Australian Government

Australian Transport Safety Bureau

Safe Transport

AVIATION RESEARCH PAPER

BE04/73

Light Utility Helicopter Safety in Australia

Australian Government

Australian Transport Safety Bureau

RESEARCH PAPER
BE04/73

Light Utility Helicopter Safety in Australia

ISBN 1 877071 71 4 June 2004

This report was produced by the Australian Transport Safety Bureau (ATSB), PO Box 967, Civic Square ACT 2608.

CONTENTS

Executive Summary **1**
Introduction **3**
Methodology **4**
Data sources 4
Data analysis 4
Results and Discussion **5**
Helicopter Accident Trends 5
Fatalities and Injuries 11
Accident Rates 13
Number of registered helicopters and flying hours 13
Accident rate per registered helicopter 16
Accident rate per flying hours 17
Fatal accident rate per flying hours 19
Type of Flying 22
Definition of flying operations 23
Type of flying operation and accidents 23
Flying hours by operation type 26
Accident rate per flying hours by flying type 27
Accident Outcomes 29
Outcome type 29
Contributing factors 32
Conclusion **35**
Appendix A **36**
Systemic Incident Analysis Model II 36

EXECUTIVE SUMMARY

Light utility helicopters made up half the fleet of registered helicopters in Australia, yet were involved in 72 per cent of helicopter accidents between January 1985 and December 2003. This report compared the relative safety of four light utility helicopter models. These are the: Robinson R22, 47G (made variously by Bell Helicopter Company, Agusta SPA Costruzioni or Kawasaki Heavy Industries), 269 (made by Hughes Helicopters or Schweizer Aircraft Corporation) and Hiller UH-12E. These helicopters are primarily single engine, reciprocating engine aircraft and the demand for them in Australia is high. The number of light utility helicopters on the civil register grew by 36 per cent between 1990 and 2002.

The aim of this report was to determine if any particular light utility helicopter model has a higher risk profile than similar aircraft. For each of the light utility helicopter models the report compared accident trends (fatal and non-fatal), accident rates per registered aircraft, fatal accident rates per hours flown and accident rates per hours flown. The report also reviewed the type of flying operation where accidents occurred and the accident outcomes for each of the models of interest.

The Robinson R22 was involved in more accidents and fatal accidents than any other light utility helicopter but also flew more hours than the other three light utility helicopters whose risk profiles were studied. The Bell/Agusta/Kawasaki 47G model had the next highest involvement in accidents followed by the Hughes/Schweizer 269 and then the Hiller UH-12E. When comparing the relative safety of different aircraft models the best available indicator is the accident rate per hours flown. The accident rate per hours flown for the Robinson R22 model indicates that up to 2002 this helicopter's record was as safe, if not safer, than other similar helicopter models. Since 2002, the Bell/Agusta/Kawasaki 47G has had the lowest accident rate per hours flown.

For the period 1990-2002, the Hiller UH-12E had the lowest accident rate per registered helicopter and the lowest fatal accident rate per hours flown. The Robinson R22 model had the lowest accident rate per flying hours and second lowest fatal accident rate per hours flown. The accident rates are summarised in Table 1.

Table 1. Accident rates for Robinson R22, Bell/Agusta/Kawasaki 47G, Hughes/Schweizer 269 and Hiller UH-12E model helicopters, 1990-2002

Helicopter model	Accident rate per 100 registered helicopters 90-02	Accident rate per 10,000 flying hours 90-02	Fatal accident rate per 100,000 flying hours 90-02
Robinson R22	6.5	1.8	1.5
Bell/Agusta/Kawasaki 47G	6.7	3.1	4.4
Hughes/Schweizer 269	11.3	4.7	6.1
Hiller UH-12E	6.0	4.6	0.0

The light utility helicopters primarily perform other aerial work (aerial mustering), flying training and aerial agricultural operations. Flying training, charter and other aerial work operations had the lowest accident rates per hour flown.

The majority of light utility helicopter accidents involved collisions with terrain or other obstacles, with a smaller proportion involving engine malfunction. The helicopters collided with the ground, trees or powerlines. 'Aircraft handling' or 'maintenance/repair/design/construction' factors contributed to the majority of accidents.

The overall trend in accident involvement and accident rate per hours flown has improved since 1990 for all the light utility helicopters. The safety profile of the two most comparable light utility helicopter models, the Robinson R22 and Bell/Agusta/Kawasaki 47G, are similar.

INTRODUCTION

This study was prompted by increasing concerns about light utility helicopter safety in Australia. Light utility helicopters make up half the fleet of helicopters in Australia. They perform a number of different flying activities with varying risk profiles, including aerial mustering, flying training, agricultural operations, as well as personal and business transport.

There are seven light utility helicopter models identified in the Australian fleet. These include Robinson R22, 47G (made by Bell Helicopter Company, Agusta SPA Costruzioni or Kawasaki Heavy Industries), 269 (made by Hughes Helicopters or Schweizer Aircraft Corporation), Hiller UH-12E, Enstrom F28, Enstrom 280 and Brantly B-2. This report concentrates on four of these models, the R22, 47G, 269 and UH-12E as they are similar in design and usage and there was sufficient data to allow meaningful comparisons of these models. These helicopters are primarily single engine, reciprocating engine aircraft and the demand for them in Australia is high. The number of Robinson R22 helicopters on the Australian Civil Register has increased by 78 per cent since 1990, while 47G helicopters have increased by 18 per cent over the same period.

The involvement of light utility helicopters in accidents is relatively high. While these models make up half the Australian helicopter fleet, they are involved in 72 per cent of helicopter accidents recorded by the ATSB. This combination of growing fleet size and high accident involvement warranted further investigation.

The objectives of the study were to:

- review and compare accident trends and rates for the light utility helicopter models flown in Australia;
- review accident outcomes and investigate the type of flying operation where accidents occur; and
- determine if any light utility helicopter model has a significantly different risk profile from similar aircraft.

METHODOLOGY

Data sources

The report analyses accident data and exposure data for all accidents where at least one Australian registered light utility helicopter was involved or where an accident to a light utility helicopter occurred in Australian airspace. Accident data were sourced from the Occurrence Analysis and Safety Information System (OASIS) database held by the ATSB. This database contains detailed information on air safety occurrences reported to the ATSB. An accident occurs where a person dies or suffers serious injury, or where an aircraft is destroyed or seriously damaged as a result of an occurrence associated with the operation of the aircraft. The data on accident outcomes are limited to accidents occurring from 1996 onwards, when the most recent accident analysis model was implemented. This model, called the 'Systemic Incident Analysis Model' (SIAM), is not comparable with the previously used 'Events and Factors' model.

Exposure data, including the number of hours flown and the number of registered civil aircraft, were sourced from the Aviation Statistics (AVSTATS) database held by the Australian Government Department of Transport and Regional Services. The department surveys aircraft owners listed on the Civil Aircraft Register twice a year. The Civil Aviation Safety Authority (CASA) compiles the register. The survey collects information on the make and model of aircraft, the type and number of engines and use of the aircraft over the preceding six-month period. Aircraft are excluded from the survey when AVSTATS is advised through the survey that the aircraft has been destroyed, withdrawn from use or sold to an unspecified owner.

The tables included in this report primarily report data at the aircraft level. That is, each count refers to a helicopter involved in a reported accident. It is possible for the same helicopter to be involved in more than one accident per year. All data is reported by calendar year unless specified otherwise.

Data analysis

Many of the tables in this report present accident data from 1985 to 2003, while those tables presenting exposure data report on the period 1990 to 2002. This is because AVSTATS commenced collecting details of aircraft models from 1990 onwards and the most recent year available from this data source is 2002.

This report is primarily concerned with helicopter models of similar size, engine type and usage. These models include Robinson R22, 47G (made by Bell Helicopter Company, Agusta SPA Costruzioni or Kawasaki Heavy Industries), 269 (made by Hughes Helicopters or Schweizer Aircraft Corporation) and Hiller UH-12E. Where a helicopter model is manufactured under licence by a number of different companies, this model is grouped together in the report. Other single engine, reciprocating engine helicopters (such as Enstrom F28, 280, amateur built helicopters and Brantly B-2) are recorded in the data sources. These helicopters are not analysed separately in this report because both the number registered and their accident numbers were too small to allow meaningful analysis.

RESULTS AND DISCUSSION

Helicopter accident trends

In the period 1985 to 2003, there were a total of 776 accidents involving 777 helicopters (both reciprocating and turbine engines). There was one collision between a Bell 47G and Robinson R22 helicopter in 1993. Table 2 shows that the number of accidents per year increased from 36 accidents in 1985 to 43 in 2001, with a peak at 57 accidents in 1990. The number of accidents per year, however, has dropped from 43 in 2001 to 29 in 2003, a 33 per cent decrease. Ninety-three of the accidents from 1985 to 2003 were fatal, resulting in 146 fatalities. In addition, there were 164 serious injuries resulting from accidents during the same period. The number of accidents recorded for each model (for the major manufacturers only) between 1985 and 2003 is presented in Table 3.

Table 2. Helicopters involved in accidents in Australia by manufacturer, 1985-2003

Manufacturer	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Aerospatiale	1	5	1	3	2	5	6	2	5	2	0	2	3	0	1	0	1	2	0	41
Agusta SPA Costruzioni	0	1	0	0	0	0	3	0	0	1	0	0	0	0	1	1	3	0	0	10
Amateur Built Aircraft	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	3	1	1	10
Bell Helicopter Co	14	13	14	16	15	12	13	10	15	7	7	7	11	9	3	9	10	4	7	196
Brantly International Inc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Enstrom Corp, RJ	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	5
Hiller Aviation	3	1	8	2	6	2	2	2	1	0	1	0	1	2	0	0	1	1	0	33
Hughes Helicopters	8	12	9	10	11	12	9	12	7	5	8	7	10	4	4	4	3	4	2	141
Kawasaki Heavy Industries	0	0	0	2	3	2	3	3	3	3	4	4	2	4	1	3	1	0	2	40
Messerschmitt-Bolkow-Blohm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Robinson Helicopter Co	9	4	3	13	17	24	20	20	17	17	13	12	16	14	16	24	19	10	17	285
Schweizer Aircraft Corp	0	0	0	0	0	0	0	0	0	1	0	1	2	1	1	3	1	1	0	11
Sikorsky Aircraft	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
Westland Helicopters	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total[1]	36	38	35	46	55	57	56	50	48	39	33	34	45	35	29	46	43	23	29	777

[1] This table includes all the models of helicopters made by the manufacturing company listed. That is both light utility helicopters and larger models are included in this table.

Table 3. All helicopters involved in accidents by manufacturer & model, 1985-2003

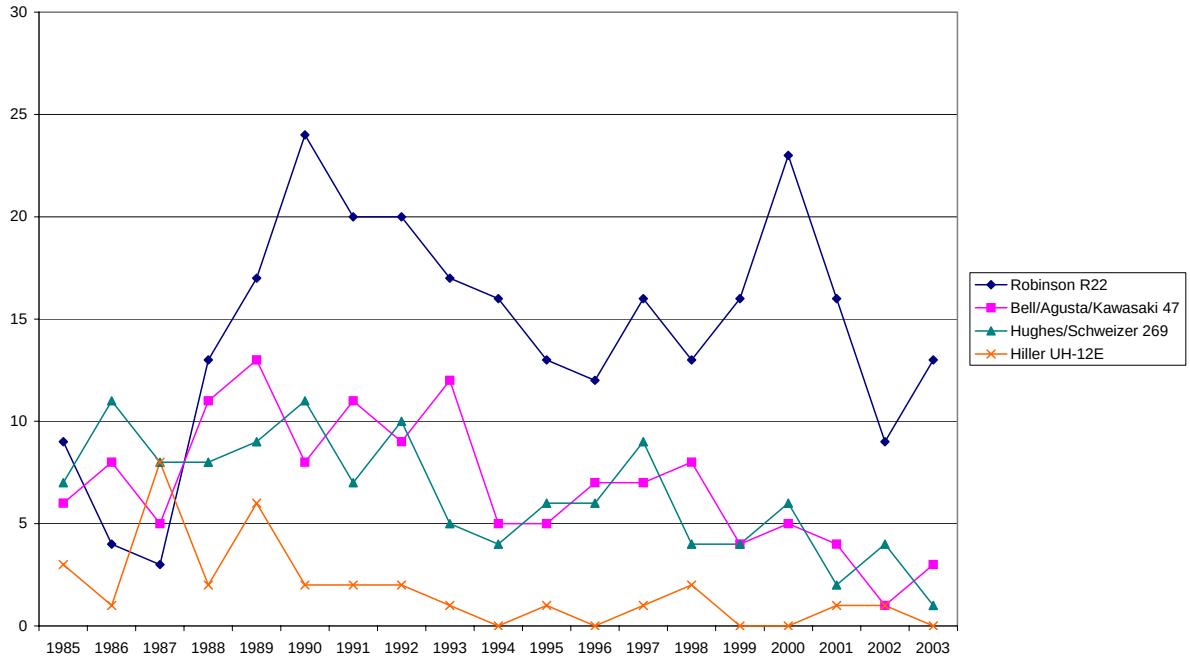
Model	Accidents	Model	Accidents
Aerospatiale		**Bell Helicopter Co**	
AS.350B	14	205	1
AS.350BA	4	205A	1
AS.350D	2	206B	33
AS.355F1	7	206B (II)	10
AS355F2	1	206B (III)	34
SA.330J	3	206L	2
SA.341G	1	206L-1	11
SA.365C-1	4	206L-3	5
SA.365C-2	1	212	2
SA.365C-3	1	214ST	3
SA315B	1	407	2
AS.350B2	2	412	3
Total	41	47G-2	14
		47G-3B	5
Agusta SPA Costruzioni		47G-3B1	33
206B	1	47G-3B2	1
47-G-2A1	2	47G-4A	4
47-G-3B1	2	47G-5	16
47G-3B-1	1	47G-3B2A	1
47J	1	47G-4	2
A109A	2	47G-5A	8
A109AII	1	47G	1
Total	10	47J-2A	3
		UH-1B	1
Amateur built aircraft		Total	196
Canadian Safari	2		
Exec 162F	3	**Hughes Helicopters**	
Exec 90	3	269A	13
Mini 500	2	269B	5
Total	10	269C	93
		369D	9
Brantly International Inc		369E	8
B-2B	1	369HS	13
Total	1	Total	141
Enstrom Corp, RJ		**Kawasaki Heavy Industries**	
280C	1	47G3B-KH4	38
F-28A	1	BK117 B-2	1
F-28C	1	BK117-A4	1
F-28F	2	Total	40
Total	5		
		Messerschmitt-Bolkow-Blohm	
Hiller Aviation		BK117 B-2	1
UH-12E	33	Total	1
Total	33		

Table 3. Continued

Model	Accidents	Model	Accidents
		Schweizer Aircraft Corp	
Robinson Helicopter Co		269C-1	2
R22	36	269C	9
R22 ALPHA	36	Total	11
R22 BETA	186		
R22 HP	11	**Sikorsky Aircraft**	
R22/A1	2	S-76A	2
R22 MARINER	3	Total	2
R44	11		
Total	285	**Westland Helicopters**	
		Scout	1
		Total	1

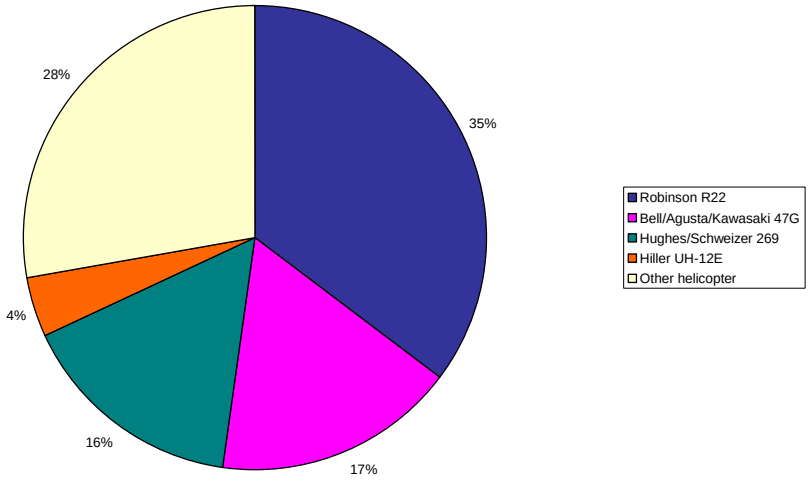
Figures 1 and 2 and Table 4 indicate that Robinson R22 helicopters were involved in more accidents than any other light utility model (35.3 per cent) and have been involved in a greater proportion of accidents than other models since 1988. The number of accidents involving Robinson R22 helicopters peaked at a total of 24 accidents in 1990, with another peak observed in 2000. The 47G and 269 models have had similar accident involvement profiles over the 19-year period, with the 47G involved in 17 per cent and the 269 involved in 15.7 per cent of accidents. Accidents involving Bell/Agusta/Kawasaki 47G helicopters peaked at 13 in 1989. These helicopters were involved in three accidents in 2003. Accidents involving Hughes/Schweizer 269 helicopters peaked at 11 in 1986 and 1993. In 2003, the 269 helicopter was involved in one accident.

Figure 1
Light utility helicopters involved in accidents, 1985-2003



The Hiller UH-12E helicopters have been involved in the fewest number of accidents of these four light utility models. They were involved in only four per cent of accidents with a peak of eight accidents in 1987. The Hiller UH-12E was not involved in any accidents in 2003.

Figure 2
All helicopters involved in accidents by helicopter model, 1985-2003



Over the same period, R22 helicopters were involved in a total of 21 fatal accidents compared with 20 for the Bell/Agusta/Kawasaki 47G, 12 for the Hughes/Schweizer 269 and two for the Hiller UH-12E. Figure 3 summarises each model's involvement in fatal accidents. The actual numbers are presented in Table 5 below.

Figure 3
Fatal helicopter accidents by helicopter model, 1985-2003

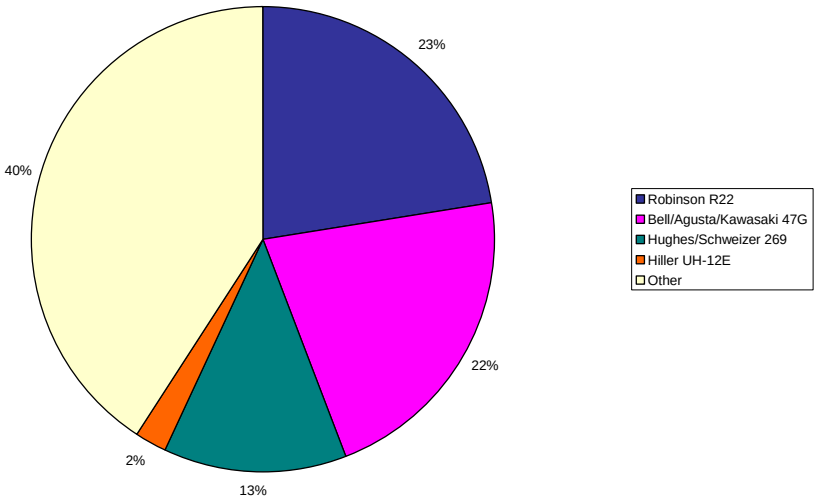


Table 4. Light utility helicopters involved in accidents, 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total	%
Robinson R22	9	4	3	13	17	24	20	20	17	16	13	12	16	13	16	23	16	9	13	274	35.3
Bell/Agusta/Kawasaki 47G	6	8	5	11	13	8	11	9	12	5	5	7	7	8	4	5	4	1	3	132	17.0
Hughes/Schweizer 269	7	11	8	8	9	11	7	10	5	4	6	6	9	4	4	6	2	4	1	122	15.7
Hiller UH-12E	3	1	8	2	6	2	2	2	1	0	1	0	1	2	0	0	1	1	0	33	4.2
Other helicopter	11	14	11	12	10	12	16	9	13	14	8	9	12	8	5	12	20	8	12	216	27.8
Total[2]	36	38	35	46	55	57	56	50	48	39	33	34	45	35	29	46	43	23	29	777	100.0

Table 5. Light utility helicopters involved in fatal accidents, 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Robinson R22	0	0	0	0	1	3	2	1	2	0	3	2	0	0	2	1	1	1	2	21
Bell/Agusta/Kawasaki 47G	2	1	0	3	1	0	1	3	1	0	0	1	1	2	2	0	1	0	1	20
Hughes/Schweizer 269	0	0	2	0	0	1	0	1	0	1	2	2	1	1	0	1	0	0	0	12
Hiller UH-12E	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Other helicopter	3	3	1	0	3	0	1	2	4	2	3	1	2	2	3	1	3	1	3	38
Total[3]	5	4	4	4	5	4	4	7	7	3	8[4]	6	4	5	7	3	5	2	6	93

[2] There were six light utility helicopters with turbine engines involved in accidents between 1985 and 2003. These were a Bell 47G in 1996 and 2003 and Hiller UH-12E in 1987, 1989, 1991 and 1992.
[3] There was one Bell 47 helicopter with a turbine engine involved in a fatal accident in 2003.
[4] There was one non-VH registered helicopter (Bell 205) involved in a fatal accident in this year.

Fatalities and Injuries

Tables 6 and 7 present data on the fatalities and serious injuries resulting from helicopter accidents. The greatest number of fatalities resulted from accidents involving Bell/Agusta/Kawasaki 47G models (29 fatalities over 19 years) followed by 26 fatalities resulting from R22 accidents. The highest number of serious injuries resulted from accidents involving the Robinson R22 model (39 serious injuries for the 19-year period). These proportions are graphically displayed in Figures 4 and 5.

Figure 4
Fatalities resulting from accidents involving helicopters, 1985-2003

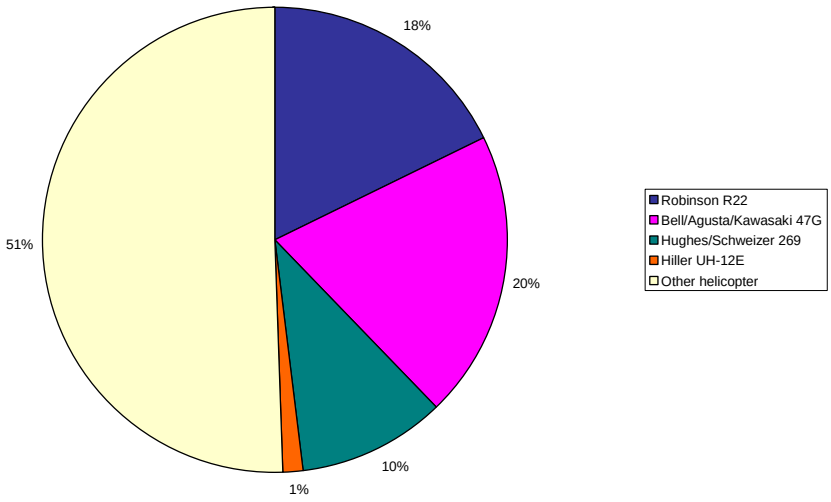


Figure 5
Serious injuries resulting from accidents involving helicopters, 1985-2003

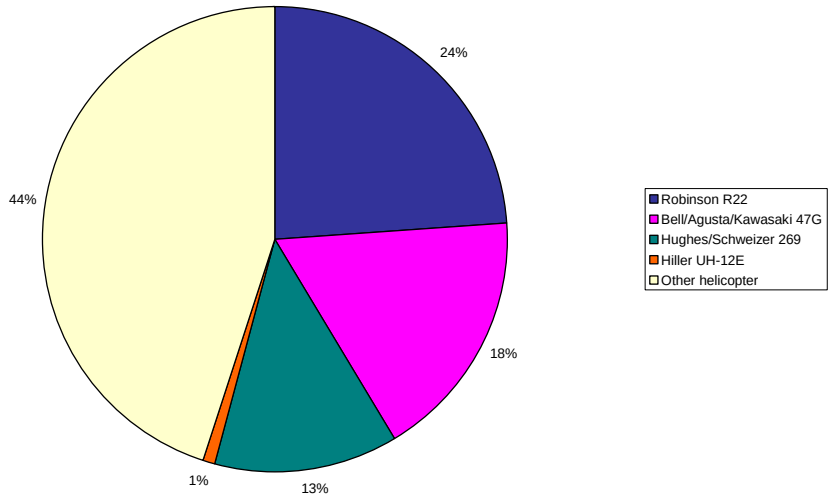


Table 6. Fatalities resulting from accidents involving helicopters, 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Robinson R22	0	0	0	0	1	4	2	1	3	0	4	3	0	0	2	1	0	1	4	26
Bell/Agusta/Kawasaki 47G	3	1	0	5	2	0	2	4	1	0	0	1	1	3	4	0	1	0	1	29
Hughes/Schweizer 269	0	0	3	0	0	1	0	1	0	1	2	2	2	1	0	2	0	0	0	15
Hiller UH-12E	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Other helicopter	4	4	1		6		7	4	9	3	4	2	2	2	3	5	5	4	9	74
Total	10	6	8	11	11	6	13	15	14	5	12	11	8	10	13	10	7	5	15	190

Table 7. Serious injuries resulting from accidents involving helicopters, 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Robinson R22	1	1	0	0	3	3	6	2	2	4	5	0	2	0	2	5	1	1	1	39
Bell/Agusta/Kawasaki 47G	3	6	0	1	3	2	1	1	2	1	1	4	0	2	0	2	0	0	0	29
Hughes/Schweizer 269	0	1	0	2	3	3	0	2	1	1	2	0	3	1	1	0	1	0	0	21
Hiller UH-12E	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Other helicopter	7	9	5	1	7	1	16	4	3	1	3	3	2	0	1	4	1	5	1	74
Total	14	24	6	7	22	14	24	12	11	9	14	11	10	6	5	13	4	6	2	214

Accident Rates

Number of registered helicopters and flying hours

Exposure data refers to the number of opportunities available for accidents to occur. Risk factors and exposure factors jointly determine the total number of accidents. If the risk remains constant while exposure increases, the number of accidents is likely to increase.

This report presents data on two exposure measures: the number of helicopters registered to be flown in Australia and the hours flown by these helicopters. Rates for these two measures were calculated to enable equivalent comparisons of accident involvement among helicopter models. An overview of the number of helicopters registered, and the flying hours of all helicopters registered in Australia, are presented in Tables 8 and 9. In 2002 helicopters manufactured by Robinson and Bell comprised over half the fleet. They also performed the vast majority of the flying in Australia in that year.

Table 8. Helicopters registered in Australia by manufacturer, 1985-2002

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	% of 2002
Aerospatiale	32	39	39	40	44	45	50	55	55	53	61	64	62	64	78	81	83	96	9.3
Agusta	5	7	7	9	12	14	13	12	13	13	15	14	17	17	21	21	21	20	1.9
Bell	178	194	206	209	253	227	217	216	235	202	214	211	207	214	232	246	248	261	25.2
Enstrom	7	5	5	5	7	6	5	5	6	7	10	8	8	10	10	10	9	10	1.0
Hiller	25	24	24	21	23	23	22	23	21	17	16	16	17	17	16	15	13	13	1.3
Hughes	58	65	67	71	89	88	90	86	88	76	72	65	71	59	63	63	62	60	5.8
Kawasaki	0	2	4	5	19	24	31	39	44	42	45	48	49	49	59	60	62	64	6.2
Robinson	40	51	70	87	158	188	215	223	236	238	248	253	275	295	337	357	379	411	39.6
Schweizer	0	0	0	0	0	0	0	2	3	4	3	7	8	8	10	11	11	13	1.3
Sikorsky	8	11	16	14	19	18	18	20	27	33	39	36	33	29	27	22	22	19	1.8
Westland	0	0	0	0	0	0	0	0	0	0	0	1	3	3	4	4	4	5	0.5
McDonnell Douglas	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	4	4	0.4
Other	0	0	0	0	0	1	1	4	8	11	13	13	14	22	39	48	58	61	5.9
Total	353	398	438	461	624	634	662	685	736	697	737	737	766	789	899	941	976	1037	100.0

Table 9. Australian annual flying hours by manufacturer, 1985-2002

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	% of 2002
Aerospatiale	15513	19410	18294	18783	22016	22145	22779	24013	22858	25641	24402	22999	23934	28091	28133	31975	30459	39875	12.8
Agusta	2871	3221	2470	3620	3935	4940	7017	3610	2699	3293	3397	3246	3199	3300	3474	4152	3453	3507	1.1
Bell	82376	77417	77636	91317	95659	77013	68253	66048	63785	74173	71102	69277	70854	68678	73049	74084	77410	82925	26.6
Enstrom	379	598	309	524	437	156	84	275	264	435	1256	1193	1396	569	564	931	1127	161	0.1
Hiller	10164	8474	7614	7396	5487	4310	3421	2455	1848	1451	2738	2721	3092	2057	1735	2176	2144	2706	0.9
Hughes	25187	27614	24115	29961	28403	31169	26995	21145	20013	20888	16595	16990	19131	13909	13506	12044	11061	11075	3.6
Kawasaki	0	366	740	709	2316	5468	7191	8786	9194	14864	13612	13743	13348	14779	14516	13054	16877	19393	6.2
Robinson	16520	21037	29308	34373	55803	70064	87128	74506	80978	87645	92470	82398	98773	100757	107308	116035	121680	136022	43.6
Schweizer	0	0	0	0	0	0	0	15	140	457	419	525	2291	2357	2748	2789	3057	3929	1.3
Sikorsky	4633	4056	5632	6918	8214	6986	7923	8688	11728	15583	14889	14107	13028	12078	11370	10471	8137	8622	2.8
Westland	0	0	0	0	0	0	0	0	0	0	0	112	257	331	273	285	328	692	0.2
McDonnell Douglas	0	0	0	0	0	0	0	0	0	437	256	296	521	389	141	352	580	781	0.3
Other	0	0	0	0	0	0	6	68	239	366	127	52	169	319	576	1207	2124	2046	0.7
Total	157643	162193	166118	193601	222270	222251	230797	209609	213746	245233	241263	227659	249993	247614	257393	269555	278437	311734	100.0

Figures 6 and 7 present information on the light utility helicopter fleet by combining the registration and flying hours data from 1990 to 2002. Figure 6 indicates that there are significantly more R22 helicopters registered than any other light utility model. The number of R22 helicopters registered grew from 188 in 1990 to 335 in 2002 a 78 per cent increase. Bell/Agusta/Kawasaki 47G helicopters increased in numbers by 18 per cent. The registered number of Hughes/Schweizer and Hiller model helicopters reduced over the period by 31 per cent and 47 per cent respectively.

Figure 6
Total helicopters registered by helicopter model, 1990-2002

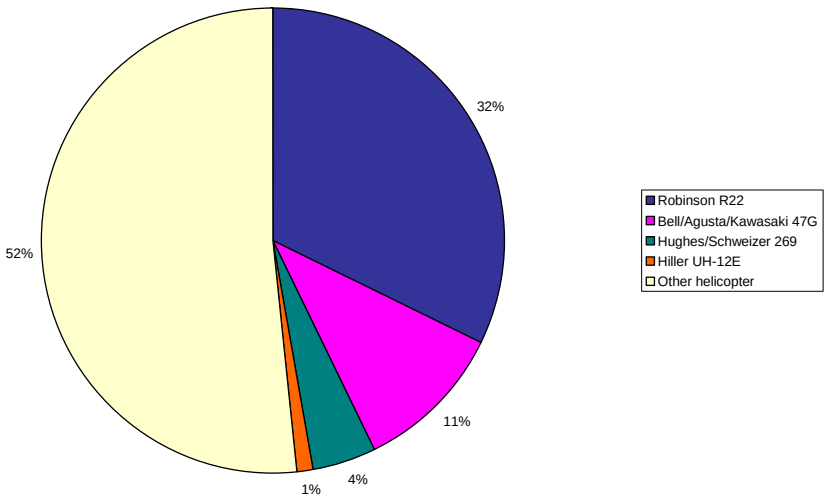
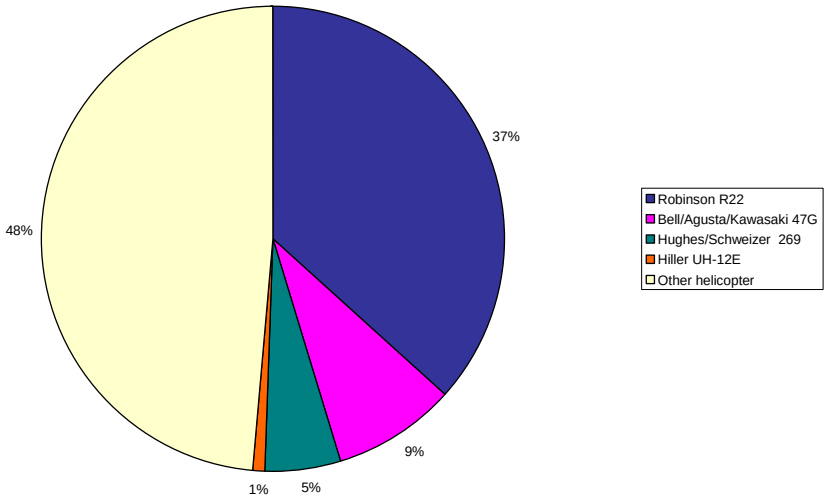


Figure 7
Total flying hours by helicopter model, 1990-2002



The Robinson R22 model also flew the most hours of any light utility helicopter in Australia (see Table 11). This model flew five times more hours than the Bell/Agusta/Kawasaki 47G model in 2002. The R22 has also experienced the

greatest growth in flying hours over the last decade, with a 68 per cent increase in flying hours between 1990 and 2002. Over the same period, flying hours for the 47G model grew by 16 per cent while the hours for both the 269 and UH-12E models dramatically decreased. These changes appear to be predominantly explained by the number of helicopters registered (see Table 10).

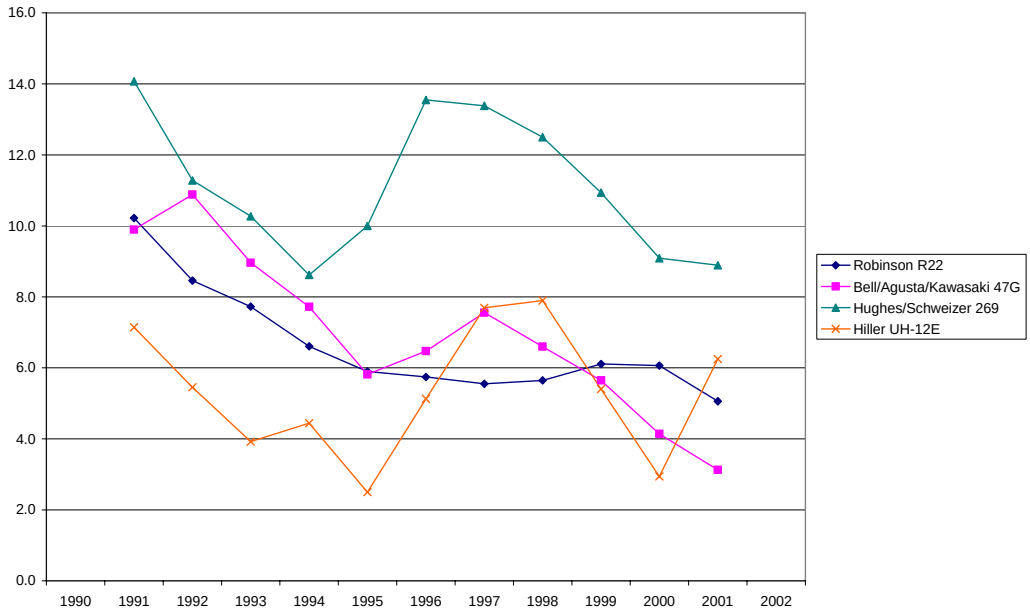
Accident rate per registered helicopter

The rate of accidents per 100 registered aircraft has decreased since 1990 for all light utility helicopters (see Table 10). Comparing the R22 with the Bell/Agusta/Kawasaki 47G model shows that the 47G rate dropped below the R22 rate in 1999 and has remained lower. The variability in the rates for Hughes/Schweizer and Hiller models reflects the small number of helicopters registered and the small number of accidents in which they are involved. The three-year central moving average (CMA) was calculated and graphed in Figure 8 to smooth out some of this variability.

Table 10. Light utility helicopter accident rates per 100 registered aircraft

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Robinson R22													
Number of accidents	24	20	20	17	16	13	12	16	13	16	23	16	9
Number registered	188	215	223	236	227	233	235	246	258	293	300	314	335
Rate per 100 registered	12.8	9.3	9.0	7.2	7.0	5.6	5.1	6.5	5.0	5.5	7.7	5.1	2.7
3-year CMA	-	10	8.5	7.7	6.6	5.9	5.7	5.5	5.6	6.1	6.1	5.1	-
Bell/Agusta/Kawasaki 47G													
Number of accidents	8	11	9	12	5	5	6	7	8	4	5	4	1
Number registered	93	92	98	104	88	93	94	91	93	104	104	106	110
Rate per 100 registered	8.6	12.0	9.2	11.5	5.7	5.4	6.4	7.7	8.6	3.8	4.8	3.8	0.9
3-year CMA	-	9.9	11	9	7.7	5.8	6.5	7.6	6.6	5.6	4.1	3.1	-
Hughes/Schweizer 269													
Number of accidents	11	7	10	5	4	6	6	9	4	4	6	2	4
Number registered	67	67	65	63	57	54	49	52	41	43	44	45	46
Rate per 100 registered	16.4	10.4	15.4	7.9	7.0	11.1	12.2	17.3	9.8	9.3	13.6	4.4	8.7
3-year CMA	-	14.1	11.3	10.3	8.6	10.0	13.5	13.4	12.5	10.9	9.1	8.9	-
Hiller UH-12E													
Number of accidents	2	1	1	1	0	1	0	1	2	0	0	1	1
Number registered	19	18	19	18	14	13	13	13	13	12	12	10	10
Rate per 100 registered	10.5	5.6	5.3	5.6	0.0	7.7	0.0	7.7	15.4	0.0	0.0	10.0	10.0
3-year CMA	-	7.1	5.5	3.9	4.4	2.5	5.1	7.7	7.9	5.4	2.9	6.3	-
Other helicopter													
Number of accidents	12	16	9	13	14	8	9	12	8	5	12	20	8
Numbered registered	267	270	280	315	311	344	346	364	384	448	481	501	536
Rate per 100 registered	4.5	5.9	3.2	4.1	4.5	2.3	2.6	3.3	2.1	1.1	2.5	4.0	1.5
3-year CMA	-	4.5	4.4	4.0	3.6	3.1	2.8	2.7	2.1	1.9	2.6	2.6	-

Figure 8
Light utility helicopter accident rates per 100 registered aircraft (3-year CMA)



Accident rate per flying hours

The overall trend in accidents per flying hours indicates improved flying safety for light utility helicopters since 1990 (see Table 11 and Figure 9). The accident rate per 10,000 flying hours dropped by 76.5 per cent and 88 per cent for R22 and Bell/Agusta/Kawasaki 47G models respectively. The Hiller UH-12E model is not included in Figure 9 due to the effect of the rate variability on interpreting trends for the other models. In 2000, there was an increase in the rate for the R22, 47G and 269 models. The number of accidents in this year increased for all three models. However, flying hours for the 47G and 269 decreased, but R22 flying hours increased.

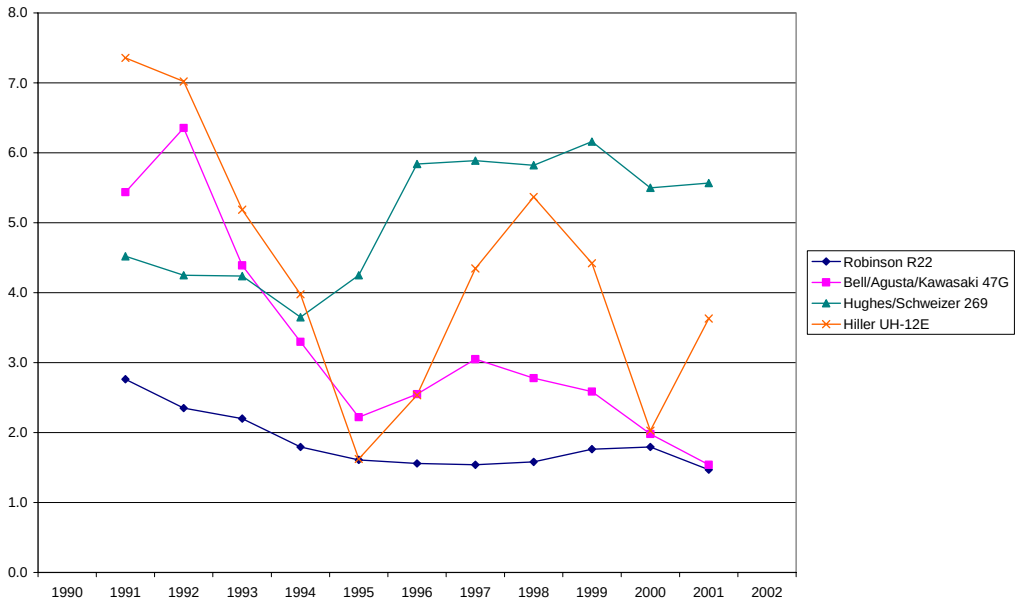
Figure 9
Light utility helicopter accident rates per 10,000 hours flown

Table 11. Light utility helicopter accident rates per 10,000 hours flown

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
Robinson R22														
Number of accidents	24	20	20	17	16	13	12	16	13	16	23	16	9	215
Flying hours	70064	87128	74506	80978	85357	89897	79382	93655	93256	97869	103934	104908	117954	1178888
Rate per 10,000 flying hours	3.4	2.3	2.7	2.1	1.9	1.4	1.5	1.7	1.4	1.6	2.2	1.5	0.8	-
3-year CMA	-	2.8	2.3	2.2	1.8	1.6	1.6	1.5	1.6	1.8	1.8	1.5	-	-
Bell/Agusta/Kawasaki 47G														
Number of accidents	8	11	9	12	5	5	6	7	8	4	5	4	1	85
Flying hours	18590	16665	16247	17457	25540	23709	22863	24025	21999	22385	21360	21965	21595	274400
Rate per 10,000 flying hours	4.3	6.6	5.5	6.9	2.0	2.1	2.6	2.9	3.6	1.8	2.3	1.8	0.5	-
3-year CMA	-	5.4	6.4	4.4	3.3	2.2	2.5	3.0	2.8	2.6	2.0	1.5	-	-
Hughes/Schweizer 269														
Number of accidents	11	7	10	5	4	6	6	9	4	4	6	2	4	78
Flying hours	24787	21591	15572	14629	14633	11840	11194	12928	8151	8117	6460	7248	7851	165001
Rate per 10,000 flying hours	4.4	3.2	6.4	3.4	2.7	5.1	5.4	7.0	4.9	4.9	9.3	2.8	5.1	-
3-year CMA	-	4.5	4.2	4.2	3.6	4.2	5.8	5.9	5.8	6.2	5.5	5.6	-	-
Hiller UH-12E														
Number of accidents	2	1	1	1	0	1	0	1	2	0	0	1	1	11
Flying hours	2533	1638	1266	1370	1221	2437	2511	2943	1448	1197	1878	1857	1776	24075
Rate per 10,000 flying hours	7.9	6.1	7.9	7.3	0.0	4.1	0.0	3.4	13.8	0.0	0.0	5.4	5.6	-
3-year CMA	-	7.4	7.0	5.2	4.0	1.6	2.5	4.3	5.4	4.4	2.0	3.6	-	-
Other helicopter														
Number of accidents	12	16	9	13	14	8	9	12	8	5	12	20	8	146
Flying hours	106277	103775	102018	99312	118482	113380	111709	116442	122760	127825	135923	142459	162558	1562920
Rate per 10,000 flying hours	1.1	1.5	0.9	1.3	1.2	0.7	0.8	1.0	0.7	0.4	0.9	1.4	0.5	-
3-year CMA	-	1.2	1.2	1.1	1.1	0.9	0.8	0.8	0.7	0.6	0.9	0.9	-	-
Total accidents	57	55	49	48	39	33	33	45	35	29	46	43	23	-

Figure 10 presents the accident rate per hours flown as a 3-year central moving average to enable visual comparison between all four helicopter models.

Figure 10
Light utility helicopter accident rates per 10,000 hours flown (3-year CMA)



In summary, Figures 9 and 10 demonstrate that the rate of accidents per hour flown has dropped since 1990 and that the R22 helicopter has consistently had lower rates than the 47G and 269 models up until 2002. In 2002, the 47G accident rate of 0.5 per 10,000 flying hours dropped below the R22 rate of 0.8. The models with the highest accident rates per hours flown have been the 269 and UH-12E.

Robinson introduced a R22 safety awareness course in 1993. The course was intended to provide extra training for pilots who were already qualified and revisionary training for pilots who needed to maintain their currency with safety procedures. Figures 9 and 10 show that the accident rate fell between 1993 and 1995 and then stabilised. The safety awareness course may have contributed to the initial reduction in the accident rates; however, further data would be needed to conclusively determine if the safety course positively influenced the accident rate for the R22 model.

Fatal accident rate per flying hours

The fatal accident rate per 100,000 hours flown is presented in Table 12 and Figure 11. They demonstrate that the fatal accident rate for light utility helicopters is low and erratic. The variability is due to the small number of fatal accidents each year. In fact, the Hiller UH-12E model was not involved in any fatal accidents between 1990 and 2002.

Figure 11
Light utility helicopter fatal accident rate per 100,000 hours flown (3-year CMA)

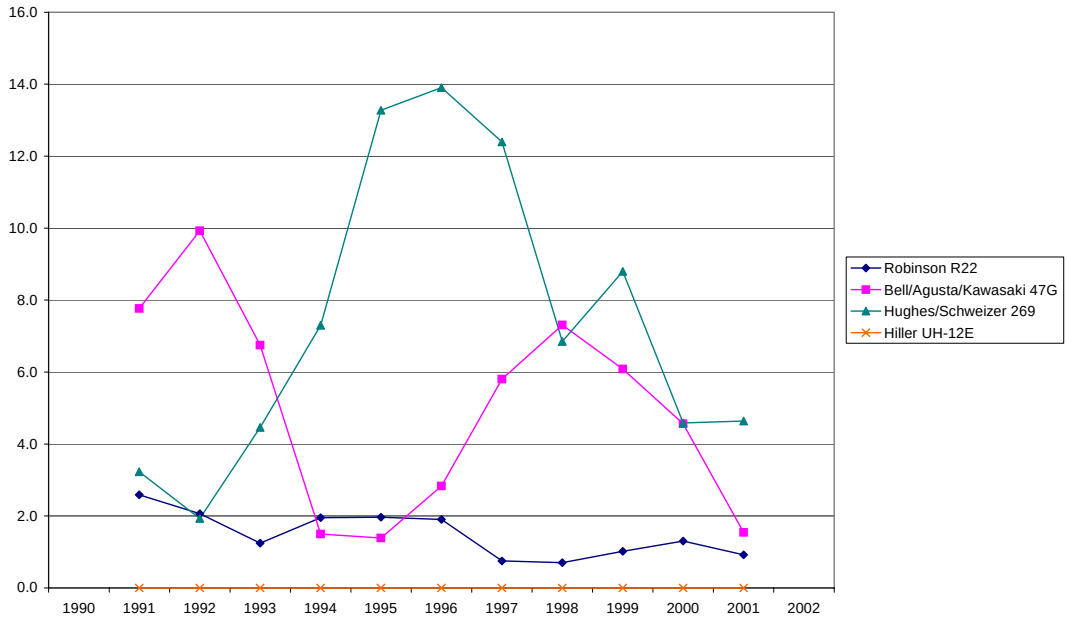


Figure 11 indicates that the Hiller UH-12E model has the lowest rate of fatal accidents per hour flown followed by the Robinson R22 and Bell/Agusta/Kawasaki 47G. The highest rate of fatal accidents per hour flown was observed for the Hughes/Schweizer 269 helicopter.

Table 12. Light utility helicopter fatal accident rates per 100,000 hours flown

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
Robinson R22														
Number of fatal accidents	3	2	1	2	0	3	2	0	0	2	1	1	1	18
Flying hours	70064	87128	74506	80978	85357	89897	79382	93655	93256	97869	103934	104908	117954	1178888
Rate per 100,000 flying hours	4.3	2.3	1.3	2.5	0.0	3.3	2.5	0.0	0.0	2.0	1.0	1.0	0.8	-
3-year CMA	-	2.6	2.1	1.2	2.0	2.0	1.9	0.8	0.7	1.0	1.3	0.9	-	-
Bell/Agusta/Kawasaki 47														
Number of fatal accidents	0	1	3	1	0	0	1	1	2	2	0	1	0	12
Flying hours	18590	16665	16247	17457	25540	23709	22863	24025	21999	22385	21360	21965	21595	274400
Rate per 100,000 flying hours	0.0	6.0	18.5	5.7	0.0	0.0	4.4	4.2	9.1	8.9	0.0	4.6	0.0	-
3-year CMA	-	7.8	9.9	6.8	1.5	1.4	2.8	5.8	7.3	6.1	4.6	1.5	-	-
Hughes/Schweizer 269														
Number of fatal accidents	1	0	1	0	1	2	2	1	1	0	1	0	0	10
Flying hours	24787	21591	15572	14629	14633	11840	11194	12928	8151	8117	6460	7248	7851	165001
Rate per 100,000 flying hours	4.0	0.0	6.4	0.0	6.8	16.9	17.9	7.7	12.3	0.0	15.5	0.0	0.0	-
3-year CMA	-	3.2	1.9	4.5	7.3	13.3	13.9	12.4	6.9	8.8	4.6	4.6	-	-
Hiller UH-12E														
Number of fatal accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flying hours	2533	1638	1266	1370	1221	2437	2511	2943	1448	1197	1878	1857	1776	24075
Rate per 100,000 flying hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
3-year CMA	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Other helicopter														
Number of fatal accidents	0	1	2	4	2	3	1	2	2	3	1	3	1	25
Flying hours	106277	103775	102018	99312	118482	113380	111709	116442	122760	127825	135923	142459	162558	1562920
Rate per 100,000 flying hours	0.0	1.0	2.0	4.0	1.7	2.6	0.9	1.7	1.6	2.3	0.7	2.1	0.6	-
3-year CMA	-	1.0	2.3	2.5	2.7	1.7	1.8	1.4	1.9	1.6	1.7	1.1	-	-
Total fatal accidents	4	4	7	7	3	8	6	4	5	7	3	5	2	65

Table 13. Summary of light utility helicopter accident rates, 1990-2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	1990-2002
Accident rate per 100 registered helicopters														
Robinson R22	12.8	9.3	9.0	7.2	7.0	5.6	5.1	6.5	5.0	5.5	7.7	5.1	2.7	6.5
Bell/Agusta/Kawasaki 47G	8.6	12.0	9.2	11.5	5.7	5.4	6.4	7.7	8.6	3.8	4.8	3.8	0.9	6.7
Hughes/Schweizer 269	16.4	10.4	15.4	7.9	7.0	11.1	12.2	17.3	9.8	9.3	13.6	4.4	8.7	11.3
Hiller UH-12E	10.5	5.6	5.3	5.6	0.0	7.7	0.0	7.7	15.4	0.0	0.0	10.0	10.0	6.0
All other helicopters	4.5	5.9	3.2	4.1	4.5	2.3	2.6	3.3	2.1	1.1	2.5	4.0	1.5	3.0
Accident rate per 10,000 flying hours														
Robinson R22	3.4	2.3	2.7	2.1	1.9	1.4	1.5	1.7	1.4	1.6	2.2	1.5	0.8	1.8
Bell/Agusta/Kawasaki 47G	4.3	6.6	5.5	6.9	2.0	2.1	2.6	2.9	3.6	1.8	2.3	1.8	0.5	3.1
Hughes/Schweizer 269	4.4	3.2	6.4	3.4	2.7	5.1	5.4	7.0	4.9	4.9	9.3	2.8	5.1	4.7
Hiller UH-12E	7.9	6.1	7.9	7.3	0.0	4.1	0.0	3.4	13.8	0.0	0.0	5.4	5.6	4.6
All other helicopters	1.1	1.5	0.9	1.3	1.2	0.7	0.8	1.0	0.7	0.4	0.9	1.4	0.5	0.9
Fatal accident rate per 100,000 flying hours														
Robinson R22	4.3	2.3	1.3	2.5	0.0	3.3	2.5	0.0	0.0	2.0	1.0	1.0	0.8	1.5
Bell/Agusta/Kawasaki 47G	0.0	6.0	18.5	5.7	0.0	0.0	4.4	4.2	9.1	8.9	0.0	4.6	0.0	4.4
Hughes/Schweizer 269	4.0	0.0	6.4	0.0	6.8	16.9	17.9	7.7	12.3	0.0	15.5	0.0	0.0	6.1
Hiller UH-12E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All other helicopters	0.0	1.0	2.0	4.0	1.7	2.6	0.9	1.7	1.6	2.3	0.7	2.1	0.6	1.6

Table 13 summarises the light utility helicopter accident rates for the 1990-2002 period. The Hiller UH-12E had the lowest accident rate per registered helicopter of six accidents per 100 registered helicopters for 1990-2002. The Hughes/Schweizer 269 model had the highest accident rate per registered helicopter for the combined period of 11.3 accidents per registered helicopter. The 269 model also had the highest accident rate and fatal accident rate per flying hours for the combined period. The fatal accident rate each year, however, indicates that in five of the 13 years the 269 model was not involved in any fatal accidents. The Robinson R22 model had the lowest accident rate per hours flown of 1.8 accidents per 10,000 flying hours and the second lowest fatal accident rate (1.5 fatal accidents per 100,000 flying hours) for the 1990-2002 period. With no fatal accidents between 1990 and 2002 the Hiller UH-12E model had the lowest fatal accident rate.

Type of flying

The type of operation in which the helicopter was engaged at the time of the accident was analysed. The results are summarised in Tables 14 and 15 and in Figure 12. A brief definition of the activities covered by each type of flying operation is listed below.

Definition of flying operations

- *Aerial agricultural*: Flying involving the carriage and/or spreading of chemicals, seeds, fertilisers and other substances for agricultural purposes, including the purposes of pest and disease control.
- *Business*: Flying associated with a business or profession, but not for hire or reward.
- *Charter*: Flying involving the carriage of passengers or cargo by the aircraft operator or his/her employees for hire or reward (but excluding scheduled regional airline operations).
- *Mustering*: Aerial stock mustering involving the use of aircraft for the movement of livestock.
- *Other aerial work*: Includes aerial spotting, advertising, cloud seeding, fire fighting, coastal surveillance, etc.
- *Private*: Flying for private pleasure, sport or recreation, or personal transport not associated with a business or profession.
- *Survey and photography*: All aerial survey and photographic work.
- *Test and ferry*: Flying associated with the testing of an aircraft or associated with its delivery or movement to a location for maintenance, hire or planned use.
- *Flying training*: Flying involving training for the issue or renewal of a licence or rating, aircraft type endorsement or conversion training. Includes solo navigation exercises conducted as part of a course of applied flying training.

Type of flying operation and accidents

The majority of accidents for the R22, 47G, and 269 model helicopters occurred while performing other aerial work with percentages ranging from 43.9 per cent to 51 per cent (see Table 14). The Robinson R22 accidents predominantly occurred while aerial mustering, followed by accidents that occurred during flying training and private flying. Accidents involving the Bell/Agusta/Kawasaki 47G model

occurred across a broader range of flying activities including mustering (21.2 per cent) charter (18.9 per cent), private (18.1 per cent) and aerial agriculture (12.9 per cent). Hughes/Schweizer 269 accidents most frequently occurred during other aerial work and private flying. The Hiller UH-12E model also has a different accident profile, with half of the accidents occurring while performing agricultural tasks.

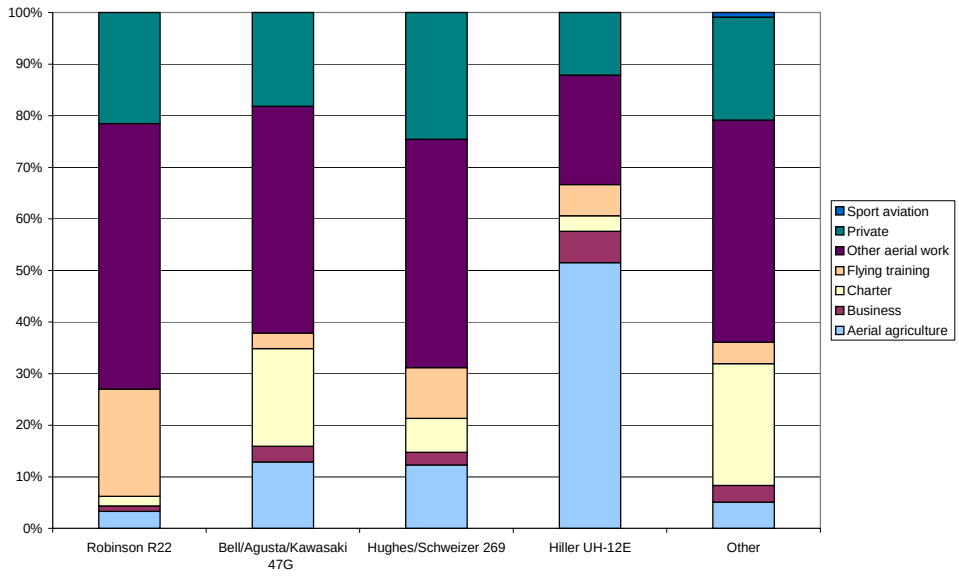
Table 14. Helicopters involved in accidents by operation type, 1985-2003

	Aerial agriculture	Business	Charter	Flying Training	Private	Sport Aviation	Other Aerial work	Total
Number of Robinson R22 accidents	9	3	5	57	59	0	141	274
Per cent of accidents	3.3	1.1	1.8	20.8	21.5	0.0	51.5	
Number of Bell/Agusta/Kawasaki 47G accidents	17	4	25	4	24	0	58	132
Per cent of accidents	12.9	3.0	18.9	3.0	18.2	0.0	43.9	
Number of Hughes/Schweizer 269 accidents	15	3	8	12	30	0	54	122
Per cent of accidents	12.3	2.5	6.6	9.8	24.6	0.0	44.3	
Number of Hiller UH-12E accidents	17	2	1	2	4	0	7	33
Per cent of accidents	51.5	6.1	3.0	6.1	12.1	0.0	21.2	
Number of other helicopter accidents	11	7	51	9	43	2	93	216
Per cent of accidents	5.1	3.2	23.6	4.2	19.9	0.9	43.1	
Total	69	19	90	84	160	2	353	777
Per cent of total	8.9	2.4	11.6	10.8	20.6	0.3	45.4	

Table 15. Helicopters involved in accidents by operation type other aerial work, 1985-2003

	Survey	Pipe & powerline patrol	Mustering	Search & rescue	Ambulance	Test & Ferry	Other	Total
Number of Robinson R22 accidents	5	2	102	1	0	15	16	141
Per cent of accidents	3.5	1.4	72.3	0.7	0.0	10.6	11.3	
Number of Bell/Agusta/Kawasaki 47G accidents	9	2	28	1	0	7	11	58
Per cent of accidents	15.5	3.4	48.3	1.7	0.0	12.1	19.0	
Number of Hughes/Schweizer 269 accidents	6	1	35	0	0	4	8	54
Per cent of accidents	11.1	1.9	64.8	0.0	0.0	7.4	14.8	
Number of Hiller UH-12E accidents	1	0	1	0	0	1	4	7
Per cent of accidents	14.3	0.0	14.3	0.0	0.0	14.3	57.1	
Number of other helicopter accidents	16	5	1	6	9	3	53	93
Per cent of accidents	17.2	5.4	1.1	6.5	9.7	3.2	57.0	
Total	37	10	167	8	9	30	92	353

Figure 12.
Percentage of light utility helicopter accidents by operation type, 1985-2003



Flying hours by operation type

Tables 16 and 17 and Figure 13 provide details of all helicopter flying hours for comparison with accidents. The R22 model mostly performs other aerial work (63.6 per cent), predominantly aerial mustering. After other aerial work, most of the R22 flying time is spent in flying training. Bell/Agusta/Kawasaki 47G helicopters perform other aerial work 50 per cent of the time. They fly a lot more charter (27 per cent) than the R22. Hughes/Schweizer 269 has a similar flying profile to the R22, except it conducts more aerial agriculture tasks (8.1 per cent). The Hiller UH-12E is predominantly used in aerial agriculture (60 per cent) and other aerial work (26.8 per cent) including both mustering and survey work.

Table 16. Flying hours of light utility helicopters by operation type 1990-2002

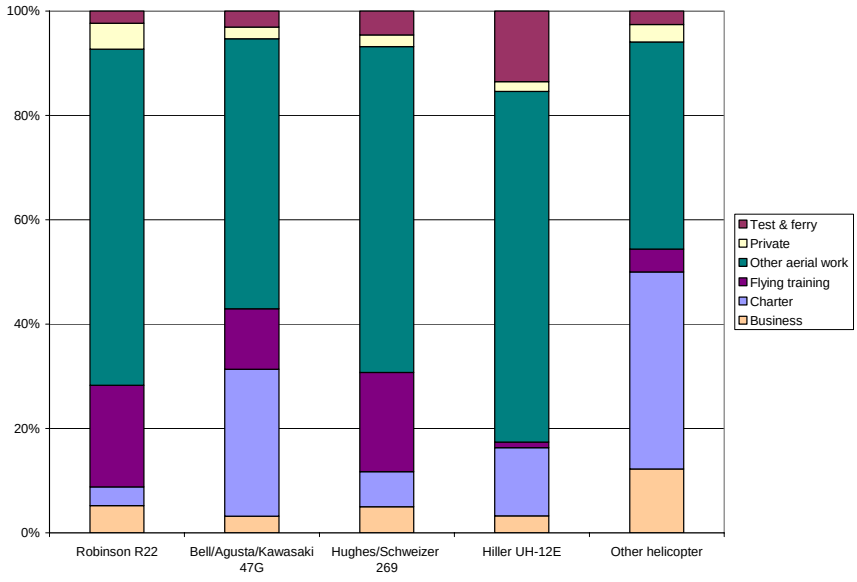
	Private	Business	Flying training	Aerial agriculture	Test & ferry	Charter	Aerial work	Total
Robinson R22 flying hours	57689	60921	227096	14416	27217	41532	750017	1178888
Per cent of flying hours	4.9	5.2	19.3	1.2	2.3	3.5	63.6	
Bell/Agusta/Kawasaki 47G flying hours	5885	8398	30542	10977	8078	74184	136336	274400
Per cent of flying hours	2.1	3.1	11.1	4.0	2.9	27.0	49.7	
Hughes/Schweizer 269 flying hours	3427	7606	28768	13381	6902	10191	94726	165001
Per cent of flying hours	2.1	4.6	17.4	8.1	4.2	6.2	57.4	
Hiller UH-12E flying hours	177	312	101	14470	1300	1257	6458	24075
Per cent of flying hours	0.7	1.3	0.4	60.1	5.4	5.2	26.8	
Other helicopter flying hours	50523	186268	66999	40408	39425	574195	603753	1561571[5]
Per cent of flying hours	3.2	11.9	4.3	2.6	2.5	36.8	38.7	
Total flying hours	117701	263505	353506	93652	82922	701359	1591290	3203935
Per cent of flying hours	3.7	8.2	11.0	2.9	2.6	21.9	49.7	

[5] This total does not include hours flown as a Regional Airline. Therefore, the total differs from Table 11. There were 1349 hours flown by other helicopters as a Regional Airline between 1990 and 2002.

Table 17. Other aerial work flying hours for light utility helicopters, 1990-2002

	Survey	Pipe & powerline patrol	Mustering	Search & rescue	Ambulance	Towing	Other aerial work	Total
Robinson R22 flying hours	30536	14554	667951	964	160	51	35801	750017
Per cent of other aerial work flying hours	4.1	1.9	89.1	0.1	0.0	0.0	4.8	
Bell/Agusta/Kawasaki 47G flying hours	22976	5377	76625	1476	45	77	29760	136336
Per cent of other aerial work flying hours	16.9	3.9	56.2	1.1	0.0	0.1	21.8	
Hughes/Schweizer 269 flying hours	4426	1509	78321	94	0	2	10374	94726
Per cent of other aerial work flying hours	4.7	1.6	82.7	0.1	0.0	0.0	11.0	
Hiller UH-12E flying hours	1613	1	3025	0	0	0	1819	6458
Per cent of other aerial work flying hours	25.0	0.0	46.8	0.0	0.0	0.0	28.2	
Other helicopter flying hours	137764	70944	37000	45347	78852	743	233103	603753
Per cent of other aerial work flying hours	22.8	11.8	6.1	7.5	13.1	0.1	38.6	
Total other aerial flying hours	197315	92385	862922	47881	79057	873	310857	1591290

Figure 13.
Percentage of light utility helicopter flying hours by operation type, 1990-2002



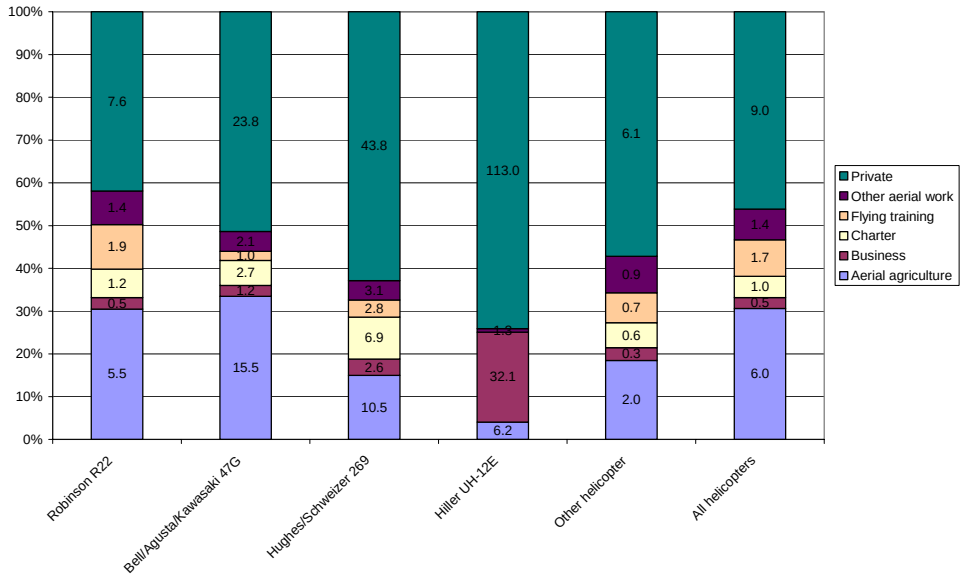
Accident rate per flying hours by flying type

To compare the relative safety of different types of flying operations, the rate of accidents per 10,000 flying hours by type of flying operation was calculated for all helicopters together and for each of the light utility helicopters. This information is presented in Figure 14. The numbers inside the columns are the actual rate for each type of flying operation. To calculate these rates by type of flying operation,

the AVSTATS classifications were manipulated to bring them in line with the ATSB accident classifications. In this instance, the ATSB does not have a test and ferry classification for accidents. After reviewing the data, it was assumed that the majority of these accidents were coded under other aerial work. As a result, the test and ferry flying hours were added to the other aerial work flying hours and used to calculate the accident rate per hours flown in other aerial work activities.

Figure 14 indicates that business flying is the safest type of flying for all helicopters, while private flying is the least safe, followed by aerial agriculture. Business, other aerial work and flying training have the lowest number of accidents per flying hours for all helicopters.

Figure 14
Helicopter accident rate per 10,000 flying hours by operation type



The majority of R22, 47G and 269 accidents occurred while performing other aerial work. The corresponding rates (1.4, 2.1 and 3.1 accidents per 10,000 hours flown) demonstrate that, given the hours flown in these activities, they are not as dangerous per hour flown as private (7.6, 23.8 and 43.8 respectively) or aerial agriculture (5.5, 15.5 and 10.5 respectively). Most of the accidents involving UH-12E helicopters occurred while flying aerial agriculture, yet again the rate per hour flown is not as high as private flying (113 per 10,000 hours flown) in the same model.

Of the helicopters performing flying training, charter and other aerial work, the 269 model has the highest accident rate and the R22 the lowest. The 47G has the highest rate of the light utility helicopters when flying aerial agriculture operations. The UH-12E has the highest accident rate for business and private operations.

Accident outcomes

Data on accident outcomes and failed aviation system defences were examined to determine if there was any difference in the type of outcomes experienced by the different reciprocating engine models. Data analysed included accidents from September 1996 to end December 2003. At the end of 1996, the ATSB commenced using a new system of classifying occurrences. This system is sufficiently different from the previous system that comparisons between pre- and post- 1996 are difficult to interpret.

All the accidents were coded for the primary outcome(s) using the Systemic Incident Analysis Model. This model classifies all the events in the accident sequence using a predetermined set of categories (see Appendix A for a summary of the categories). For the purposes of this study, if any outcome was considered inevitable given the preceding events in the accident sequence, then this outcome was not included. For example, if the helicopter hit powerlines and was not capable of controlled flight, the subsequent collision with the ground was not included. However, it is acknowledged that accidents can have multiple contributing factors. For example, a helicopter may experience engine problems and also experience airframe problems with the landing gear when attempting a difficult landing (see example below).

Occurrence Number 199801376
During a property inspection prior to commencing spraying, the engine failed. The helicopter was about 700 feet above ground level at the time. During the subsequent landing, the helicopter rolled onto its side after a cross tube on one side failed. The failed area had been weakened by corrosion. The engine crankcase was fractured, consistent with a connecting rod failure. Logbook records indicated that the engine had been over-sped some 200 operating hours earlier.

Outcome type

The majority of accidents involving Robinson R22 or Bell/Agusta/Kawasaki 47G helicopters resulted in a collision with terrain or obstacles as opposed to losing flying capability. The exact ratio was 86 per cent collisions to 14 per cent loss of flying capability for the R22 and 73 per cent to 27 per cent for the 47G model (see Figure 15). Hughes/Schweizer 269 accidents resulted in half collisions and half loss of flying capability, while the Hiller UH-12E had four out of six accidents resulting from a loss of flying capability.

Figure 15
Percentage of collision versus loss of control outcomes for light utility helicopter accidents

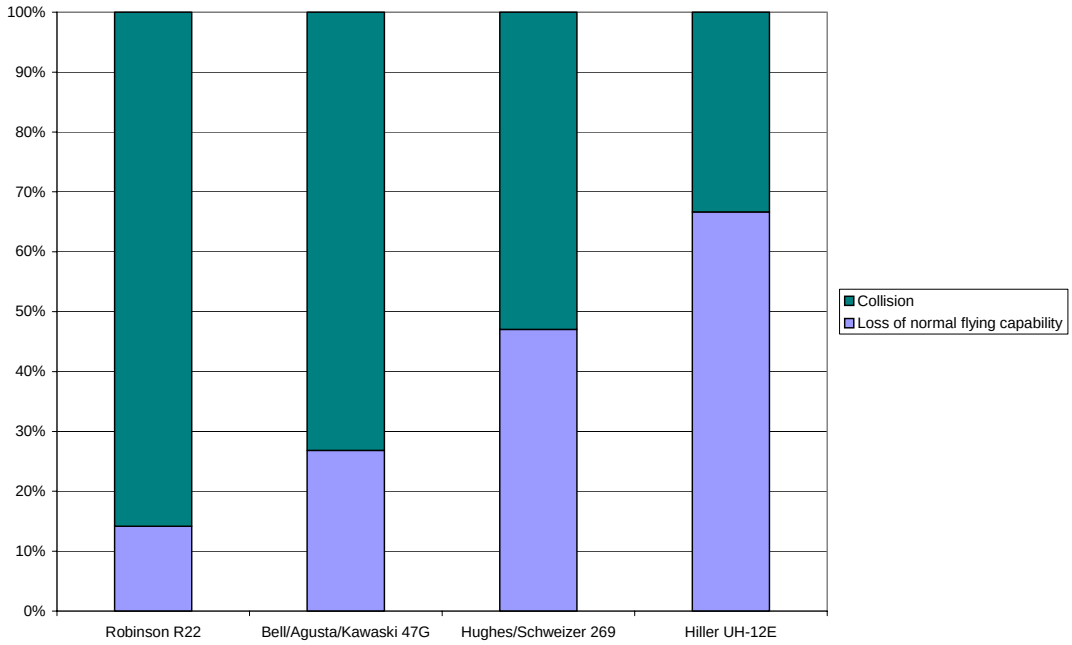


Table 18 and Figure 16 provide more information on the collision and loss of flying capability accidents.

Figure 16
Outcomes of light utility helicopter accidents, 1996-2003

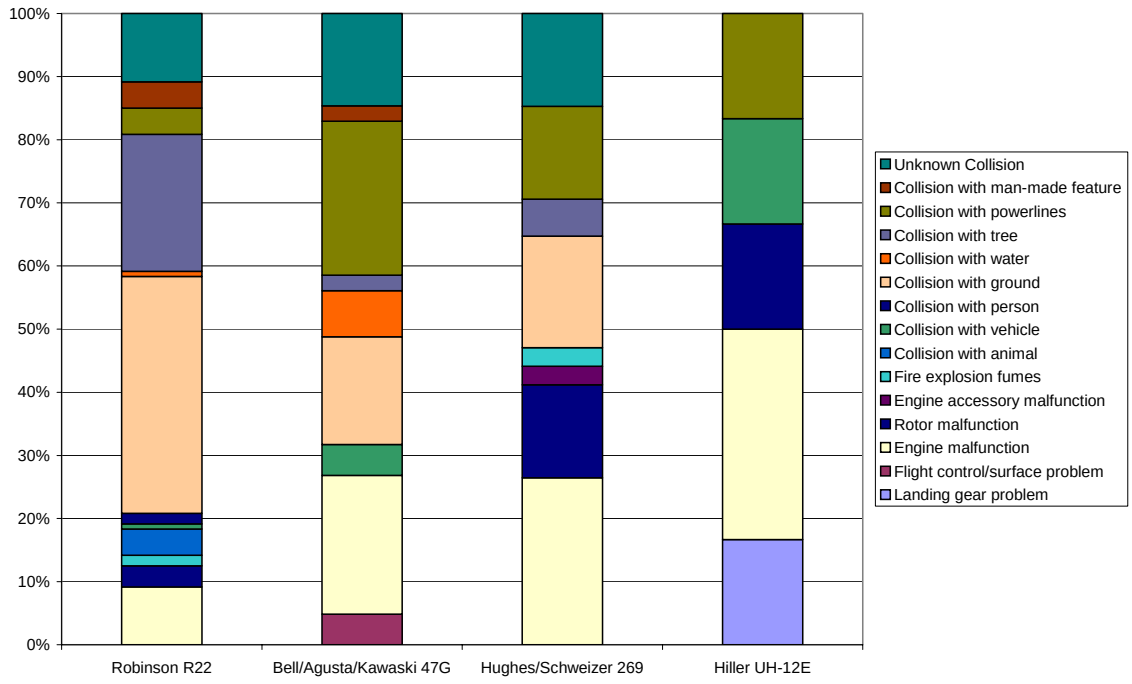


Table 18. Accident outcomes involving light utility helicopters in Australia, 1996-2003

SIAM Codings		Robinson R22 (%)	Bell/ Agusta/ Kawasaki 47G (%)	Hughes/ Schweizer 269 (%)	Hiller UH-12E (%)
Loss of normal flying capability					
Airframe	Landing gear problem	0	0	0	1 (16.7)
	Flight control/surface problem	0	2 (4.9)	0	0
Powerplant	Engine malfunction	11 (9.2)	9 (22)	9 (26.5)	2 (33.3)
	Rotor malfunction	4 (3.3)	0	5 (14.7)	1 (16.7)
	Engine accessory malfunction	0	0	1 (2.9)	0
Fire explosion fumes		2 (1.7)	0	1 (2.9)	0
Total loss of normal flying capability		**17 (14.2)**	**11 (26.8)**	**16 (47.1)**	**4 (66.7)**
Collision (controlled aircraft)					
Object & moveable features	Collision with animal	5 (4.2)	0	0	0
	Collision with vehicle	1 (0.8)	2 (4.9)	0	1 (16.7)
	Collision with person	2 (1.7)	0	0	0
Terrain & fixed features	Collision with ground	45 (37.5)	7 (17.1)	6 (17.6)	0
	Collision with water	1 (0.8)	3 (7.3)	0	0
	Collision with tree	26 (21.7)	1 (2.4)	2 (5.9)	0
	Collision with powerlines	5 (4.2)	10 (24.4)	5 (14.7)	1 (16.7)
	Collision with man-made feature	5 (4.2)	1 (2.4)	0	0
	Unknown	13 (10.8)	6 (14.6)	5 (14.7)	0
Total collision		**103 (85.8)**	**30 (73.2)**	**18 (52.9)**	**2 (33.3)**
Total outcomes		**120**	**41**	**34**	**6**

The accidents involving loss of flying capability were primarily due to engine failure. The 47G and 269 models experienced a greater proportion of engine failures than the R22 model. While the ratio of rotor malfunction to engine malfunction was approximately one to two for most of the light utility models, rotor malfunction did not appear to play a large role in accident outcomes.

The R22 model collided with the ground most frequently, followed by accidents involving a collision with a tree. The 47G model collided with powerlines most frequently. The next most common collision was with the ground. The accident outcomes for the 269 model were similar to the 47G. The Hiller UH-12E model struck a powerline and a vehicle during the 13-year period.

In summary, the light utility helicopters are primarily involved in collisions with the ground, trees or powerlines with a smaller percentage of accidents resulting from engine malfunction. The type of object collided with appears to be related to the type of flying performed by the light utility helicopter model.

Occurrence Number 200004592
During mustering operations, the pilot was experiencing difficulty in turning a herd of cattle. The pilot stated that he tracked directly towards a group of cattle and pitched the helicopter into a nose up attitude. As the helicopter pitched nose up, the tail rotor struck the ground. The helicopter lifted into a level attitude and rotated clockwise for three to four revolutions before impacting the ground and rolling on to its right side.

Occurrence Number 199905026
The pilot reported that about 10 minutes after take-off and when he had climbed to about 500 feet, the engine oil temperature indication rose. He suspected an electrical problem associated with the indicator, but also had doubts as to whether he had properly secured the engine oil filler cap during the pre-flight inspection. Consequently, he decided to land to check. He reported that, during the approach, he saw the main power line and thought he was positioned such that he was clear of all power lines. The pilot reported that he did a reconnaissance of the proposed landing site by conducting a descending right turn from 500 feet. During the final approach, the helicopter struck a power line. The helicopter fell to the ground and was destroyed by the impact. The pilot reported that he never saw the wire and the last thing he recalled was feeling as though the helicopter had been 'grabbed.'

Contributing factors

The features of the aviation system that contributed to helicopter accidents were examined. The results for each of the models of interest are presented in Table 19 and Figure 17. In the majority of accidents 'aircraft handling' or 'maintenance/repair/design/construction' were factors. 'Aircraft handling' refers to incidents when the pilot (intentionally or unintentionally) flew the aircraft outside the specified operating parameters. Examples demonstrating how 'aircraft handling' and 'maintenance/repair/design/construction' factors contributed to occurrences are presented below.

Occurrence Number 199700664
The pilot reported that he was engaged in moving cattle on a flooded property. While hovering at about 30-40 feet behind some cattle, the pilot's attention was diverted momentarily, allowing the engine and main rotor RPM to decay. He was unable to regain rotor RPM and elected to attempt a landing onto a nearby dry patch of ground. In turning the helicopter towards the dry ground, the pilot inadvertently turned down wind, overpitching the main rotor blades. During the ensuing deep flare to land, the tail rotor contacted the water and the main rotor blades severed the tailboom. The helicopter then settled into the water and rolled over. Both the pilot and passenger were able to exit the helicopter safely.

Occurrence Number 200102239
While cruising at about 1,000 feet above ground level, approximately one hour after departure, the engine suddenly began to run roughly and then lost all power. During the subsequent forced landing, the helicopter impacted the rocky terrain heavily, resulting in substantial damage to all sections of the helicopter.

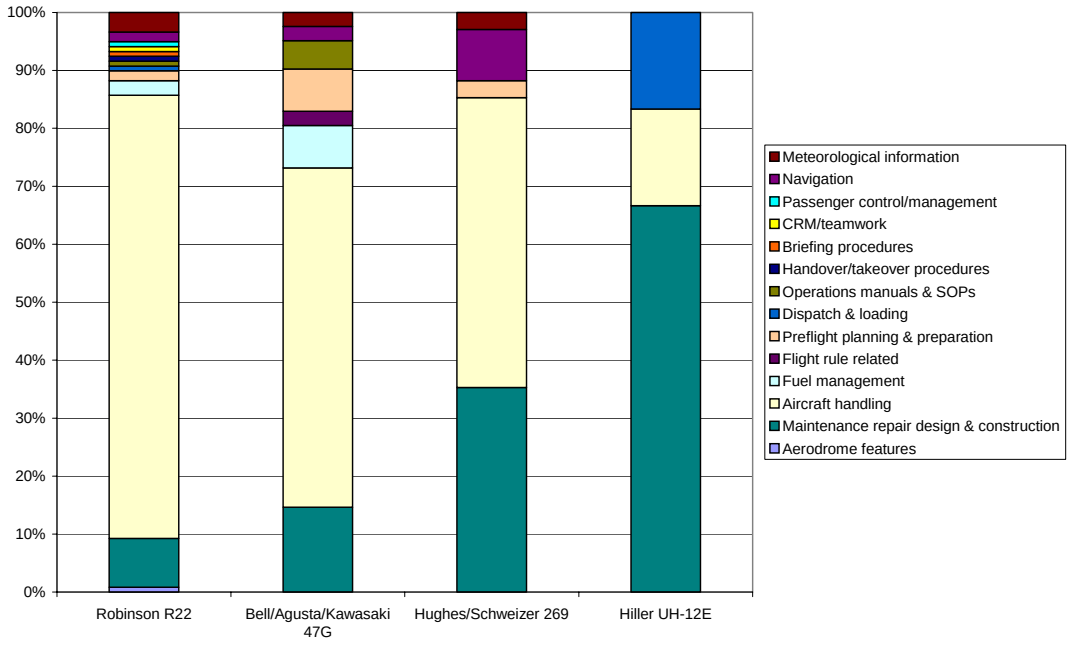
Technical disassembly of the engine revealed that one of the exhaust valve heads had separated from its stem section and was embedded in the ceiling of the cylinder head. The engine had undergone significant repair work prior to the accident. During the maintenance action, the intake valve rocker arm had mistakenly been fitted to the exhaust valve position, and the exhaust valve rocker arm was fitted to the inlet valve position.

Table 19. Contributing factors to light utility helicopters accidents in Australia, 1996-2003

SIAM Coding		Robinson R22 (%)	Bell/ Agusta/ Kawasaki 47G (%)	Hughes/ Schweizer 269 (%)	Hiller UH-12E (%)
Aerodrome features	Runway layout, conditions	1 (0.84)	0	0	0
Maintenance repair design & construction		10 (8.4)	6 (14.6)	12 (35.3)	4 (66.7)
Flight management	Aircraft handling	91 (76.5)	24 (58.5)	17 (50)	1 (16.7)
	Fuel management	3 (2.52)	3 (7.32)	0	0
	Flight rule related	0	1 (2.44)	0	0
	Preflight planning & preparation	2 (1.68)	3 (7.32)	1 (2.94)	0
General procedures & standards	Dispatch & loading	1 (0.84)	0	0	1 (16.7)
	Operations manuals & SOPs	1 (0.84)	2 (4.88)	0	0
	Handover/takeover procedures	1 (0.84)	0	0	0
	Briefing procedures	1 (0.84)	0	0	0
	CRM/teamwork	1 (0.84)	0	0	0
	Passenger control/management	1 (0.84)	0	0	0
Navigation	Area familiarisation	2 (1.68)	1 (2.44)	3 (8.82)	0
Meteorological information		4 (3.36)	1 (2.44)	1 (2.94)	0
Total		**119**	**41**	**34**	**6**

The greatest proportion of aircraft handling accidents were by Robinson R22 helicopter pilots, followed by Bell/Agusta/Kawasaki 47G pilots. Bell/Agusta/Kawasaki 47G helicopters were involved in the greatest number of wirestrike accidents. Wirestrike accidents can result from not checking wire locations prior to commencing flying operations (pre-flight planning and preparation) or flying into wires after checking their location at some point in time (navigation). Both of these factors contributed to Bell/Agusta/Kawasaki 47G accidents. The variations in the proportion of accidents could be an indication of the differing nature of operations commonly undertaken by the different aircraft types.

Figure 17
Contributing factors to light utility helicopters accidents, 1996-2003



Maintenance/repair/design/construction contributed to 66.1 per cent of UH-12E accidents, 35.3 per cent of 269 accidents, 14.6 per cent of 47G accidents and 8.4 per cent of R22 accidents. It is not clear if the greater proportion of accidents experienced by Hiller and Hughes/Schweizer models is due to a combination of an ageing fleet and declining fleet size. Fuel management problems also contributed to a small proportion of R22 and 47G accidents.

CONCLUSION

Helicopters are playing an increasing role in the Australian civil aviation fleet. Over the past 20 years, their numbers have tripled and their flying hours have doubled. It is important to monitor the safety trends in this expanding aviation sector.

Helicopter safety has improved since 1990. The number of accidents, the accident rate per flying hours and the accident rate per registered aircraft have decreased between 1990 and 2002. Robinson R22 helicopters have been involved in more accidents than any other light utility helicopter. When considering accidents alone, this model's record appears less safe than other light utility helicopters. However, this model has flown more hours than other light utility helicopter models in Australia and the rate per hours flown indicates that, up to 2002, this helicopter's record was as safe, if not safer, than other similar helicopter models. Since 2002, the Bell/Agusta/Kawasaki 47G had the lowest accident rate per hours flown as well as the lowest rate per registered helicopter.

For the combined 1990-2002 period, the Robinson R22 model had the lowest accident rate per flying hours of 1.8 accidents per 10,000 flying hours compared with 3.1 accidents per 10,000 flying hours for the 47G model.

Light utility helicopters are involved in a small number of fatal accidents each year. Between 1990 and 2002, the Hiller UH-12E was not involved in any fatal accidents. The Robinson R22 had the next lowest fatal accident rate per hours flown for the combined 1990 to 2002 period and the Hughes/Schweizer 269 model had the highest fatal accident rate. The R22 model also had the second lowest ratio of fatal to all accidents, followed by the 269 and then the 47G model.

The light utility models are predominantly utilised in other aerial work, flying training and aerial agriculture operations. Most of the accidents occur while flying other aerial work. Private flying is the least safe aerial operation for the light utility models. Aerial agricultural operations were also over-represented in accidents for the 47G model. Flying training, charter and other aerial work were relatively safer operations.

Accidents predominantly involved collisions with terrain or other obstacles, with a smaller proportion involving engine malfunction. The helicopters either collided with the ground, trees or powerlines with the object primarily being determined by the type of flying at the time. 'Aircraft handling' or 'maintenance/repair/design/construction' contributed to the majority of accidents.

Flying hours and the number of registered 269 and UH-12E models greatly reduced during the period studied. Given this, the most valid safety comparisons were between the R22 and 47G helicopter models. Comparing accident rates per flying hours and the number of registered aircraft, these two models were considered to have similar safety profiles.

APPENDIX A

Systemic Incident Analysis Model II

1 Outcomes

What was the first event that made this a unsafe occurrence?

Loss of normal flying capability/function

- **Airframe**
  - Internal fixture/fitting problem
  - Landing gear problem
  - Flight control/surface problem
  - Structural problem
  - Door or window problem
- **Powerplant**
  - Engine malfunction
  - Propeller/rotor malfunction
  - Engine accessory malfunction
- **Systems**
  - Electrical failure
  - Hydraulic failure
  - Fuel system failure
  - Avionics system failure
    - Navigation system failure
    - Communications system failure
    - Automatic flight system failure
  - Instruments failure
  - Life support system failure
- **Crew injury/incapacitation**
- Fire, explosion or fumes
- Cargo problem
- Balance/centre of gravity problem

Collision (controlled aircraft/vehicle operations)

- **Objects and moveable features**
  - Collision with animal
  - Birdstrike
  - Collision with moveable equipment
  - Collision with person
- **Terrain and fixed features**
  - Natural
    - Collision with ground
    - Collision with water
    - Collision with foliage/tree
  - Man made
    - Collision with building
    - Collision with powerline/wire
    - Collision with miscellaneous man made feature

Other aircraft
Other aircraft is airborne
Collision with aircraft in controlled airspace
Collision with aircraft OCTA
Other aircraft is on the ground
Collision with stationary aircraft
Collision with moving aircraft on the ground

Injury to non-operational person (controlled operation)
Passengers (including parachutists)
Bystanders

2 Defences
What features of the aviation system failed resulting in this outcome?

Aircraft features
Monitoring/warning systems
Airframe including gear/flight control warnings
Transponders
Engine and APU
Avionics system
GPWS
Stall warnings
ACAS/TCAS
Aircraft lighting
Anti/de icing systems

Aerodrome features
Runway/taxiway layout/conditions
Aerodrome lighting and marking
Aerodrome animal and bird control
Aerodrome security

Maintenance, repair design and construction

Navigation
Navigation equipment
Charts
Area familiarisation

Flight management
Fuel management
Aircraft handling
Communication
Air-air communication procedures
Air-ground communication procedures

- Flight rule related
  - Other IFR procedures
  - Other VFR procedures
  - Self separation procedures
  - GAAP procedures
- Preflight planning and preparation

ATS procedures, facilities and standards

- Co ordination (ground-ground)
- Clearances and instructions
  - Verbal clearance/instruction
  - Datalink clearance/instruction
  - SID/STAR
  - Other published instructions
- Facilities
  - TAAATS
    - TAAATS alerts
    - TAAATS hardware/software
  - Non TAAATS ATS facilities
- Procedures and standards including separation
- Passing/providing information
- SARTIME

General procedures and standards

- Dispatch and loading procedures
- Acts, regulations and orders
- Operations manuals and SOPs
- Handover/takeover procedures
- Briefing procedures
- CRM/teamwork
- Passenger control/management

Meteorological information

ATSB

Light Utility Helicopter Safety in Australia

ISBN 1 877071 71 4

www.atsb.gov.au

1800 621 372