewmembers aboard than those with glass cockpits, which were more likely to be operated by a single pilot. The difference in the number of flight crew was statistically significant: χ^2 (1, N = 266) = 7.063, p = 0.008. In approximately half of the conventional aircraft cases with two pilots, the second pilot was identified as a flight instructor, which is consistent with the previously presented results indicating that conventional aircraft were more likely to be used for instructional flights.

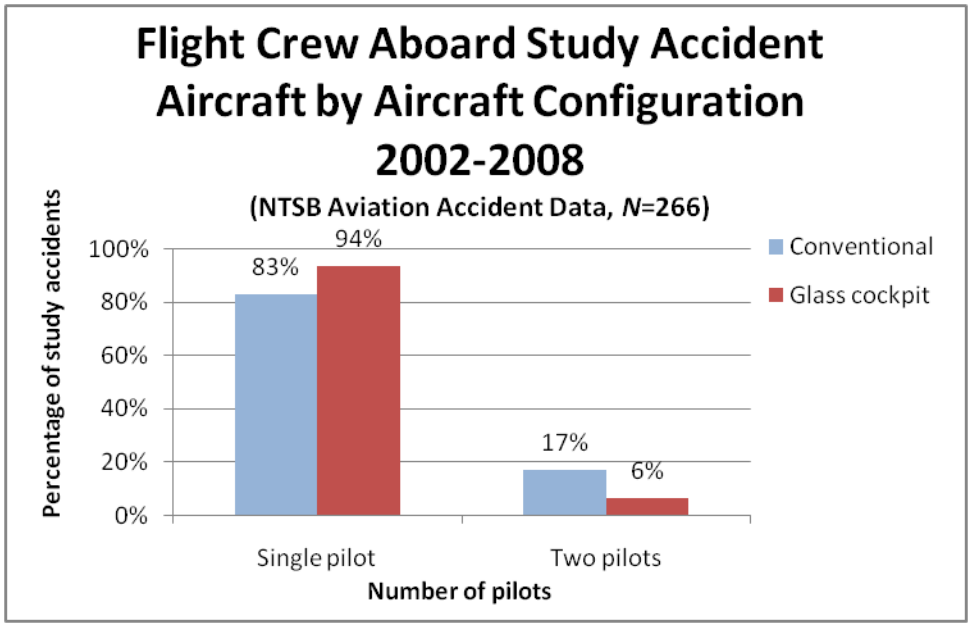

Figure 19. Comparison of number of pilots aboard study accident aircraft.

Pilot Age

Age data were available for 257 of the 266 accident pilots considered in the study. Accident pilots in the glass cockpit cohort ranged in age from 18 to 76, with a median age of 47. Accident pilots in the conventional cohort ranged in age from 17 to 77, with a median age of 43. Accident pilots flying glass cockpit aircraft were significantly older than those flying conventional aircraft (U = 6736.5, N (conventional) = 139, N (glass cockpit) = 118, p = 0.014). Much of the difference between the conventional and glass cockpit study cohorts with regard to age can be attributed to differences in the percentage of young pilots. Of the 139 accident pilots

in the conventional aircraft cohort whose age was known, 38 (27 percent) were under 30 years old. In contrast, for the glass cockpit cohort, only 14 of the 118 accident pilots (12 percent) for whom age information was available were under 30 years old.

Pilot Certificate Level

Of those accident pilots for whom certificate information was available, 26 percent held airline transport pilot (ATP) or commercial certificates, 50 percent held private pilot certificates, and 24 percent held student pilot certificates. As shown in figure 20, nearly equal proportions of the two cohorts held commercial or ATP certificates, but the two cohorts differed significantly with regard to student and private pilot certificates: χ^2 (2, N = 261) = 21.931, $p < 0.001$. In comparison, the data concerning the FAA's U.S. civil airman certificate for 2002 through 2008[59] indicate that an average of approximately 14 percent of active pilots held a student pilot certificate, 38 percent a private pilot certificate, and 43 percent a commercial pilot certificate or ATP.

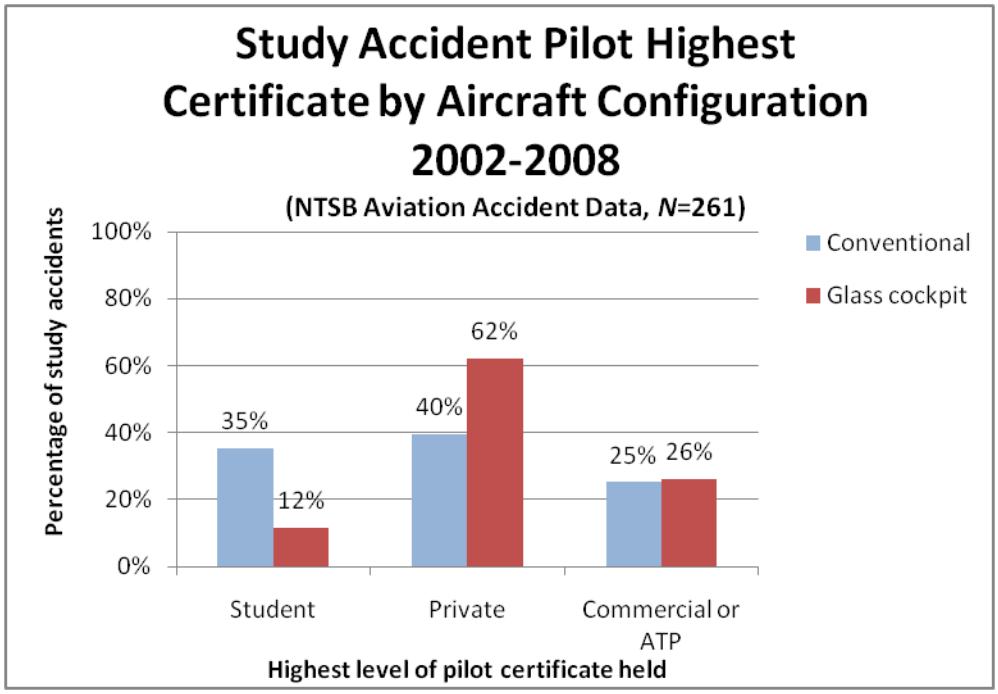

Figure 20. Comparison of study accident pilots by certificate level.

Pilot Instrument Rating

As illustrated in figure 21, approximately 65 percent of accident pilots in the glass cockpit cohort were rated for instrument flight, compared to 37 percent of those in the

[59] See <http://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/2008/>.

conventional cohort.[60] The difference in instrument rating between the aircraft cohorts was statistically significant: χ^2 (1, N = 257) = 20.828, p < 0.001. In comparison, the FAA's U.S. civil airman statistics indicate that, on average, 51 percent of the active pilot population from 2002 to 2008 held an instrument rating.

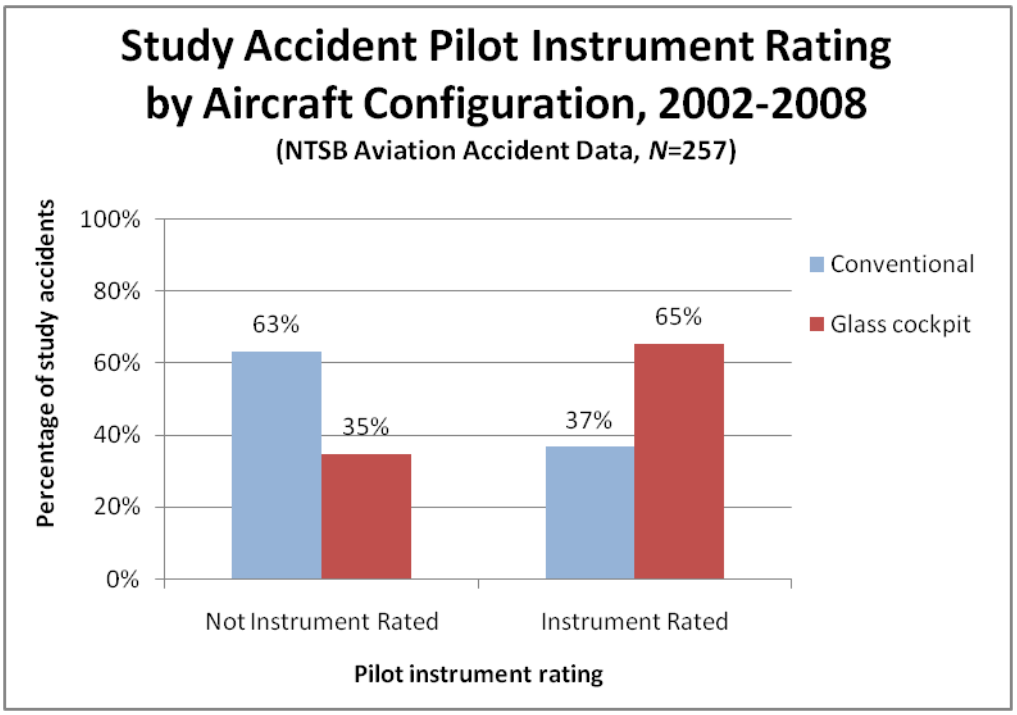

Figure 21. Comparison of study accident pilots by instrument rating.

Pilot Flight Hours

The most commonly available measures of accident pilot flight experience were total flight hours in all aircraft and total time in the accident aircraft make and model. The total flight time of accident pilots in glass cockpit aircraft ranged from 22 to approximately 25,000 hours, while the total flight time for accident pilots in conventional aircraft ranged from 1 to 23,000 hours. The median number of total flight hours for glass cockpit pilots was higher than the median total flight hours for pilots of conventional aircraft (466 hours and 167 hours, respectively), and accident pilots in the glass cockpit cohort had significantly more total flight hours than those in the conventional cohort: U = 5503.0, N (conventional) = 138, N (glass cockpit) = 118, p <0.001.

Flight experience in the accident aircraft make and model for pilots in glass cockpit aircraft ranged from 11 to approximately 1,430 hours and for accident pilots in conventional aircraft, from 1 to approximately 6,200 hours. Median flight experience in make and model for glass cockpit pilots was higher than for those flying conventional aircraft (99 hours and 70 hours,

[60] Insufficient data were available to compare instrument flight experience and currency at the time of the accident.

respectively). However, the overall distributions of flight time in the accident make/model were not significantly different: U = 6087.5, *N* (conventional) = 129, *N* (glass cockpit) = 106, *p*= 0.148. It is important to note that data concerning flight experience in aircraft make and model made no distinction in cockpit design, so some pilots may have been experienced in the aircraft type while having little experience with the particular cockpit display in the aircraft.

Summary of Quantitative Analysis Results

Study comparisons of total and active aircraft, flight hours, and accidents showed similar patterns of accident rates for study aircraft. A comparison of the accidents from 2002 through 2008 involving the glass cockpit and conventional study cohorts with the number of registered aircraft indicates that the glass cockpit aircraft study cohort experienced a lower accident rate but a higher fatal accident rate. Analyses of the study-specific estimates obtained from the FAA's 2006 and 2007 GAATAA Surveys indicate that the 2-year, 2006 and 2007 accident rate per 100,000 flight hours was similar for both study groups, but the fatal accident rate per flight hour was higher for the glass cockpit cohort.

Statistical comparisons of accident characteristics identified several variables with distributions significantly different between the conventional and glass cockpit groups, including (1) accident severity, (2) purpose of accident flights, (3) planned length of accident flight, (4) number of pilots, (5) pilot age, (6) pilot certification level, (7) pilot total flight experience, and (8) pilot instrument rating. Accidents involving glass cockpit aircraft were more likely to be associated with personal/business flights, longer flights, and single-pilot operations, while conventional aircraft were more likely to be associated with instructional flights, shorter flights, and two-pilot operations. Accident pilots of glass cockpit-equipped aircraft were older, held higher levels of pilot certification, were more likely to hold an instrument rating, and had more flight hours than those flying aircraft with conventional instruments. The glass cockpit cohort was involved in more accidents in IMC, but the difference was only marginally significant.

These results are consistent with GAATAA Survey data indicating that the conventional cohort flew more instructional flight hours. A younger pilot group, two-pilot crews, and shorter flights are consistent with new pilots learning to fly. Aircraft in the conventional cockpit cohort were more likely to be involved in an accident but less likely to be involved in a fatal accident, which is also consistent with the conventional aircraft being used to conduct more instructional flights, which historically have had lower fatal accident rates than personal flying.[61]

Differences in accident rates between the study cohorts followed a similar pattern. The 2-year fatal accident rates for 2006 and 2007 were similarly low for both cohorts during instructional flights. The total accident rate was higher for conventional aircraft during both instructional and personal/business flying, but the fatal accident rate was highest for glass cockpit aircraft during personal/business flights.

[61] *Annual Review of U.S. General Aviation Accident Data, 2005*, Annual Review NTSB/ARG-09/01, "Focus on General Aviation Safety: Instructional Flight" (Washington, DC: National Transportation Safety Board, 2009).

Finally, accident and fatal accident rates were higher for the glass cockpit cohort in IMC and at night despite the aircraft being flown by pilots with higher levels of certification and more flight experience—and the additional capabilities of glass cockpit displays, which were intended to improve the safety of those flight operations. The tables that follow summarize the results of all statistical tests included in this study. Table 7 summarizes all comparisons of categorical accident variables in this chapter, with total numbers of cases included in each comparison, relative percentages, chi-square values, and significance.

Table 7. Summary of chi-square analyses.

	Total Accidents	Conventional		Glass cockpit		χ^2	*p*
		N	% within cohort	*N*	% within cohort		
Accident Severity	266					8.216	0.004
Fatal		23	16%	39	31%		
NonFatal		118	84%	86	69%		
Total		141		125			
Light Condition	266					3.058	0.080
Day		122	87%	98	78%		
Night		19	13%	27	22%		
Total		141		125			
Weather	264					3.639	0.056
VMC		129	92%	105	85%		
IMC		11	8%	19	15%		
Total		140		124			
Flight Plan	250					11.718	0.001
VFR/None		110	83%	76	64%		
IFR		22	17%	42	36%		
Total		132		118			
Purpose of Flight	258					31.616	< 0.001
Instructional		66	49%	19	16%		
Personal/Business		70	51%	103	84%		
Total		136		122			
Accident Event Type	255					3.980	0.046
Collision with Terrain		11	8%	19	16%		
Other		126	92%	99	84%		
Total		137		118			
Flight Crew Aboard	266					7.063	0.008
Single Pilot		117	83%	117	94%		
Two Pilots		24	17%	8	6%		
Total		141		125			
Highest Pilot Certificate	261					21.931	< 0.001
Student		49	35%	14	12%		
Private		55	40%	76	62%		
Commercial or ATP		35	25%	32	26%		
Total		139		122			
Pilot Instrument Rating	257					20.828	< 0.001
Not Instrument Rated		88	63%	41	35%		
Instrument Rated		51	37%	77	65%		
Total		**139**		**118**			

Table 8 summarizes all comparisons of continuous accident variables in this chapter, with total numbers of cases included, median values, sums of ranks, Z-scores and Mann-Whitney U values, and significance.

Table 8. Summary of Mann-Whitney analyses.

	N	Median	Sum of Ranks	*Z*	*U*	*p*
Pilot Age				2.467	6736.5	0.014
Conventional	139	43yrs	16466.5			
Glass Cockpit	118	47yrs	16686.5			
Total	257					
Pilot Total Flight Time				4.469	5503.0	<0.001
Conventional	138	167hrs	15094.0			
Glass Cockpit	118	466hrs	17802.0			
Total	256					
Pilot Flight Time in Make/Model				1.445	6087.5	0.148
Conventional	129	70hrs	14472.5			
Glass Cockpit	106	99hrs	13257.5			
Total	235					
Planned Flight Length				4.807	5649.5	<0.001
Conventional	140	25nm	15519.5			
Glass Cockpit	122	96nm	18933.5			
Total	**262**					