5. UNIT REPLACEMENT AND RESTORATION COSTS OF DAMAGED AIRCRAFT

5.1 INTRODUCTION

The cost of damage to aircraft in aviation accidents is borne directly by operators and indirectly by users and society in the form of higher fares and costs.[1] Determining these costs provides a measure for evaluation of FAA investment and regulatory programs that affect the likelihood of aircraft being damaged or destroyed.

5.1.1. Replacement

For the purpose of evaluating the cost of aircraft replacement, a destroyed aircraft is assigned the value of an equivalent replacement. This valuation assumption is consistent with the opportunity cost of the loss of the use of a typical aircraft; the value of a new aircraft would overstate the typical loss. (Even though a destroyed aircraft might be replaced by a new aircraft, the new aircraft provides additional value over the one it replaces.) The aircraft values reported below are based on transactions in the well-defined market for used aircraft, except for military aircraft which will be discussed later in this section. The aircraft value in an orderly market without excess aircraft capacity or excess demand for aircraft is referred to as the "base" value, which reflects the long-run relationship between current value, age and original price of an aircraft. A base value reflects historic trends and may be more appropriate if the expected accidents to be valued occur over a long time period. Current market values are also reported below. For general aviation aircraft, estimated market values are used.

5.1.2. Restoration

The NTSB classifies aircraft involved in accidents as "destroyed," having "substantial damage," having "minor damage," or having "no damage." The cost incurred as a result of "minor damage" to aircraft is generally a negligible percentage of the market value and is not evaluated in this report. An aircraft with "substantial damage" is one that is damaged but repairable; industry data discussed below provide a means of estimating the relationship between the cost of damage and the total value of the aircraft.

5.2 AIR CARRIER AIRCRAFT

5.2.1. Replacement

Replacement values for air carriers were derived from a proprietary database developed by Ascend from Flightglobal.[2] The first step in establishing an average fleet valuation is to develop an industry database covering each aircraft and aircraft type in the U.S. air carrier fleet

[1] Insurance represents a transfer payment between the insurance company and the insured and does not directly affect the economic losses in an accident.
[2] http://www.ascendworldwide.com/what-we-do/ascend-data/aircraft-airline-data/ascend-online-fleets.html

that was in service as of November 2014. The average value was developed using an estimated current market value for each aircraft delivered in a given year, and then aggregating these values into the economic values aircraft categories.

The valuation database uses industry data on recent sales and asking prices of airplanes on the used market. There is an active market in used commercial aircraft, and thus it is possible to obtain reliable estimates of a destroyed aircraft.

The summary of values for passenger and all-cargo air carrier aircraft is shown in Table 5-1. The first column for each operator group reports the number of aircraft in the Ascend database that were used in developing weighted averages.[3] The second column reports current market (2014) values. The average market value of a passenger aircraft was about $13.5 million in 2014, while the average market value of an all-cargo aircraft was $13.6 million. The range in values among the aircraft groups was quite large reflecting the different average size and average age of aircraft in each group.

Table 5-1: 2014 Estimated Market Values of Air Carrier Aircraft

Aircraft Category	Passenger		All-Cargo	
	Col. 1 Number of Aircraft	Col. 2 Weighted Average Current Market Value (millions)	Col. 3 Number of Aircraft	Col. 4 Weighted Average Current Market Value (millions)
Wide-body more than 300 seats	50	$35.0		
Wide-body 300 seats and below	449	$29.7		
Four-engine wide-body			62	$44.1
Three-engine wide-body			164	$6.6
Two-engine wide-body			290	$30.7
Narrow-body more than 160 seats	583	$19.3	171	$13.8
Narrow-body 160 seats and below	2,494	$14.0	47	$1.1
RJ more than 60 seats	713	$14.0	NR	NR
RJ 60 seats and below	916	$2.9	2	$3.3
Turboprop more than 60 seats	87	$11.0	15	$6.0
Turboprop 20-60 seats	214	$2.7	113	$1.1
Turboprop under 20 seats (Part 23)	92	$1.7	263	$0.6
Turboprop under 20 seats (Part 25)	NR	NR	14	$3.2
All Aircraft	**5,598**	**$13.5**	**1,141**	**$13.6**

Source: Ascend Flightglobal Consultancy
Col 1: Number of passenger aircraft in database
Col 2: The weighted average current market value of aircraft described in column 1
Col 3: Number of all-cargo aircraft in database
Col 4: The weighted average current market value of aircraft described in column 3

[3] This differs from the Form 41 fleet sizes because the Ascend database contains all aircraft in the U.S. air carrier fleet, including those operated by carriers not required to report Form 41 data.

Table 5-2 provides current market values for passenger air carrier aircraft. It also shows the standard deviation of each aircraft group value, which is based on the number and value of each aircraft within the group. The average monthly lease rates for each aircraft group are also shown. Lease rate data were not available for some of the aircraft that had a reported market value.

Table 5-2: 2014 Passenger Air Carrier Fleet Sizes and Values

Aircraft Category	Col. 1 Number of Aircraft with Market Value Data	Col. 2 Weighted Average Current Market Value (millions)	Col. 3 Standard Deviation of Market Value (millions)	Col. 4 Number of Aircraft with Lease Rate Data	Col. 5 Weighted Average Monthly Market Lease Rate (thousands)	Col. 6 Standard Deviation of Monthly Market Lease Rate (thousands)
Wide-body more than 300 seats	50	$35.00	$50.10	50	$444.70	$406.20
Wide-body 300 seats and below	449	$29.70	$20.90	448	$370.80	$202.90
Narrow-body more than 160 seats	583	$19.30	$13.50	583	$206.10	$96.60
Narrow-body 160 seats and below	2,494	$14.00	$10.30	2,483	$160.10	$86.00
RJ more than 60 seats	713	$14.00	$4.60	713	$157.50	$34.30
RJ 60 seats and below	916	$2.90	$0.80	916	$56.00	$5.40
Turboprop more than 60 seats	87	$11.00	$2.80	87	$137.80	$25.00
Turboprop 20-60 seats	214	$2.70	$1.50	143	$43.30	$21.20
Turboprop under 20 seats (Part 23)	92	$1.70	$1.10	0	N/A	N/A
All Aircraft	**5,598**	**$13.50**	**$16.00**	**5,423**	**$163.70**	**$127.60**

Source: Ascend Flightglobal Consultancy
Col 1: Number of aircraft in database with current market value data
Col 2: The weighted average current market value of aircraft described in column 1
Col 3: The standard deviation of current market value of aircraft described in column 1
Col 4: Number of aircraft in database with lease rate data
Col 5: The weighted average monthly market lease rate (net dry operating lease) of aircraft described in column 4
Col 6: The standard deviation of monthly market lease rate of aircraft described in column 4

Table 5-3 shows current market values and monthly lease rates for all-cargo air carrier aircraft. The values of all-cargo air carrier aircraft are generally lower than equivalent passenger aircraft, except for the wide-body aircraft categories. Lease rate data were not available for some of the aircraft that had a reported market value.

Table 5-3: 2014 Cargo Air Carrier Fleet Sizes and Values

Aircraft Category	Col. 1 Number of Aircraft with Market Value Data	Col. 2 Weighted Average Current Market Value (millions)	Col. 3 Standard Deviation of Market Value (millions)	Col. 4 Number of Aircraft with Lease Rate Data	Col. 5 Weighted Average Monthly Market Lease Rate (thousands)	Col. 6 Standard Deviation of Monthly Market Lease Rate (thousands)
Four-engine wide-body	62	$44.10	$45.10	62	$520.80	$349.70
Three-engine wide-body	164	$6.60	$4.40	111	$219.50	$44.80
Two-engine wide-body	290	$30.70	$35.70	277	$394.30	$295.10
Narrow-body more than 160 seats	171	$13.80	$2.80	168	$195.60	$16.90
Narrow-body 160 seats and below	47	$1.10	$1.80	23	$71.10	$25.20
RJ 60 seats and below	2	$3.30	$0.00	0	N/A	N/A
Turboprop more than 60 seats	15	$6.00	$0.80	15	$85.00	$0.00
Turboprop 20-60 seats	113	$1.10	$0.80	0	N/A	N/A
Turboprop under 20 seats (Part 23)	263	$0.60	$0.40	0	N/A	N/A
Turboprop under 20 seats (Part 25)	14	$3.20	$2.10	0	N/A	N/A
All Aircraft	**1,141**	**$13.60**	**$25.30**	**689**	**$294.60**	**$252.70**

Source: Ascend Flightglobal Consultancy
Col 1: Number of aircraft in database with current market value data
Col 2: The weighted average current market value of aircraft described in column 1
Col 3: The standard deviation of current market value of aircraft described in column 1
Col 4: Number of aircraft in database with lease rate data
Col 5: The weighted average monthly market lease rate (net dry operating lease) of aircraft described in column 4
Col 6: The standard deviation of monthly market lease rate of aircraft described in column 4

5.2.2. Restoration

Restoration costs were estimated for commercial air carriers by analysis of the Accidents database developed by Ascend Flightglobal Consultancy.[4] The database provided by Ascend included all commercial aircraft accidents throughout the world from November 1, 1994 to November 1, 2014. Since this section of the report is meant to provide estimates of damage incurred by air carrier aircraft involved in accidents, a number of accidents were excluded from the analysis based on the following criteria:

- Accidents resulting from war terrorism or other unlawful activity were excluded
- Accidents occurring while aircraft were engaged in types of service other than passenger or all-cargo operation were excluded
  - e.g., aircraft conducting crop dusting, parachuting, or training were excluded
- Accidents occurring while the aircraft was non-operational were excluded
  - e.g., aircraft that suffered weather-related damage while parked were excluded
- Accidents involving military or government operators were excluded

[4] http://www.ascendworldwide.com/what-we-do/ascend-data/accident-and-loss-data/

Aircraft that were destroyed were excluded from the analysis because the replacement cost is assumed to equal the current market value of the aircraft. Aircraft that suffered no damage and aircraft without an estimated loss percentage were also excluded from the analysis.

Table 5-4 shows the number of accident aircraft included in the passenger air carrier analysis and the average loss percentage for those aircraft. There were 947 accident aircraft included in the analysis, with an average loss percentage of 21 percent. The weighted average current market value for the U.S. fleet (as calculated in Section 5.2.1) is also shown. The average loss percentage was applied to the U.S. fleet average market value to calculate the average loss value for an accident involving an aircraft in the U.S. fleet. The average loss value for a U.S. passenger air carrier aircraft involved in an accident was $2.8 million.

Table 5-4: Restoration Costs – Passenger Air Carrier Aircraft

Aircraft Category	Col. 1 Number of Accident Aircraft	Col. 2 Average Loss Percentage	Col. 3 Weighted Average Current Market Value (millions) of U.S. Fleet	Col. 4 Average Loss Value for U.S. Fleet
Wide-body more than 300 seats	82	11%	$35.00	$3.80
Wide-body 300 seats and below	113	15%	$29.70	$4.40
Narrow-body more than 160 seats	49	8%	$19.30	$1.50
Narrow-body 160 seats and below	343	22%	$14.00	$3.10
RJ more than 60 seats	45	28%	$14.00	$3.90
RJ 60 seats and below	36	19%	$2.90	$0.50
Turboprop more than 60 seats	51	20%	$11.00	$2.10
Turboprop 20-60 seats	141	30%	$2.70	$0.80
Turboprop under 20 seats (Part 23)	84	26%	$1.70	$0.40
Piston engine (Part 25)	3	36%	NR	NR
All Aircraft	**947**	**21%**	**$13.50**	**$2.80**

Source: Ascend Flightglobal Consultancy
Col 1: Number of aircraft involved in accidents that met the criteria outlined in section 5.2.2
Col 2: The average loss percentage sustained by the aircraft described in column 1
Col 3: The weighted average current market value of the U.S. fleet, as described in column 2 of Table 5-1
Col 4: Column 2 multiplied by column 3

Table 5-5 shows the number of accident aircraft included in the all-cargo air carrier analysis and the average loss percentage for those aircraft. There were 153 accident aircraft included in the analysis, with an average loss percentage of 29 percent. The weighted average current market value for the U.S. fleet (as calculated in Section 5.2.1) is also shown. The average loss percentage was applied to the U.S. fleet average market value to calculate the average loss value for an accident involving an aircraft in the U.S. fleet. The average loss value for a U.S. all-cargo air carrier aircraft involved in an accident was $3.9 million.

Table 5-5: Restoration Costs – All-Cargo Air Carrier Aircraft

Aircraft Category	Col. 1 Number of Accident Aircraft	Col. 2 Average Loss Percentage	Col. 3 Weighted Average Current Market Value (millions) of U.S. Fleet	Col. 4 Average Loss Value for U.S. Fleet
Four-engine wide-body	37	21%	$44.10	$9.20
Three-engine wide-body	22	14%	$6.60	$0.90
Two-engine wide-body	6	30%	$30.70	$9.20
Narrow-body more than 160 seats	12	33%	$13.80	$4.60
Narrow-body 160 seats and below	16	29%	$1.10	$0.30
Turboprop more than 60 seats	9	42%	$6.00	$2.50
Turboprop 20-60 seats	23	39%	$1.10	$0.40
Turboprop under 20 seats (Part 23)	28	37%	$0.60	$0.20
All Aircraft	**153**	**29%**	**$13.60**	**$3.90**

Source: Ascend Flightglobal Consultancy
Col 1: Number of aircraft involved in accidents that met the criteria outlined in section 5.2.2
Col 2: The average loss percentage sustained by the aircraft described in column 1
Col 3: The weighted average current market value of the U.S. fleet, as described in column 2 of Table 5-1
Col 4: Column 2 multiplied by column 3

5.3 GENERAL AVIATION AIRCRAFT

5.3.1. Replacement

Replacement values for general aviation aircraft were based on a methodology similar to that used for commercial air carriers. The primary source of data was the *Aircraft Bluebook (Fall, 2014)*.[5] For rotorcraft not covered in the *Aircraft Bluebook*, the average of the high and low Pre-Owned values from the Aircraft Cost Evaluator were used, where available. Finally, for some air carrier class fixed-wing aircraft operated as GA, a dataset from Ascend Flightglobal was consulted.

Aircraft in the fleet were assigned to one of the 18 Economic Value Aircraft Categories. The number of aircraft of each model and their age were based on detailed data from the *FAA General Aviation Survey*, 2013 data set.[6]

There have been significant changes in the composition of the general aviation fleet since the early 1980's which make it desirable to have additional information on aircraft values. There was a major decline in GA aircraft production—primarily smaller piston aircraft—after 1983. The fleet age profile for smaller piston aircraft is significantly different than that for larger turbine aircraft. In examining the active population of general aviation aircraft in the GA Survey, GRA made some observations:

[5] *Aircraft Bluebook. Overland Park, KS: Penton, Fall 2014.*
[6] Data provided by Tetratech. The analysis here used the actual sample records and appropriate expansion factors.

- More than two thirds (68%) of the fleet are piston fixed-wing aircraft
- 84% of single-engine fixed-wing piston and 91% of multiengine fixed-wing piston aircraft are more than 30 years old (manufactured before 1984)
- Relatively few models compose large percentages of the fixed-wing piston fleet
- These older fixed-wing piston aircraft tend to have similar values, within their Economic Values Category
- There is wide variation in the values of pre- and post-1984 aircraft

In order to devote more resources to investigating the values of newer, more valuable, more varied aircraft populations, GRA identified values for the majority of three classes of pre-1984 aircraft from the *Aircraft Bluebook*, calculated the weighted mean values, and applied this to the entire class. Table 5-6 shows these classes, the mean values, and the percentage of the active fleet that the values are based on.

Table 5-6: Estimated Market Values of Pre-1984 General Aviation Piston Aircraft with Fewer than Ten Seats ($2014)

Aircraft Category	Market Value	Aircraft	Share of Aircraft	Weighted Value
Piston engine airplanes 1-3 seats	Evaluated	18,113	70%	$27,664
	Not Evaluated	7,716	30%	
Piston engine airplanes 4-9 seats one-engine	Evaluated	48,889	63%	$38,621
	Not Evaluated	28,152	37%	
Piston engine airplanes 4-9 seats multi-engine	Evaluated	9,146	78%	$111,093
	Not Evaluated	2,541	22%	

Sources: FAA's *General Aviation and Part 135 Activity Survey CY 2013, Aircraft Bluebook* (Fall, 2014).

For aircraft in other Economic Values Aircraft Categories, and for smaller piston aircraft which were manufactured in 1984 or later, values were calculated as follows:

- Calculate the weighted mean year of manufacture of the active fleet for each model (1984 and later aircraft only for the aircraft categories shown in Table 5-6)
- Identify the value for an aircraft of that year from the *Aircraft Bluebook*
- Apply that value to all examples of that model (examples made in 1984 and later for the aircraft categories shown in Table 5-6)

After applying data from the Aircraft Bluebook, two broad classes of aircraft still had many models without available values: for rotorcraft, value data was supplemented with data from the *Aircraft Cost Evaluator*; for larger fixed-wing aircraft types normally operated by air carriers, Ascend values were added. These values were used together with the relative numbers of aircraft of each model in a particular Economic Values Category to obtain a weighted average value for that class.

The summary of valuation for the general aviation aircraft groups is shown in Table 5-7. This valuation is provided in terms of an average value per aircraft, a minimum and maximum

value per aircraft, and a statistical standard deviation that applies to the average value. Overall, the average GA aircraft has a value of $519,695; the large standard deviation reflects the broad range of values in some aircraft categories.

Table 5-7: Estimated Market Values of General Aviation Aircraft ($2014)

Aircraft Category	Certification	All Years					
		Col. 1 Fleet Total	Col. 2 Average Value Per Aircraft	Col. 3 Minimum Value Per Aircraft	Col. 4 Maximum Value Per Aircraft	Col 5. Standard Deviation of Average Value	Col. 6 Average Age
Piston engine airplanes, 1-3 seats	Part 23	29,046	$33,201	$27,664	$320,000	$23,201	45
Piston engine airplanes, 4-9 seats one-engine	Part 23	93,817	$59,768	$26,000	$945,000	$69,098	40
Piston engine airplanes, 4-9 seats multi-engine	Part 23	12,896	$125,372	$111,093	$1,070,000	$74,357	38
Piston engine airplanes, 10 or more seats	Part 23	453	$87,330	$60,000	$190,000	$43,095	56
Turboprop airplanes, 1-9 seats one-engine	Part 23	3,828	$714,179	$35,000	$1,625,000	$580,531	15
Turboprop airplanes, 1-9 seats multi-engine	Part 23	803	$675,523	$80,000	$4,400,000	$840,985	31
Turboprop airplanes, 10-19 seats	Part 23	5,384	$1,068,640	$300,000	$3,300,000	$710,464	23
Turboprop airplanes, 20 or more seats	Part 25	425	$1,903,301	$200,000	$3,050,000	$1,012,434	29
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	1,706	$1,840,114	$75,000	$3,300,000	$937,446	14
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	8,384	$5,144,237	$110,000	$22,000,000	$4,511,782	16
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	1,764	$17,006,419	$120,000	$71,000,000	$12,984,957	13
Rotorcraft piston <= 6,000 lbs.	Part 27	2,977	$206,934	$54,000	$310,000	$92,365	19
Rotorcraft turbine <= 6,000 lbs.	Part 27	4,067	$1,185,951	$125,000	$4,550,000	$715,197	22
Rotorcraft piston > 6,000 lbs.	Part 29	10	NA	NA	NA	NA	55
Rotorcraft turbine > 6,000 lbs.	Part 29	2,088	$3,321,674	$325,000	$8,300,000	$2,093,111	27
Other		4,326	NA	NA	NA	NA	21
Experimental		21,721	NA	NA	NA	NA	18
Light Sport		6,232	NA	NA	NA	NA	8
All Aircraft		**199,927**	**$519,695**	**$26,000**	**$71,000,000**	**NA**	**34**

Sources: FAA's *General Aviation and Part 135 Activity Survey CY 2013, Aircraft Bluebook* (Fall, 2014); Conklin and de Decker's *Aircraft Cost Evaluator* (v14.2.0, 2014); Ascend Flightglobal data.

NA=Not Available

Note: "Rotorcraft piston > 6,000 lbs.," Other, Experimental and Light Sport aircraft Economic Values Categories are included in calculating fleet total and average age for all aircraft but not in calculating estimated market values.

Note: The primary source of aircraft market values is the *Aircraft Bluebook*. Values for certain carrier-class fixed-wing aircraft obtained from Ascend FlightGlobal. For rotorcraft, if no *Aircraft Bluebook* value was available, the average of the high and low pre-owned values from *The Aircraft Cost Evaluator* were used, where available.

Col 1: Total number of aircraft in GA Survey.

Col 2: Average aircraft value weighted by the number of aircraft.

Col 3: The lowest aircraft value reported for each economic values class.

Col 4: The highest aircraft value reported for each economic values class.

Col 5: Square root of (n*(x-average price)^2)/(n*(n-1)) where n is the number of observations and x is aircraft price.

Col 6: Average aircraft age (weighted) in 2013.

As was noted previously, no data were available in certain aircraft categories. As a result, average values are less relevant for at least some economic evaluations. For example, FAA may be faced with an investment or regulatory decision that disproportionately affects GA piston or

GA turbine operators. In extreme cases, these decisions may affect only one group or the other. Other decisions may affect aircraft of only certain ages, such as a requirement to bring an old design up to a modern standard. The values relevant for use in such a benefit-cost study should reflect the aircraft actually affected. One way to reflect such value differences is to use either pre-1984 or 1984-and-later data depending upon which is most representative. Table 5-8 shows the estimated market values for the 129,463 aircraft manufactured before 1984. As can be seen, these aircraft are 46 years old on average and have an average market value of approximately $87,000.

Table 5-8: Estimated Market Values of Pre-1984 General Aviation Aircraft ($2014)

Aircraft Category	Certification	All Years					
		Col. 1 Fleet Total	Col. 2 Average Value Per Aircraft	Col. 3 Minimum Value Per Aircraft	Col. 4 Maximum Value Per Aircraft	Col. 5 Standard Deviation of Average Value	Col. 6 Average Age
Piston engine airplanes, 1-3 seats	Part 23	25,829	$27,664	$27,664	$27,664	$0	49
Piston engine airplanes, 4-9 seats one-engine	Part 23	77,312	$38,621	$38,621	$38,621	$0	46
Piston engine airplanes, 4-9 seats multi-engine	Part 23	11,688	$111,093	$111,093	$111,093	$0	41
Piston engine airplanes 10 or more seats	Part 23	426	$87,330	$60,000	$190,000	$43,095	58
Turboprop airplanes, 1-9 seats one-engine	Part 23	587	$105,108	$35,000	$317,000	$68,395	38
Turboprop airplanes, 1-9 seats multi-engine	Part 23	625	$458,030	$80,000	$925,000	$170,213	35
Turboprop airplanes, 10-19 seats	Part 23	2,091	$650,600	$300,000	$1,100,000	$235,688	37
Turboprop airplanes, 20 or more seats	Part 25	177	$2,113,560	$200,000	$3,050,000	$1,048,762	38
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	336	$247,219	$75,000	$260,000	$46,918	36
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	1,355	$746,235	$110,000	$5,300,000	$434,950	36
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	175	$709,193	$120,000	$950,000	$239,724	35
Rotorcraft piston <= 6,000 lbs.	Part 27	748	$90,573	$54,000	$129,000	$16,589	45
Rotorcraft turbine <= 6,000 lbs.	Part 27	1,642	$551,658	$125,000	$1,880,000	$235,759	38
Rotorcraft piston > 6,000 lbs.	Part 29	10	NA	NA	NA	NA	55
Rotorcraft turbine > 6,000 lbs.	Part 29	969	$4,391,913	$325,000	$5,640,000	$1,884,789	42
Other		1,164	NA	NA	NA	NA	41
Experimental		4,319	NA	NA	NA	NA	50
Light Sport		10	NA	NA	NA	NA	32
All Aircraft		**129,463**	**$87,163**	**$27,664**	**$5,640,000**	**NA**	**46**

Sources: FAA's *General Aviation and Part 135 Activity Survey CY 2013, Aircraft Bluebook* (Fall, 2014); Conklin and de Decker's *Aircraft Cost Evaluator* (v14.2.0, 2014); Ascend Flightglobal data.

NA=Not Available

Note: "Rotorcraft piston > 6,000 lbs.," Other, Experimental and Light Sport aircraft Economic Values Categories are included in calculating fleet total and average age for all aircraft but not in calculating estimated market values.

Note: The primary source of aircraft market values is the *Aircraft Bluebook*. Values for certain carrier-class fixed-wing aircraft obtained from Ascend FlightGlobal. For rotorcraft, if no *Aircraft Bluebook* value was available, the average of the high and low pre-owned values from *The Aircraft Cost Evaluator* were used, where available.

Col 1: Total number of aircraft in GA Survey.

Col 2: Average aircraft value weighted by the number of aircraft.

Col 3: The lowest aircraft value reported for each economic values class.

Col 4: The highest aircraft value reported for each economic values class.

Col 5: Square root of (n*(x-average price)^2)/(n*(n-1)) where n is the number of observations and x is aircraft price.

Col 6: Average aircraft age (weighted) in 2013.

Table 5-9 shows the market values for the 70,464 GA aircraft that were manufactured in 1984 or later. These aircraft have an average age of 12 years and an average market value of $2.1

million, which reflects both higher average values within each category as well as a higher proportion of large turbine engine aircraft in the post-1984 fleet.

Table 5-9: Estimated Market Values of General Aviation Aircraft Manufactured 1984 and Later ($2014)

Aircraft Category	Certification	All Years					
		Col. 1 Fleet Total	Col. 2 Average Value Per Aircraft	Col. 3 Minimum Value Per Aircraft	Col. 4 Maximum Value Per Aircraft	Col. 5 Standard Deviation of Average Value	Col. 6 Average Age
Piston engine airplanes, 1-3 seats	Part 23	3,216	$94,389	$31,500	$320,000	$49,026	13
Piston engine airplanes, 4-9 seats one-engine	Part 23	16,505	$183,575	$26,000	$945,000	$121,580	13
Piston engine airplanes, 4-9 seats multi-engine	Part 23	1,208	$325,453	$123,000	$1,070,000	$200,276	15
Piston engine airplanes 10 or more seats	Part 23	27	NA	NA	NA	NA	22
Turboprop airplanes, 1-9 seats one-engine	Part 23	3,241	$680,539	$120,000	$1,625,000	$550,630	11
Turboprop airplanes, 1-9 seats multi-engine	Part 23	178	$1,740,716	$370,000	$4,400,000	$1,631,896	18
Turboprop airplanes, 10-19 seats	Part 23	3,294	$1,324,451	$450,000	$3,300,000	$779,273	13
Turboprop airplanes, 20 or more seats	Part 25	248	$1,739,857	$1,000,000	$3,050,000	$951,792	23
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	1,369	$1,970,136	$850,000	$3,300,000	$852,256	8
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	7,029	$5,681,700	$200,000	$22,000,000	$4,490,888	12
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	1,589	$18,375,019	$150,000	$71,000,000	$12,593,097	11
Rotorcraft piston <= 6,000 lbs.	Part 27	2,229	$230,778	$65,000	$310,000	$82,946	10
Rotorcraft turbine <= 6,000 lbs.	Part 27	2,425	$1,472,286	$310,000	$4,550,000	$673,583	11
Rotorcraft piston > 6,000 lbs.	Part 29	0	NA	NA	NA	NA	NA
Rotorcraft turbine > 6,000 lbs.	Part 29	1,118	$2,383,574	$400,000	$8,300,000	$1,795,408	13
Other		3,162	NA	NA	NA	NA	14
Experimental		17,402	NA	NA	NA	NA	11
Light Sport		66,,223	NA	NA	NA	NA	8
All Aircraft		**70,464**	**$2,072,990**	**$26,000**	**$71,000,000**	**NA**	**12**

Sources: FAA's *General Aviation and Part 135 Activity Survey CY 2013, Aircraft Bluebook* (Fall, 2014); Conklin and de Decker's *Aircraft Cost Evaluator* (v14.2.0, 2014); Ascend Flightglobal data.

NA=Not Available

Note: "Rotorcraft piston > 6,000 lbs.," Other, Experimental and Light Sport aircraft Economic Values Categories are included in calculating fleet total and average age for all aircraft but not in calculating estimated market values.

Note: The primary source of aircraft market values is the *Aircraft Bluebook*. Values for certain carrier-class fixed-wing aircraft obtained from Ascend FlightGlobal. For rotorcraft, if no *Aircraft Bluebook* value was available, the average of the high and low pre-owned values from *The Aircraft Cost Evaluator* were used, where available.

Col 1: Total number of aircraft in GA Survey.

Col 2: Average aircraft value weighted by the number of aircraft.

Col 3: The lowest aircraft value reported for each economic values class.

Col 4: The highest aircraft value reported for each economic values class.

Col 5: Square root of (n*(x-average price)^2)/(n*(n-1)) where n is the number of observations and x is aircraft price.

Col 6: Average aircraft age (weighted) in 2013.

5.3.2. Restoration

Restoration values for general aviation aircraft were estimated using the market values developed in the previous section and estimated restoration costs as a percentage of market value from the previous edition of this report. The values are reported by Economic Values Category only, because a further breakdown by aircraft type is not feasible.

In the 2007 Economic Values report, databases from Airclaims and AVEMCO provided average hull value of aircraft, average hull damage and the number of aircraft losses. Average hull value and average hull damage values were weighted by the number of aircraft with data to obtain averages for all aircraft. Average hull damage value was then divided by the average hull value, resulting in "damage/value" percentage for all aircraft as well as for each Economic Values Category. For the economic values categories not covered in the AVEMCO or Airclaims databases, the "damage/value" percentage for all aircraft was used.

In this report, the "damage/value" percentages from the 2007 report were applied to 2014 market values from Tables 5-7 through 5-9.[7] Restoration costs by Economic Values Category are shown in Tables 5-10 through 5-12. Table 5-10 shows restoration costs averaged across aircraft of all ages. Damage as a percentage of hull value ranges from 1% (for a Category with a single claim in the claims database) to 29%, and is 20% overall.

Table 5-10: General Aviation Restoration Costs ($2014)

Aircraft Category	Certification	Col. 1 Average of Hull Value	Col. 2 Average of Hull Damage	Col. 3 Damage/ Value
Piston engine airplanes, 1-3 seats	Part 23	$33,201	$9,624	29%
Piston engine airplanes, 4-9 seats one-engine	Part 23	$59,768	$12,065	20%
Piston engine airplanes, 4-9 seats multi-engine	Part 23	$125,372	$30,008	24%
Piston engine airplanes, 10 or more seats	Part 23	$87,330	$9,151	10%
Turboprop airplanes, 1-9 seats one-engine	Part 23	$714,179	$145,546	20%
Turboprop airplanes, 1-9 seats multi-engine	Part 23	$675,523	$137,668	20%
Turboprop airplanes, 10-19 seats	Part 23	$1,068,640	$7,845	1%
Turboprop airplanes, 20 or more seats	Part 25	$1,903,301	$387,884	20%
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	$1,840,114	$375,007	20%
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	$5,144,237	$1,059,169	21%
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	$17,006,419	$1,038,907	6%
Rotorcraft piston <= 6,000 lbs.	Part 27	$206,934	$42,172	20%
Rotorcraft turbine <= 6,000 lbs.	Part 27	$1,185,951	$241,691	20%
Rotorcraft piston > 6,000 lbs.	Part 29	NA	NA	NA
Rotorcraft turbine > 6,000 lbs.	Part 29	$3,321,674	$676,942	20%
Other		NA	NA	NA
Experimental		NA	NA	NA
Light Sport		NA	NA	NA
All Aircraft		**$519,695**	**$105,911**	**20%**

*Average Hull Value=Average Market Value from table 5-7; Average Hull Damage="Damage/Value" for *All Aircraft* (~20%) multiplied by Average Hull Value; "Damage/Value"="Damage/Value" for All Aircraft.
NA = Not Available
Col 1: Average aircraft hull value for each economic values category.
Col 2: Column 1 times Column 3.
Col 3: Average of restoration cost as a percentage of hull value for this Category in 2007 Economic Values report. Based on claims in databases from Airclaims and AVEMCO.

[7] For this report, no underwriters would provide data on loss percentages.

Table 5-11 shows general aviation restoration values for aircraft that were manufactured before 1984. Average hull damage is about 26 percent of average hull value, and ranges as high as 33 percent.

Table 5-11: General Aviation Restoration Costs for Pre-1984 Aircraft ($2014)

Aircraft Category	Certification	Col. 1 Average of Hull Value	Col. 2 Average of Hull Damage	Col. 3 Damage/ Value
Piston engine airplanes, 1-3 seats	Part 23	$27,664	$9,035	33%
Piston engine airplanes, 4-9 seats one-engine	Part 23	$38,621	$8,187	21%
Piston engine airplanes, 4-9 seats multi-engine	Part 23	$111,093	$27,268	25%
Piston engine airplanes, 10 or more seats	Part 23	$87,330	$9,151	10%
Turboprop airplanes, 1-9 seats one-engine	Part 23	$105,108	$27,363	26%
Turboprop airplanes, 1-9 seats multi-engine	Part 23	$458,030	$119,240	26%
Turboprop airplanes, 10-19 seats	Part 23	$650,600	$4,776	1%
Turboprop airplanes, 20 or more seats	Part 25	$2,113,560	$550,226	26%
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	$247,219	$64,359	26%
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	$746,235	$232,171	31%
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	$709,193	$218,213	31%
Rotorcraft piston <= 6,000 lbs.	Part 27	$90,573	$23,579	26%
Rotorcraft turbine <= 6,000 lbs.	Part 27	$551,658	$143,614	26%
Rotorcraft piston > 6,000 lbs.	Part 29	NA	NA	NA
Rotorcraft turbine > 6,000 lbs.	Part 29	$4,391,913	$1,143,353	26%
Other		NA	NA	NA
Experimental		NA	NA	NA
Light Sport		NA	NA	NA
All Aircraft		**$87,163**	**$22,691**	**26%**

*Average Hull Value=Average Market Value from table 5-7; Average Hull Damage="Damage/Value" for *All Aircraft* (~20%) multiplied by Average Hull Value; "Damage/Value"="Damage/Value" for All Aircraft.
NA = Not Available
Col 1: Average aircraft hull value for each economic values category.
Col 2: Column 1 times Column 3.
Col 3: Average of restoration cost as a percentage of hull value for this Category in 2007 Economic Values report. Based on claims in databases from Airclaims and AVEMCO.

Restoration values for the aircraft manufactured in 1984 or later are summarized in Table 5-12. Average hull damage is about 15 percent of average hull value, ranging as high as 20 percent for the least-valuable Category.

Table 5-12: General Aviation Restoration Costs for 1984 and Later Aircraft ($2014)

Aircraft Category	Certification	Col. 1 Average of Hull Value	Col. 2 Average of Hull Damage	Col. 3 Damage/ Value
Piston engine airplanes, 1-3 seats	Part 23	$94,389	$18,837	20%
Piston engine airplanes, 4-9 seats one-engine	Part 23	$183,575	$26,366	14%
Piston engine airplanes, 4-9 seats multi-engine	Part 23	$325,453	$57,046	18%
Piston engine airplanes, 10 or more seats	Part 23	NA	NA	15%
Turboprop airplanes, 1-9 seats one-engine	Part 23	$680,539	$105,089	15%
Turboprop airplanes, 1-9 seats multi-engine	Part 23	$1,740,716	$268,801	15%
Turboprop airplanes, 10-19 seats	Part 23	$1,324,451	$204,521	15%
Turboprop airplanes, 20 or more seats	Part 25	$1,739,857	$268,668	15%
Turbojet/turbofan airplanes, <= 12,500 lbs.	Part 23/25	$1,970,136	$304,227	15%
Turbojet/turbofan airplanes, > 12,500 lbs. and <= 65,000 lbs.	Part 25	$5,681,700	$896,295	16%
Turbojet/turbofan airplanes, > 65,000 lbs.	Part 25	$18,375,019	$453,111	2%
Rotorcraft piston <= 6,000 lbs.	Part 27	$230,778	$35,637	15%
Rotorcraft turbine <= 6,000 lbs.	Part 27	$1,472,286	$227,350	15%
Rotorcraft piston > 6,000 lbs.	Part 29	NA	NA	NA
Rotorcraft turbine > 6,000 lbs.	Part 29	$2,383,574	$368,070	15%
Other		NA	NA	NA
Experimental		NA	NA	NA
Light Sport		NA	NA	NA
All Aircraft		**$2,072,990**	**$320,110**	**15%**

*Average Hull Value=Average Market Value from table 5-7; Average Hull Damage="Damage/Value" for *All Aircraft* (~20%) multiplied by Average Hull Value; "Damage/Value"="Damage/Value" for All Aircraft.
NA = Not Available
Col 1: Average aircraft hull value for each economic values category.
Col 2: Column 1 times Column 3.
Col 3: Average of restoration cost as a percentage of hull value for this Category in 2007 Economic Values report. Based on claims in databases from Airclaims and AVEMCO.

5.4 MILITARY AIRCRAFT

5.4.1. Replacement

Estimating replacement values for military aircraft is considerably more complex than it is for air carrier or general aviation aircraft. One problem is that used military aircraft do not sell in the open market. The second problem is that there is a lengthy and complex procurement process for military aircraft, which often makes unit cost estimates for individual types inappropriate as measures of opportunity costs.

The example of the B-52 bomber illustrates the two problems discussed above. First, there is no used market for this aircraft. It is an aircraft for which there are few substitutes. Second, what would it cost to actually replace a B-52 that is lost in an accident? It is not possible

to buy one B-52 or a newer plane that has similar characteristics.[8] A new military procurement program would cost a substantial sum of money, which could not be counted as a cost against one aircraft lost in an accident.

Data used to estimate military aircraft replacement values were obtained from Selected Acquisition Reports by each branch of the services. These reports include research and development, procurement, military construction, and acquisition related maintenance and operations costs. The data were applied for each model of aircraft that was in the SAR data and fleet data. Aircraft without data were assumed to have the same average replacement cost as the group they were in. Summary values based on fleet weighted replacement costs are reported in Table 5-11.

5.4.2. Restoration

Data on military restoration costs were developed from prior data provided by the military services, and are based on the repair cost of aircraft damaged in accidents. For this update, the military did not provide data for restoration costs. Therefore, the update was performed by applying the percentage that restoration costs were of replacement costs in the prior report to the current replacement cost estimates. Estimated restoration costs average 3 percent of aircraft value as shown above in Table 5-11. We believe this number may be low because the military self-insures against accident losses and are more likely to include accidents with minor damage in their estimates. For military aircraft with substantial damage, it may be better to use the air carrier restoration percentages reported above for aircraft of a similar size.

[8] The B-52 aircraft program has had a number of aircraft upgrades, which adds to the complexity in determining a market value. See: B-52 Stratofortress Historical Snapshot. Page accessed August 14, 2015.

Table 5-13: Summary of Military Aircraft Values and Restoration Costs (FY2013) ($ millions) – Average Weighted by Fleet

Aircraft Type	Col. 1 Total Fleet	Col. 2 Average Replacement Value	Col. 3 Average Restoration Value	Col. 4 Restoration Percentage
Turbojet/fan 3+ Engine	834	$147.9	$0.7	0.5%
Turbojet/fan Attack/Fighter	3,256	$108.3	$2.1	1.9%
Turbojet/fan Other	977	$118.1	$8.9	7.5%
Turboprop	1,569	$43.9	$1.8	4.0%
Piston	32	NA	NA	N/A
Rotary Wing Aircraft	6,030	$32.2	$2.0	6.1%
UAV	301	$373.6	NA	N/A
Glider	N/A	NA	NA	N/A
All Aircraft	**12,999**	**$74.6**	**$2.4**	**3.0%**

Sources (Aircraft Restoration): Use Restoration Percentage by aircraft group (Table 5-11 FAA Economic Values 2007) to calculate the Average Restoration Value
Sources (Aircraft Replacement): Selected Acquisition Report (SAR); Air Force, Air Force Reserve and Air National Guard (U.S. Air Force Fact Sheets); Navy, Naval Reserve, Marine Corps, and Marine Corps Reserve (Fact Sheets)
Replacement and restoration values were not available for all aircraft types
Col 1: Total number of aircraft for each aircraft type in military service
Col 2: Average replacement value for each aircraft type, weighted by fleet
Col 3: Average restoration value for each aircraft type, weighted by fleet
Col 4: Restoration Percentage FAA Economic Values FY2007