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. 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 the proprietary Fleets Analyzer database developed by 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 that was in service as of October 2018. 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.

[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] Fleets data and market insights This is now a Cirium product.

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 (2018) values. The average market value of a passenger aircraft was about $17.6 million in 2018, while the average market value of an all-cargo aircraft was $15.9 million. The range in values among the individual aircraft groups was quite large reflecting the different average size and average age of aircraft in each group.

Table 5-1: 2018 Estimated Market Values of Air Carrier Aircraft

Aircraft Category	Passenger		All-Cargo	
	Number of Aircraft	Weighted Average Current Market Value (millions)	Number of Aircraft	Weighted Average Current Market Value (millions)
Wide-body more than 300 seats	52	$111.9		
Wide-body 300 seats and below	488	$34.2		
Four-engine wide-body			90	$43.8
Three-engine wide-body			142	$4.7
Two-engine wide-body			383	$33.1
Narrow-body more than 160 seats	1,061	$29.8	53	$2.9
Narrow-body 160 seats and below	2,586	$14.6	194	$9.5
RJ more than 60 seats	1,111	$13.6	NR	NR
RJ 60 seats and below	706	$1.2	16	$0.6
Turboprop more than 60 seats	45	$9.6	96	$1.1
Turboprop 20-60 seats	96	$2.3	17	$3.7
Turboprop under 20 seats (Part 23)	26	$1.0	240	$0.5
Turboprop under 20 seats (Part 25)	NR	NR	NR	NR
All Aircraft	**6,171**	**$17.6**	**1,231**	**$15.9**

Source: FlightGlobal Fleets Analyzer
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

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.

[3] This differs from the Form 41 fleet sizes because the Fleets Analyzer 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: 2018 Passenger Air Carrier Fleet Sizes and Values

	1	2	3	4	5	6
Aircraft Category	**Number of Aircraft with Market Value Data**	**Weighted Average Current Market Value (millions)**	**Standard Deviation of Market Value (millions)**	**Number of Aircraft with Lease Rate Data**	**Weighted Average Monthly Market Lease Rate (thousands)**	**Standard Deviation of Monthly Market Lease Rate (thousands)**
Wide-body more than 300 seats	52	$111.9	$35.4	52	$881.3	$240.8
Wide-body 300 seats and below	488	$34.2	$34.8	487	$324.8	$237.5
Narrow-body more than 160 seats	1,061	$29.8	$13.9	1,061	$274.8	$91.2
Narrow-body 160 seats and below	2,586	$14.6	$10.0	2,585	$168.3	$82.1
RJ more than 60 seats	1,111	$13.6	$6.0	1,111	$138.8	$44.2
RJ 60 seats and below	706	$1.2	$0.2	706	$41.7	$4.0
Turboprop more than 60 seats	45	$9.6	$2.7	45	$111.1	$18.0
Turboprop 20-60 seats	96	$2.3	$1.7	75	$36.2	$19.6
Turboprop under 20 seats (Part 23)	26	$1.0	$0.5	19	$19.8	$0.6
All Aircraft	**6,171**	**$17.6**	**$18.8**	**6,141**	**$182.8**	**$141.1**

Source: FlightGlobal Fleets Analyzer
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 5: 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: 2018 Cargo Air Carrier Fleet Sizes and Values

	1	2	3	4	5	6
Aircraft Category	**Number of Aircraft with Market Value Data**	**Weighted Average Current Market Value (millions)**	**Standard Deviation of Market Value (millions)**	**Number of Aircraft with Lease Rate Data**	**Weighted Average Monthly Market Lease Rate (thousands)**	**Standard Deviation of Monthly Market Lease Rate (thousands)**
Four-engine wide-body	90	$43.8	$48.2	90	$489.5	$301.1
Three-engine wide-body	142	$4.7	$2.2	113	$145.6	$20.3
Two-engine wide-body	383	$33.1	$31.2	383	$356.1	$207.6
Narrow-body more than 160 seats	53	$2.9	$2.0	33	$82.0	$7.6
Narrow-body 160 seats and below	194	$9.5	$3.5	194	$156.5	$38.7
RJ 60 seats and below	16	$0.6	$0.9	2	$65.0	$5.0
Turboprop more than 60 seats	96	$1.1	$0.3	50	$30.2	$4.2
Turboprop 20-60 seats	17	$3.7	$0.6	17	$59.4	$12.3
Turboprop under 20 seats (Part 23)	240	$0.5	$0.3	69	$19.3	$1.2
All Aircraft	**1,231**	**$15.9**	**$26.8**	**951**	**$246.0**	**$217.2**

Source: FlightGlobal Fleets Analyzer
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 5: 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 Fleets Analyzer database developed by FlightGlobal.[4] The database included all commercial aircraft accidents throughout the world from July 1, 1998 to July 1, 2018. 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

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.

[4] Fleets data and market insights

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 798 accident aircraft included in the analysis, with an average loss percentage of 20 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 $3.6 million.

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

	1	2	3	4
Aircraft Category	**Number of Accident Aircraft**	**Average Loss Percentage**	**Weighted Average Current Market Value (millions) of U.S. Fleet**	**Average Loss Value (millions) for U.S. Fleet**
Wide-body more than 300 seats	48	14%	$111.9	$15.3
Wide-body 300 seats and below	107	14%	$34.2	$4.8
Narrow-body more than 160 seats	54	9%	$29.8	$2.7
Narrow-body 160 seats and below	306	21%	$14.6	$3.1
RJ more than 60 seats	41	26%	$13.6	$3.5
RJ 60 seats and below	22	20%	$1.2	$0.2
Turboprop more than 60 seats	61	21%	$9.6	$2.0
Turboprop 20-60 seats	97	29%	$2.3	$0.7
Turboprop under 20 seats (Part 23)	60	25%	$1.0	$0.2
Piston engine (Part 25)	2	52%	NR	NR
All Aircraft	**798**	**20%**	**$17.6**	**$3.6**

Source: FlightGlobal Fleets Analyzer
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 128 accident aircraft included in the analysis, with an average loss percentage of 31 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 $4.9 million.

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

	1	2	3	4
Aircraft Category	**Number of Accident Aircraft**	**Average Loss Percentage**	**Weighted Average Current Market Value (millions) of U.S. Fleet**	**Average Loss Value for U.S. Fleet**
Four-engine wide-body	32	18%	$43.8	$8.1
Three-engine wide-body	17	16%	$4.7	$0.8
Two-engine wide-body	8	29%	$33.1	$9.6
Narrow-body more than 160 seats	12	30%	$2.9	$0.9
Narrow-body 160 seats and below	10	32%	$9.5	$3.0
Turboprop more than 60 seats	6	55%	$1.1	$0.6
Turboprop 20-60 seats	14	38%	$3.7	$1.4
Turboprop under 20 seats (Part 23)	28	43%	$0.5	$0.2
Piston engine (Part 25)	1	70%	NR	NR
All Aircraft	**128**	**31%**	**$15.9**	**$4.9**

Source: FlightGlobal Fleets Analyzer
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 4 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 (GA) aircraft were based on a methodology similar to that used for commercial air carriers. The primary source of data was the *Aircraft Bluebook (Fall, 2018)*.[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 nine Economic Values Aircraft Categories. The number of aircraft of each model and their age were based on data from FAA's Aircraft Registration Database, 2017 data set.[6] This is a change from previous releases of the Economic Values report, which used actual sample records and expansion factors (to match the Aircraft Registration Database) from the GA Survey by FAA's Office of Aviation Policy and Plans (APO-100). While populations in earlier reports were based on estimates of the population of *active* aircraft (those flown at least once during the year, based on survey responses), populations in this report are based on counts of all registered aircraft, whether flown or not during 2017.

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

[5] *Aircraft Bluebook. Overland Park, KS: Penton, Fall 2018.*
[6] *2017 Aircraft Registration Database* Aircraft Registration

was a major decline in GA aircraft production—primarily smaller piston engine aircraft—after 1982. The fleet age profile for smaller piston aircraft is significantly different than that for larger turbine aircraft. In examining the registered population of general aviation aircraft in the Aircraft Registration Database, it was possible to make some observations:

- More than two thirds (69%) of the fleet are piston fixed-wing aircraft
- 85% of single-engine fixed-wing piston and 91% of multiengine fixed-wing piston aircraft are more than 35 years old (manufactured before 1983)
- 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 Aircraft Category
- There is wide variation in the values of pre- and post-1983 aircraft

In order to devote more resources to investigating the values of newer, more valuable, and more varied aircraft populations, values were identified for the majority of pre-1983 piston-engine 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-1983 General Aviation Piston Aircraft ($2018)

Aircraft Category	Market Value	Aircraft	Share of Aircraft	Weighted Value
Piston engine airplanes, one-engine	Evaluated	78,179	66%	$43,958
	Not Evaluated	40,389	34%	
Piston engine airplanes, multi-engine	Evaluated	8,334	68%	$93,657
	Not Evaluated	4,004	32%	

Sources: FAA's *Aircraft Registration Database 2017, Aircraft Bluebook* (Fall, 2018).

For aircraft in other Aircraft Categories, and for piston-engine fixed-wing aircraft which were manufactured in 1983 or later, values were calculated as follows:

- Identify aircraft owned by air carriers, and exclude them from analysis
- Calculate the weighted mean year of manufacture of the registered fleet for each model (1983 and later production only for piston-engine fixed-wing aircraft)
- Identify the value for an aircraft of that year from the Aircraft Bluebook
- Apply that value to all examples of that model (examples manufactured in 1983 and later for piston-engine fixed-wing aircraft)

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 Aircraft Category to obtain a weighted average value for that class.

Because the Aircraft Registration Database includes aircraft owned by air carriers as well as general aviation aircraft, an attempt was made to identify the air carrier-owned aircraft and

exclude them. Since the registered owner of air carrier aircraft may be a leasing company, or a bank acting as trustee, this was not completely successful. 5,084 aircraft registered to air carriers were identified and excluded.

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 $470,740; the large standard deviation reflects the broad range of values in some aircraft categories.

Table 5-7: Estimated Market Values of General Aviation Aircraft ($2018)

		1	2	3	4	5	6
Aircraft Category	**Certification**	**All Years**					
		Fleet Total	**Average Value Per Aircraft**	**Minimum Value Per Aircraft**	**Maximum Value Per Aircraft**	**Standard Deviation of Average Value**	**Average Age**
Piston engine airplanes, one-engine	Part 23	161,470	$62,929	$26,000	$1,076,500	$60,978	48
Piston engine airplanes, multi-engine	Part 23	15,957	$113,681	$85,500	$1,240,000	$91,205	47
Turboprop airplanes, one-engine	Part 23	2,911	$1,717,582	$120,000	$3,500,000	$992,554	11
Turboprop airplanes, multi-engine	Part 23/25	4,909	$936,622	$43,000	$14,515,000	$1,337,784	37
Turbojet/turbofan airplanes	Part 23/25	16,110	$5,916,615	$75,000	$56,000,000	$8,611,581	18
Rotorcraft piston	Part 27Part/29	3,712	$202,862	$54,000	$525,000	$89,150	25
Rotorcraft turbine, one-engine	Part 27/Part 29	4,250	$1,001,434	$90,000	$5,425,000	$690,188	22
Rotorcraft turbine, multi-engine	Part 27/Part 29	1,454	$2,667,205	$275,000	$19,700,000	$2,404,607	17
Other		42,672	NA	NA	NA	NA	23
All Aircraft		**253,445**	**$470,740**	**$26,000**	**$56,000,000**	**NA**	**40**

Sources: FAA's Aircraft Registration Database 2017, Aircraft Bluebook (Fall, 2018); Conklin and de Decker's Aircraft Cost Evaluator (v18.2.0, 2018); Ascend Flightglobal data.

NA=Not Available

Note: Other Economic Values Category, and aircraft in other categories which could not be valued 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. Where 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 the Aircraft Registration Database with complete enough data to be assigned to an Aircraft Category.

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 2017.

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-1983 or 1983-and-later data depending upon which is most representative. Table 5-8 shows the estimated market values for the 165,794 registered aircraft manufactured before 1983. As can be seen, these aircraft are 54 years old on average and have an average market value of approximately $62,000.

Table 5-8: Estimated Market Values of Pre-1983 General Aviation Aircraft ($2018)

		1	2	3	4	5	6
		All Years					
Aircraft Category	Certification	Fleet Total	Average Value Per Aircraft	Minimum Value Per Aircraft	Maximum Value Per Aircraft	Standard Deviation of Average Value	Average Age
Piston engine airplanes, one-engine	Part 23	137,055	$43,958	$43,958	$43,958	$0	54
Piston engine airplanes, multi-engine	Part 23	14,595	$93,657	$93,657	$93,657	$0	49
Turboprop airplanes, one-engine	Part 23	106	$160,000	$120,000	$120,000	$164,924	52
Turboprop airplanes, multi-engine	Part 23/25	2,413	$523,881	$43,000	$2,950,000	$407,519	56
Turbojet/turbofan airplanes	Part 23/25	1,922	$476,743	$75,000	$3,700,000	$323,047	50
Rotorcraft piston	Part 27/Part 29	1,020	$83,932	$54,000	$129,000	$19,050	53
Rotorcraft turbine, one-engine	Part 27/Part 29	1,120	$449,354	$90,000	$1,900,000	$371,166	47
Rotorcraft turbine, multi-engine	Part 27/Part 29	224	$1,814,615	$275,000	$11,750,000	$1,120,531	41
Other		7,339	NA	NA	NA	NA	68
All Aircraft		**165,794**	**$62,163**	**$38,000**	**$11,750,000**	**NA**	**54**

Sources: FAA's Aircraft Registration Database 2017, Aircraft Bluebook (Fall, 2018); Conklin and de Decker's Aircraft Cost Evaluator (v18.2.0, 2018); Ascend Flightglobal data.

NA=Not Available

Note: Other Economic Values Category, and aircraft in other categories which could not be valued 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. Where 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 the Aircraft Registration Database with complete enough data to be assigned to an Aircraft Category.

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 2017.

Table 5-9 shows the market values for the 87,651 GA aircraft that were manufactured in 1983 or later. These aircraft have an average age of 14 years and an average market value of $2 million, which reflects both higher average values within each category as well as a higher proportion of turbine engine aircraft in the post-1983 fleet.

Table 5-9: Estimated Market Values of General Aviation Aircraft Manufactured 1984 and Later ($2018)

		1	2	3	4	5	6
Aircraft Category	Certification	All Years					
		Fleet Total	Average Value Per Aircraft	Minimum Value Per Aircraft	Maximum Value Per Aircraft	Standard Deviation of Average Value	Average Age
Piston engine airplanes, one-engine	Part 23	24,415	$189,352	$26,000	$1,076,500	$100,584	16
Piston engine airplanes, multi-engine	Part 23	1,362	$390,694	$85,500	$1,240,000	$202,841	18
Turboprop airplanes, one-engine	Part 23	2,805	$1,728,106	$120,000	$3,500,000	$987,491	10
Turboprop airplanes, multi-engine	Part 23/25	2,496	$1,480,881	$170,000	$14,515,000	$1,846,880	20
Turbojet/turbofan airplanes	Part 23/25	14,188	$6,684,558	$145,000	$56,000,000	$8,935,712	14
Rotorcraft piston	Part 27/Part 29	2,692	$221,356	$55,000	$525,000	$81,150	14
Rotorcraft turbine, one-engine	Part 27/Part 29	3,130	$1,163,206	$270,000	$5,425,000	$678,337	14
Rotorcraft turbine, multi-engine	Part 27/Part 29	1,230	$2,826,578	$275,000	$19,700,000	$2,543,528	13
Other		35,333	NA	NA	NA	NA	14
All Aircraft		**87,651**	**$2,017,850**	**$26,000**	**$56,000,000**	**NA**	**14**

Sources: FAA's Aircraft Registration Database 2017, Aircraft Bluebook (Fall, 2018); Conklin and de Decker's Aircraft Cost Evaluator (v18.2.0, 2018); Ascend Flightglobal data.

NA=Not Available

Note: Other Economic Values Category, and aircraft in other categories which could not be valued 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. Where 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 the Aircraft Registration Database with complete enough data to be assigned to an Aircraft Category.

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 2017.

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 Aircraft 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 2018 market values from Tables 5-7 through 5-9.[7] Restoration costs by Aircraft 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 20% to 24%, and is 20% overall.

Table 5-10: General Aviation Restoration Costs ($2018)

		1	2	3
Aircraft Category	**Certification**	**Average of Hull Value**	**Average of Hull Damage**	**Damage/ Value**
Piston engine airplanes, one-engine	Part 23	$62,929	$12,995	21%
Piston engine airplanes, multi-engine	Part 23	$113,681	$27,209	24%
Turboprop airplanes, one-engine	Part 23	$1,717,582	$350,035	20%
Turboprop airplanes, multi-engine	Part 23/25	$936,622	$190,879	20%
Turbojet/turbofan airplanes	Part 23/25	$5,916,615	$1,205,779	20%
Rotorcraft piston	Part 27/Part 29	$202,862	$41,342	20%
Rotorcraft turbine, one-engine	Part 27/Part 29	$1,001,434	$204,088	20%
Rotorcraft turbine, multi-engine	Part 27/Part 29	$2,667,205	$543,564	20%
Other		NA	NA	NA
All Aircraft		**$470,740**	**$95,935**	**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. Based on claims in databases from Airclaims and AVEMCO.

Table 5-11 shows general aviation restoration values for aircraft that were manufactured before 1983. Average hull damage is about 26 percent of average hull value, and ranges as high as 31 percent.

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

Table 5-11: General Aviation Restoration Costs for Pre-1983 Aircraft ($2018)

		1	2	3
Aircraft Category	**Certification**	**Average of Hull Value**	**Average of Hull Damage**	**Damage/ Value**
Piston engine airplanes, one-engine	Part 23	$43,958	$9,746	22%
Piston engine airplanes, multi-engine	Part 23	$93,657	$22,795	24%
Turboprop airplanes, one-engine	Part 23	$160,000	$41,653	26%
Turboprop airplanes, multi-engine	Part 23/25	$523,881	$136,383	26%
Turbojet/turbofan airplanes	Part 23/25	$476,743	$148,326	31%
Rotorcraft piston	Part 27/Part 29	$83,932	$21,850	26%
Rotorcraft turbine, one-engine	Part 27/Part 29	$449,354	$116,981	26%
Rotorcraft turbine, multi-engine	Part 27/Part 29	$1,814,615	$472,401	26%
Other		NA	NA	NA
All Aircraft		**$62,163**	**$16,183**	**26%**

*Average Hull Value=Average Market Value from Table 5-8; Average Hull Damage="Damage/Value" for All Aircraft (~26%) 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. Based on claims in databases from Airclaims and AVEMCO.

Restoration values for the aircraft manufactured in 1983 or later are summarized in Table 5-12. Average hull damage is about 15 percent of average hull value, ranging as high as 18 percent. While the damage value percentages are lower, the absolute values of damages are higher in the post-1983 fleet, which reflects the higher values of the newer aircraft.

Table 5-12: General Aviation Restoration Costs for 1983 and Later Aircraft ($2018)

		1	2	3
Aircraft Category	**Certification**	**Average of Hull Value**	**Average of Hull Damage**	**Damage/ Value**
Piston engine airplanes, one-engine	Part 23	$189,352	$29,053	15%
Piston engine airplanes, multi-engine	Part 23	$390,694	$68,482	18%
Turboprop airplanes, one-engine	Part 23	$1,728,106	$266,853	15%
Turboprop airplanes, multi-engine	Part 23/25	$1,480,881	$228,677	15%
Turbojet/turbofan airplanes	Part 23/25	$6,684,558	$1,054,497	16%
Rotorcraft piston	Part 27/Part 29	$221,356	$34,182	15%
Rotorcraft turbine, one-engine	Part 27/Part 29	$1,163,206	$179,622	15%
Rotorcraft turbine, multi-engine	Part 27/Part 29	$2,826,578	$436,479	15%
Other		NA	NA	NA
All Aircraft		**$2,017,850**	**$311,595**	**15%**

*Average Hull Value=Average Market Value from Table 5-7; Average Hull Damage="Damage/Value" for All Aircraft (~15%) 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. 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 should 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 5-13. Values from these reports were indexed to 2018 dollars.

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 5-13. This number is believed to 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 Bomber Page accessed March 23, 2015

Table 5-13: Summary of Military Aircraft Values and Restoration Costs (FY2018 $ Millions) – Average Weighted by Fleet

	1	2	3	4
Aircraft Type	**Total Fleet**	**Average Replacement Value**	**Average Restoration Value**	**Restoration Percentage**
Turbojet/fan 3+ Engine	834	$159.4	$0.8	0.5%
Turbojet/fan Attack/Fighter	3,256	$116.7	$2.2	1.9%
Turbojet/fan Other	977	$127.3	$9.5	7.5%
Turboprop	1,569	$47.3	$1.9	4.0%
Piston	32	N/A	N/A	N/A
Rotary Wing Aircraft	6,030	$34.7	$2.1	6.1%
UAV	301	$402.7	N/A	N/A
Glider	N/A	N/A	N/A	N/A
All Aircraft	**12,999**	**$80.4**	**$2.6**	**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