6. ECONOMIC VALUES RELATED TO AIRCRAFT PERFORMANCE FACTORS

6.1 INTRODUCTION

Certain types of investment programs or regulatory changes can affect aircraft performance. This can occur by changing the weight of the aircraft, which in turn changes the fuel burn as well as altering the time in certain phases of flight. This section covers two elements related to aircraft performance:

- The changes in fuel use caused by incremental changes in aircraft weight
- The proportion of time spent in various phases of flight on representative aircraft missions, which may also be influenced by changes in aircraft weight

Measures are developed for air carrier and general aviation aircraft. Data were not available on military aircraft performance. This section also contains data on the price of aviation fuel and sources for updated information on fuel prices.

The objective of this section is to provide values for use in economic analyses related to investment and regulatory decisions that alter the performance of aircraft. For example, increases in aircraft weight affect fuel burn. The issue of when mandated increases in aircraft weight affect the suitability of an aircraft for specific missions is not directly examined in this section. For example, aircraft are designed with a target mission in terms of payload and range in mind, and these are performed at an assumed maximum aircraft weight. If a regulation were to cause a large change in aircraft weight, then the aircraft may not be capable of performing some of the missions for which it was designed. In this section, the values presented assume that the incremental changes in aircraft weight do not occur at the limits of the payload-range envelope.

When regulatory actions occur during the aircraft design phase, aircraft weight increases will often cause an increase in installed power, fuel capacity, and so forth to maintain the target payload-range capability. Essentially, the increase in aircraft weight requires an increase in the amount of fuel used to fly the same mission. The increase in fuel used adds weight to the aircraft requiring additional fuel to be carried. The aircraft design would then be optimized for these new performance parameters. The re-optimization of an aircraft design is not considered in the values developed below. Re-optimization of a design may be the most appropriate type of analysis in some cases; however, it is not possible to capture this in a standard economic value.

6.2 APPROACH

The current analysis was performed in 2024 and is an update to the previously-published analyses that were performed in 2015 and 2019. Tables 6-1 through 6-4 include the results of the 2024 analysis together with the results of the previous analyses. In most cases, the aircraft / stage length combinations analyzed in the 2015 and 2019 analyses were not re-analyzed in 2024 because there were no changes to the underlying data that would affect results.

The aircraft selected for analysis were based on review of FAA's Air Traffic Services Business Model (ATSBM) data[1] regarding the types of aircraft operating in the National Airspace System (NAS) and the stage lengths at which they were operated, along with ch-aviation U.S. air carrier fleet data.[2] FAA selected the most frequently observed aircraft within each aircraft category/user group combination and determined the typical stage length(s) for the missions performed by this aircraft.

These form the basis for the mission lengths over which the increases in fuel burn (based on increases in aircraft weight) were calculated, and for which flight segment times were developed. Research conducted for a prior economic values study (FAA-APO-98-8: Tables 7-16 and 7-18) showed that the incremental fuel burn per pound of additional weight was relatively constant over the range of weight added. Weight penalties used in this report range from 100 to 500 pounds depending on aircraft type.

6.2.1. Air Carrier Aircraft

The air carrier aircraft presented in this report were the most common aircraft types operated by U.S. air carriers in November 2023 based on fleet size data from ch-aviation. In some cases, aircraft manufacturer data necessary for calculating fuel burn were not available for the selected aircraft. In these cases, the next most common aircraft type for which data were available was chosen.

6.2.2. General Aviation Aircraft

General aviation aircraft performance data were not updated for this 2024 analysis. The results of the 2015 and 2019 analyses are presented in this report

6.2.3. Aircraft Performance Data

The data presented in this analysis were based on flight test results obtained at aircraft certification and represent the nominal level of performance at aircraft delivery. The performance manuals are produced by the aircraft manufacturer and represent the optimal performance achievable by the operator. Due to external and internal configuration changes, the aircraft's actual performance will vary as a factor of weight, operating conditions, etc. In addition, it can be expected that actual aircraft performance will degrade as the aircraft ages,

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[1] The ATSBM provides data on all flights operating under instrument flight rules (IFR) that were operated in the NAS.

[2] https://www.ch-aviation.com/aircraft

further restricting its capabilities. For example, no factor has been applied to account for degradation in fuel efficiency over time.

6.2.3.1. General Assumptions

The analysis was performed in accordance with Approved Transport Category Operations, in particular Part 25, paragraph 25.121 and amendment 42. Regulatory performance is calculated with air conditioning bleeds off. Small aircraft performance is determined with reference to Part 23, Part 27, Part 29 or Part 135 requirements.

Climb, cruise, descent, and holding fuel flows are calculated on the basis of an economic air conditioning mode. Takeoff performance is calculated for zero wind, dry, hard and level runway, and no obstacles. Holding and diversion fuel allowances were calculated for the respective aircraft weights at the beginning of the hold or diversion profile.

6.2.3.2. Aircraft Parameters

The Operating Empty Weight (OEW) is the weight of a typical aircraft, as equipped for passenger operations. Included in the OEW is the manufacturer’s empty weight plus standard and operational items. Standard items include unusable fuel, seats, carpet, engine oil, emergency equipment, toilet fluids and chemicals, galley, buffet, etc. Operational items include crew, baggage, manuals, food, beverages, and life vests, among others.

The Maximum Zero Fuel Weight (MZFW) is the maximum allowable weight of the aircraft before fuel is added.

The Maximum Structural Payload is the difference between the MZFW and the OEW. For purposes of this analysis, payloads between 75 and 95 percent of the maximum structural payload were assumed for the base case performance analysis for passenger aircraft, and payloads between 45 and 80 percent of the maximum structure payload were assumed for cargo aircraft. An additional calculation involving a 500-, 200-, or 100-pound payload increment was then performed. The difference in fuel burn against the base case was determined to be the incremental fuel burn for the weight increment.

The Maximum Landing Weight (MLW) is the certified maximum allowable weight of the aircraft at touchdown.

Mission Takeoff Weight is the total of OEW, passenger and/or cargo weight, mission fuel weight and reserve fuel weight. Takeoff weight may be limited by aircraft performance. Mission Takeoff Weight may be less than the Maximum Takeoff Weight (MTOW).

The combination of maximum payload and maximum fuel weight plus the OEW may exceed the MTOW. In such situations, the operator must balance (reduce) payload, reserves, and mission needs to achieve the requirements of the flight profile to reduce the overall weight to MTOW or below. This involves a tradeoff between the payload and fuel load carried, and generally affects the maximum range that can be achieved.

6.2.3.3. Flight Profile

A mission is conducted over a specified distance. The effects of wind were not included in the analysis. The mission distance is applied from takeoff point (origin airport) to landing point (destination airport). No distance credit is taken for the taxi-out, takeoff, approach and landing, and taxi-in, as these segments may not be in the same direction as the desired flight path.

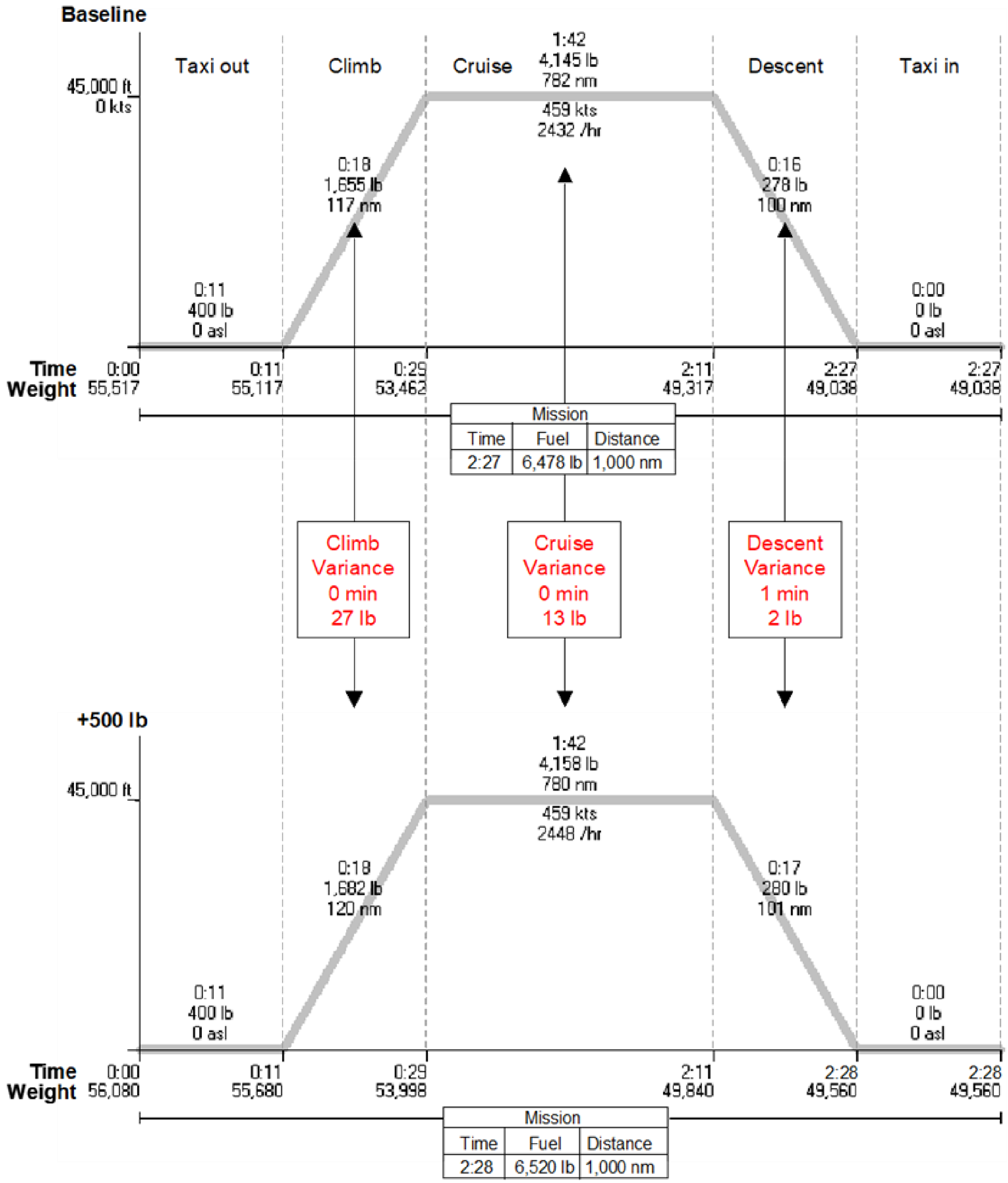
All of the factors shown above must be taken into account for proper mission planning. A computer model was used with given parameters to calculate the optimal result. For optimization purposes, the computer model iterates to achieve the best payload vs. time ratio. This is due to most costs being time based.

The current industry practice is to allow the aircraft to maintain straight and level flight (in the mission cruise portion) for a minimum of 30 percent of the mission distance. This is to allow for safe movement about the cabin and the servicing of passengers.

Figure 6-1 illustrates the development of performance changes related to a 500-pound weight penalty for a Gulfstream IV operating at a 1,000 nm stage length. The assumptions include an instrument standard (ISA) day, zero winds, level operation, 70 percent payload, Mach 0.8 cruise speed and National Business Aviation Association (NBAA) instrument flight rules (IFR) reserves. It shows the mission time, fuel burn and distance for each flight segment. The top part of the figure is the baseline mission, and the bottom part is the same mission with a 500-pound weight penalty. The mission with the 500-pound weight penalty uses 42 more pounds of fuel, while the flight time for the mission is increased by one minute from 2 hours 27 minutes to 2 hours 28 minutes.

The performance models and manufacturer data also permit estimation of the time an aircraft spends in various mission segments of a flight including taxi-out, takeoff, climb, cruise, descent, landing, and taxi-in. Not all mission segments are available for each aircraft analyzed, using manufacturer data.

Figure 6-1: Gulfstream IV Illustrative Performance Calculations
1,000nm Stage Length and 500 lb Weight Penalty*



Total variance for 500 lb weight increase = 1 min of additional flight time and 42 lb or 6.3 U.S. gallons of additional fuel

* Range 1,000 nm, ISA, zero winds, sea level takeoff, 70% payload, cruise at Mach 0.80 and NBAA IFR reserves

6.3 AIR CARRIER AIRCRAFT

This section presents the analysis of weight penalties and mission segments for air carrier aircraft. It considers aircraft used in passenger or combination service as well as those used in all-cargo service.

6.3.1. Incremental Fuel Burn

As noted above, incremental fuel burn related to an increase in aircraft weight was calculated for selected aircraft types and selected stage lengths. The aircraft types selected present a sampling of the most common aircraft in use within each economic values category. Mission lengths were based on typical mission lengths for each aircraft type, as observed in FY2013, FY2018, and FY2023 ATSBM data; in many cases, the aircraft analyzed in 2024 used the same stage lengths as were used for other aircraft in the same aircraft category in the 2015 and 2019 analyses for ease of comparison. For most aircraft models, multiple mission lengths were analyzed. In some cases, new stage lengths were added to reflect industry trends that have developed since the previous analysis, such as longer-haul flights on newer technology aircraft. A weight penalty of 500 pounds was used for most larger narrow-body and wide-body jet aircraft, while a weight penalty of 200 pounds was used for most smaller narrow-body, regional jet and turboprop aircraft. In a few cases, these weight penalties did not produce reliable results, so a different weight penalty was used.

Tables 6-1 through 6-3 present the results for all commercial aircraft (including both passenger and all-cargo aircraft). The tables present the aircraft type, passenger or cargo configuration, the stage lengths analyzed, the weight penalty and the incremental fuel burn in pounds per flight.[3] In addition, the incremental fuel burn per pound of weight added is calculated in U.S. gallons per flight.[4] Also shown is the total flight time for the specific mission analyzed. The incremental fuel burn in gallons per hour per pound of weight added is calculated by dividing the incremental fuel burn per flight per pound of weight added by the flight time.

As noted above, prior research has shown that the incremental fuel burn per pound of weight added is relatively constant for the weight increases considered in this section. Therefore, the additional fuel consumption per year can be estimated by the amount of weight added times the incremental fuel burn times the annual utilization in flight hours. For example, assume that a regulation imposes a 200-pound weight penalty on a B737-700W that operates over a 500 nm average stage length for 3,000 hours per year. The annual cost at $3.11 per gallon for the additional fuel consumed because of the increase in aircraft weight is $6,531 (3,000 hours x $3.11 per gallon x 0.0035 incremental gallons per flight hour per pound of weight added x 200-pound weight penalty).

[3] Shorter distances generally imply different speed schedules and lower cruising altitudes leading to a different optimum. Therefore, some aircraft behave differently than others when flown on a shorter stage length versus a longer state length. However, the data tend to reflect the reality of using a long-range aircraft on a short-range flight.
[4] Fuel weight in pounds is converted to U.S. gallons by using 6.7 lbs. per gallon.

Table 6-1: Widebody Air Carrier Aircraft – Incremental Fuel Burn

			1	2	3	4	5	6
Aircraft Category	**Service Type**	**Aircraft Type**	**Stage Length (nautical miles)**	**Weight Penalty (pounds)**	**Incremental Fuel Burn per Flight (pounds)**	**Incremental Fuel Burn per Flight per Pound of Weight Added (gallons)**	**Flight Time (hours)**	**Incremental Fuel Burn per Flight Hour per Pound of Weight Added (gallons)**
Widebody 580k lbs or more MTOW	Passenger	B747-400	5,000	500	199	0.059	11.2	0.0053
		B777-200	2,200	500	58	0.017	4.7	0.0036
			5,000	500	176	0.052	10.1	0.0052
		B777-300	2,000	500	68	0.020	4.7	0.0043
			5,000	500	210	0.063	10.3	0.0061
		A350-900	2,000	500	57	0.017	4.6	0.0037
			5,000	500	191	0.057	10.3	0.0056
			7,000	500	268	0.080	14.6	0.0055
Widebody less than 580k lbs MTOW	Passenger/ All-Cargo	B767-300	2,200	500	85	0.025	5.3	0.0048
			5,000	500	203	0.061	11.3	0.0054
	Passenger	A330-200	2,000	500	63	0.019	3.9	0.0048
			5,000	500	146	0.044	10.6	0.0041
		A330-900	2,000	500	66	0.020	4.0	0.0049
			5,000	500	165	0.049	10.7	0.0046
		B787-8	2,000	500	48	0.014	4.7	0.0031
			5,000	500	175	0.052	10.3	0.0051
		B787-9	1,000	500	38	0.011	2.0	0.0057
			2,000	500	59	0.018	4.0	0.0044
			5,000	500	168	0.050	10.3	0.0049
			7,000	500	261	0.078	14.4	0.0054
		B787-10	2,000	500	66	0.020	4.1	0.0048
			5,000	500	207	0.062	10.2	0.0061
Four-engine widebody	All-Cargo	B747-8	5,000	500	246	0.073	10.3	0.0071
Three-engine widebody	All-Cargo	MD-11F	1,500	500	60	0.018	3.3	0.0054
			4,000	500	159	0.047	8.8	0.0054
Two-engine widebody	All-Cargo	A300F	700	500	26	0.008	1.7	0.0047
			1,500	500	57	0.017	3.6	0.0048
		B767-300F	500	500	20	0.006	1.1	0.0054
		B777-200F	1,500	500	55	0.017	4.2	0.0039
			4,000	500	171	0.051	9.4	0.0544

Table 6-2: Narrowbody Air Carrier Aircraft – Incremental Fuel Burn

			1	2	3	4	5	6
Aircraft Category	**Service Type**	**Aircraft Type**	**Stage Length (nautical miles)**	**Weight Penalty (pounds)**	**Incremental Fuel Burn per Flight (pounds)**	**Incremental Fuel Burn per Flight per Pound of Weight Added (gallons)**	**Flight Time (hours)**	**Incremental Fuel Burn per Flight Hour per Pound of Weight Added (gallons)**
Narrowbody 165k lbs or more MTOW	Passenger / All-Cargo	B757-200	1,000	500	37	0.011	2.7	0.0042
			2,000	500	80	0.024	4.8	0.0049
	Passenger	A321	500	500	10	0.003	1.5	0.0020
			1,000	500	14	0.004	2.4	0.0018
			2,000	500	22	0.006	4.8	0.0013
		A320	500	500	13	0.004	1.4	0.0028
			1,000	500	16	0.005	2.4	0.0020
			2,000	500	26	0.008	4.6	0.0017
		A320neo	500	500	7	0.002	1.3	0.0017
			1,000	500	13	0.004	2.3	0.0017
			2,000	500	31	0.009	4.5	0.0020
		A321neo	1,000	500	13	0.004	2.4	0.0016
			2,000	500	27	0.008	4.6	0.0017
			3,000	500	42	0.013	6.8	0.0018
		B737-800W	1,000	500	41	0.012	2.7	0.0046
			2,000	500	89	0.027	4.9	0.0054
		B737 MAX 8	500	500	15	0.004	1.4	0.0032
			1,000	500	36	0.011	2.3	0.0046
			2,000	500	79	0.023	4.5	0.0052
		B737 MAX 9	1,000	500	13	0.004	2.5	0.0016
			2,000	500	25	0.007	4.8	0.0015
		B737-900	500	500	6	0.002	1.4	0.0012
			1,000	500	9	0.003	2.3	0.0012
			2,000	500	20	0.006	4.4	0.0014
Narrowbody less than 165k lbs MTOW	Passenger/ All-Cargo	B737-300	500	200	10	0.007	1.6	0.0048
			500	500	22	0.007	1.6	0.0041
			1,000	200	21	0.016	2.7	0.0057
	Passenger	E190	250	500	45	0.013	0.9	0.0145
			1,000	500	70	0.021	2.8	0.0073
		A319	500	200	7	0.005	1.5	0.0035
			1,000	200	13	0.010	2.6	0.0037
		B717-200	500	500	24	0.007	1.6	0.0046
		B737-700W	500	200	7	0.005	1.5	0.0035
			500	500	19	0.006	1.6	0.0036
			1,000	200	17	0.013	2.6	0.0048
		A220-100	500	200	9	0.007	1.3	0.0052
			1,000	200	18	0.013	2.4	0.0055
		A220-300	500	200	11	0.008	1.3	0.0063
			1,000	200	22	0.016	2.4	0.0067

Table 6-3: RJ and Turboprop Air Carrier Aircraft – Incremental Fuel Burn

			1	2	3	4	5	6
Aircraft Category	**Service Type**	**Aircraft Type**	**Stage Length (nautical miles)**	**Weight Penalty (pounds)**	**Incremental Fuel Burn per Flight (pounds)**	**Incremental Fuel Burn per Flight per Pound of Weight Added (gallons)**	**Flight Time (hours)**	**Incremental Fuel Burn per Flight Hour per Pound of Weight Added (gallons)**
RJ more than 60 seats	Passenger	CRJ700	250	200	5	0.004	0.9	0.0040
			500	200	9	0.007	1.5	0.0045
		CRJ900	250	200	5	0.004	0.9	0.0039
			500	200	8	0.006	1.5	0.0040
			750	500	27	0.008	1.7	0.0047
		E175	250	200	4	0.003	1.0	0.0031
			500	200	11	0.008	1.5	0.0054
		E175 E2	250	200	4	0.003	1.0	0.0031
			500	200	10	0.008	1.5	0.0051
RJ 60 seats and below	Passenger	CRJ200	250	200	5	0.004	0.9	0.0040
			500	200	13	0.010	1.5	0.0064
		ERJ 145	250	200	3	0.002	0.9	0.0024
			500	200	12	0.009	1.5	0.0059
Turboprop more than 60 seats	Passenger	Dash 8-400	200	500	6	0.002	1.0	0.0017
			500	500	16	0.005	2.0	0.0024
	All-Cargo	ATR 72-200	250	500	9	0.003	1.3	0.0021
			500	500	19	0.006	2.3	0.0025
		ATR 72-600	200	500	5	0.001	0.9	0.0016
			500	500	15	0.004	2.1	0.0021
Turboprop 20-60 seats	Passenger	Dash 8-100	200	200	2	0.001	1.1	0.0014
			500	200	5	0.004	2.2	0.0017
		E120	200	200	4	0.003	1.0	0.0029
			500	200	6	0.004	2.0	0.0023
		SF340	200	200	1	0.001	1.1	0.0007
			500	200	2	0.001	2.2	0.0007
	All-Cargo	ATR 42-300	200	200	2	0.001	1.1	0.0013
			500	200	4	0.003	2.3	0.0013
Turboprop under 20 seats	Passenger	Beech 1900	200	200	4	0.003	1.2	0.0025
			500	200	19	0.014	2.6	0.0055
	All-Cargo	Beech 65a90	150	200	2	0.001	1.0	0.0015
		Beech 99	100	200	0.2	0.000	0.5	0.0003
		Cessna 208	150	100	1	0.001	1.0	0.0012

6.3.2. Flight Profiles

Flight profiles for air carrier aircraft are presented in Table 6-4. These are based on simple averages of the data from some of the specific aircraft that were used for calculating the incremental fuel burn shown in Tables 6-1 to 6-3.[5] Since flight profiles were not available for some aircraft used in Tables 6-1 to 6-3, the specific aircraft types used in Table 6-4 are shown in the table. Not all mission segments could be calculated for each aircraft, and some have been aggregated.

Table 6-4: Air Carrier Aircraft – Breakdown of Flight Profiles

Aircraft Category	Aircraft Types Included in this Table	Average Flight Profiles (minutes)					
		Taxi Out and Take off	Climb	Cruise	Descent and Landing	Taxi In	Total
Widebody 580k lbs or more MTOW	B777-200	NC	20	401	24	NC	445
Widebody less than 580k lbs MTOW	A330-200	12	14	437	22	5	490
Four-engine widebody	No Detailed Flight Path Data Available						
Three-engine widebody	No Detailed Flight Path Data Available						
Two-engine widebody	No Detailed Flight Path Data Available						
Narrowbody 165k lbs or more MTOW	A320; A321; B737-800W	12	18	112	19	5	167
Narrowbody less than 165k lbs MTOW	E190; A319; B737-300; B737-700W	12	20	65	19	5	120
RJ more than 60 seats	CRJ700; CRJ900; E175; E175 E2	12	20	21	17	5	74
RJ 60 seats and below	CRJ200	12	23	19	16	5	74
Turboprop more than 60 seats	ATR 72-200; Dash 8-400	11	21	46	17	5	100
Turboprop 20 - 60 seats	ATR 42-300; Dash 8-100; EMB-120; SF340	11	18	50	13	5	97
Turboprop under 20 seats	Beech 1900; Beech 65a90; Cessna 208	6	18	46	14	5	89

Source: GRA analysis of aircraft manufacturer data
NC = not calculated

[5] Weighted averages were not calculated because there was not a good representation of the aircraft within each group. Thus, the category averages should be viewed as approximations of the amount of flight time in each flight segment of a typical aircraft mission.

6.4 GENERAL AVIATION

Table 6-5 contains the results of the performance analysis of weight penalties for selected general aviation and air taxi aircraft. As noted above, this section presents the results of analyses performed in 2015 and 2019 as general aviation and air taxi performance data were not updated in the 2024 analysis. The underlying performance data does not differentiate between air taxi and other general aviation aircraft. The same mission analysis rules as above were used except that a weight penalty of 100 pounds was applied to all aircraft. In addition, rotorcraft performance is considered in this section. As can be seen, most aircraft were evaluated over one proposed mission length, except for the Global Express business jet which was evaluated at two mission lengths. The table shows the amount of the weight penalty, the incremental fuel burn per flight in pounds, and the incremental fuel burn per flight per pound of added weight in gallons. The flight time for the assumed mission and the incremental fuel burn per pound of weight added per flight hour are also shown in this table.

Table 6-5: General Aviation and Air Taxi Aircraft – Incremental Fuel Burn

Aircraft Category	Aircraft Type	FAR Part	1 Stage Length (nautical miles)	2 Weight Penalty (pounds)	3 Incremental Fuel Burn per Flight (pounds)	4 Incremental Fuel Burn per Flight per Pound of Weight Added (gallons)	5 Flight Time (hours)	6 Incremental Fuel Burn per Flight Hour per Pound of Weight Added (gallons)
Piston engine airplanes, one-engine	Cessna 172	23	150	100	0.725	0.001	1.4	0.0007
	Cirrus SR22	23	250	100	de minimis	de minimis	1.5	de minimis
Piston engine airplanes, multi-engine	Piper PA-30	23	250	100	0.648	0.001	1.7	0.0006
	Beech Baron	23	250	100	0.769	0.001	1.4	0.0008
Turboprop airplanes, one-engine	TBM700	23	300	100	1.307	0.002	1.2	0.0017
	Cessna 208	23	150	100	0.499	0.001	1.0	0.0008
	Pilatus PC-12	23	270	100	3.090	0.005	1.3	0.0037
Turboprop airplanes, multi-engine	Beech King Air B200	23	300	100	0.826	0.001	1.0	0.0012
Turbojet/turbofan airplanes	Phenom 100	23	400	100	2.040	0.003	1.3	0.0023
	Cessna 560	25	400	100	4.553	0.007	1.2	0.0057
	Global Express	25	900	100	4.000	0.006	1.9	0.0031
		25	1,450	100	4.000	0.006	3.1	0.0020
Rotorcraft piston	R44	27	100	100	1.411	0.002	1.7	0.0013
Rotorcraft turbine, one-engine	Bell 206	27	100	100	2.792	0.004	0.9	0.0047
	Bell UH-1	29	100	100	1.500	0.002	1.0	0.0022
Rotorcraft turbine, multi-engine	EC145/BK117	29	100	100	1.031	0.002	0.8	0.0031

Source: GRA analysis of aircraft manufacturer data

Col 1: Typical stage length(s) for aircraft type based on analysis of FAA Air Traffic Services Business Model (ATSBM) data
Col 2: A weight penalty of 100 pounds was used for general aviation aircraft
Col 3: The incremental fuel (in pounds) that would be burned based on manufacturer data and Columns 1 and 2
Col 4: Column 3 divided by Column 2 divided by 6.7 (conversion factor of jet fuel in pounds to gallons)
Col 5: Manufacturer data based on Column 1
Col 6: Column 4 divided by Column 5

Table 6-6 summarizes performance data for the general aviation and air taxi aircraft. Performance profiles allow consideration of the proportion of mission length spent in each part of the flight profile. This permits calculation of costs by amount of time in each part of the flight using the cost data per flight hour from Section 4.

Table 6-6: General Aviation and Air Taxi Aircraft – Breakdown of Flight Profiles

Aircraft Category	Aircraft Type	Stage Length (nautical miles)	Fuel Type	Data in minutes					
				Taxi Out and Takeoff	Climb	Cruise	Descent and Landing	Taxi In	Total
Piston engine airplanes, one-engine	Cessna 172	150	Avgas	1	9	70	6	NC	87
	Cirrus SR22	250	Avgas	NC	5	88	NC	NC	93
Piston engine airplanes, multi-engine	Piper PA-30	250	Avgas	1	9	85	7	NC	102
	Beech Baron	250	Avgas	1	8	58	16	NC	83
Turboprop airplanes, one-engine	TBM700	300	Jet A	1	14	40	15	NC	70
	Cessna 208	150	Jet A	1	11	32	15	NC	59
	Pilatus PC-12	270	Jet A	NC	10	57	8	NC	75
Turboprop airplanes, multi-engine	Beech King Air B200	300	Jet A	1	7	43	10	NC	61
Turbojet/turbofan airplanes	Phenom 100	400	Jet A	1	9	63	6	NC	79
	Cessna 560	400	Jet A	1	8	48	16	NC	72
	Global Express	900	Jet A	1	10	93	13	5	132
		1,450	Jet A	1	10	160	13	5	199
Rotorcraft piston	R44	100	Avgas	NC	NC	100	NC	NC	100
Rotorcraft turbine, one-engine	Bell 206	100	Jet A	NC	NC	53	NC	NC	53
	Bell UH-1	100	Jet A	NC	NC	60	NC	NC	60
Rotorcraft turbine, multi-engine	EC145/BK117	100	Jet A	NC	NC	46	NC	NC	46

Source: GRA analysis of aircraft manufacturer data
NC = Not Calculated

6.5 FUEL COSTS

In order to apply the incremental fuel burn data to an economic analysis, fuel price information is required. Data have been developed for both air carrier (Jet-A) and general aviation fuel (Jet-A and Avgas). Piston engine aircraft consume aviation gasoline (Avgas) while all other aircraft consume Jet-A.

Table 6-7 presents fuel consumption (Jet-A) reported by carriers filing Form 41, Schedule P-1.2(a). In addition to fuel consumption, carriers report fuel cost, from which an average cost per gallon was calculated. Readers should be cautioned that large air carriers generally buy fuel in significant quantities and therefore pay substantially less than other users. In addition, some carriers purchase hedge contracts to insulate themselves from rapid increases in fuel prices. Smaller carriers may pay more than the average price of fuel for Form 41 carriers.

Table 6-7: Year Ended June 2023 Fuel Cost and Consumption by Region for U.S. Majors, Nationals, and Large Regionals

Region	Fuel Consumption (gallons, millions)	Cost	Average Cost per Gallon
Domestic: Intra-Alaska	27	$84m	$3.11
Domestic: All other service	11,941	$37,308m	$3.12
International: Atlantic	2,793	$8,584m	$3.07
International: Latin America	1,540	$5,030m	$3.27
International: Pacific	1,340	$3,916m	$2.92
Total	**17,640**	**$54,922m**	**$3.11**

Source: Form 41, Schedule P-1.2(a)
Note: Includes scheduled service only

Table 6-8 reports general aviation fuel prices for Jet-A and Avgas. These data are for December 2022. While the prices in Table 6-7 are pretax and represent advance bulk purchases by commercial carriers, those in

Table 6-8 include tax and represent retail purchases for refueling at general aviation airports, which accounts for the large differences in fuel prices. Also, aviation gasoline costs slightly more per gallon than jet fuel, with prices averaging about $6.49 per gallon for Avgas vs. $6.36 per gallon for Jet-A fuel.

Table 6-8: General Aviation Jet-A and Avgas Per Gallon Fuel Prices ($2022)

Region	Jet-A High Price	Jet-A Low Price	Jet-A Average Price	Avgas High Price	Avgas Low Price	Avgas Average Price
Alaskan	$11.00	$5.00	$8.28	$11.50	$7.44	$9.84
Eastern	$10.59	$4.54	$6.94	$9.79	$4.41	$6.80
New England	$10.55	$4.75	$7.14	$9.86	$5.36	$6.96
Great Lakes	$9.38	$3.99	$6.13	$9.28	$4.65	$6.46
Central	$9.98	$4.00	$6.08	$8.51	$4.74	$6.24
Southern	$10.03	$4.12	$6.15	$10.85	$4.26	$6.29
Southwest	$10.56	$4.20	$6.07	$9.50	$3.50	$6.14
NW Mountain	$10.10	$4.63	$6.68	$8.90	$4.92	$6.83
Western Pacific	$10.11	$4.23	$6.64	$9.89	$4.65	$6.80
Nationwide	**$11.00**	**$3.99**	**$6.36**	**$11.50**	**$3.50**	**$6.49**

The table above shows results of a fuel price survey of U. S. fuel suppliers performed in December 2022.
Prices include taxes and fees.
Source: www.airnav.com

Table 6-9 shows the average rate of fuel consumption (gallons per hour) and the estimated annual fuel use in millions of gallons for the general aviation fleet in 2022.

Table 6-9: 2022 General Aviation Total Fuel Consumed and Average Fuel Consumption Rate by Aircraft Type (Includes Air Taxi Aircraft; Excludes Commuter Aircraft)

Aircraft Category	Jet Fuel		Aviation Gasoline: 100 Low Lead		Automotive Gasoline		Total Fuel Use	
	Average Rate (GPH)	Estimated Fuel Use (Millions of Gallons)	Average Rate (GPH)	Estimated Fuel Use (Millions of Gallons)	Average Rate (GPH)	Estimated Fuel Use (Millions of Gallons)	Average Rate (GPH)	Estimated Fuel Use (Millions of Gallons)
Piston engine airplanes, 1-3 seats	41.5	1.9	9.3	27.6	6.7	0.7	9.7	30.3
Piston engine airplanes, 4-9 seats one-engine	19.1	1.1	13.0	127.8	8.8	1.3	13.0	131.3
Piston engine airplanes, 4-9 seats multi-engine	24.0	0.7	31.2	42.1	31.5	0.2	31.1	43.0
Piston engine airplanes 10 or more seats	76.7	1.4	51.2	1.9	-	-	59.6	3.3
Turboprop airplanes, 1-9 seats one-engine	56.5	47.9	21.0	3.4	30.0	a	50.8	51.4
Turboprop airplanes, 1-9 seats multi-engine	84.7	5.6	32.0	0.3	-	-	78.0	5.9
Turboprop airplanes, 10-19 seats	91.1	144.4	105.2	2.0	-	-	91.2	146.5
Turboprop airplanes, 20 or more seats	140.1	38.9	146.0	1.6	-	-	140.3	40.5
Turbojet/turbofan airplanes, <= 12,500 lbs	120.8	56.8	138.9	0.1	90.0	a	120.9	57.0
Turbojet/turbofan airplanes, > 12,500 lbs and <= 65,000 lbs	291.2	1,081.1	137.1	1.2	-	-	290.8	1,082.4
Turbojet/turbofan airplanes, > 65,000 lbs	517.0	543.5	-	-	-	-	517.0	543.5
Rotorcraft piston <= 6,000 lbs	16.8	0.1	14.3	7.4	13.1	a	14.3	7.5
Rotorcraft turbine <= 6,000 lbs	42.9	59.7	23.8	a	-	-	42.9	59.7
Rotorcraft piston > 6,000 lbs	65.0	a	-	-	-	-	65.0	0.0
Rotorcraft turbine > 6,000 lbs	75.8	44.7	-	-	86.0	a	75.8	44.7
Other	-	-	3.6	0.1	3.6	a	12.3	1.9
Experimental	72.9	21.1	10.4	4.8	5.3	1.0	26.9	27.3
Light Sport	4.5	a	5.4	0.5	5.0	a	5.1	1.8
All Aircraft	**196.3**	**2,049.0**	**14.3**	**221.0**	**6.5**	**4.5**	**84.5**	**2,278.2**

Source: GRA analysis of responses to the FAA's General Aviation and Part 135 Activity Survey CY2022
a = < 0.05
Total fuel use includes consumption of: jet fuel (Jet-A), aviation gasoline and other fuels (including fuel mixtures and propane), but estimates for use of these fuel types are not reported separately.
Some piston aircraft are equipped with diesel engines. These consume jet fuel instead of gasoline.
Totals may not add due to rounding