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U.S. DOMESTIC AIRLINE FUEL EFFICIENCY RANKING, 2014

Guozhen Li, Irene Kwan, and Daniel Rutherford, Ph.D.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

www.theicct.org

communications@theicct.org

BEIJING | BERLIN | BRUSSELS | SAN FRANCISCO | WASHINGTON

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For additional information:

International Council on Clean Transportation
1225 I Street NW, Suite 900
Washington DC 20005 USA

www.theicct.org | communications@theicct.org

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1. INTRODUCTION

Aircraft play a vital role in our modern economy by quickly and conveniently transporting goods and people, although at a cost to the global climate and public health. According to the U.S. Environmental Protection Agency (EPA), commercial aircraft—including passenger aircraft, cargo, and other chartered flights—accounted for 11% of greenhouse gas (GHG) emissions from the U.S. transportation sector in 2013 (U.S. EPA, 2015). Moreover, the Federal Aviation Administration (FAA) estimates that under a business as usual scenario, GHG emissions from U.S. aviation will increase by more than 100% by 2050 compared with 2005 levels (FAA, 2015), with even faster growth expected globally. Yet GHG emissions from aircraft are currently unregulated either in the United States or internationally.

Aviation emissions gained further visibility after the EPA took first steps to address GHG emissions from aircraft in June 2015. The agency proposed to find that "greenhouse gas (GHG) emissions from certain classes of engines used in aircraft contribute to the air pollution that causes climate change and endangers public health and welfare" (U.S. EPA, 2015). As laid out in its Advanced Notice of Proposed Rulemaking, the EPA may potentially adopt and implement the International Civil Aviation Organization's (ICAO) 2016 carbon dioxide (CO_2) emissions standard for new aircraft operating in the United States. The standard may contribute to the U.S. goal of achieving carbon-neutral growth for commercial aviation by 2020 (FAA, 2015).

Until recently, surprisingly little public information about airline fuel efficiency has been available to policymakers, investors, and consumers. Information about how airlines can operate their aircraft more efficiently could be used to craft policies to reward more efficient airlines while promoting practices that reduce fuel consumption. Because fuel makes up a large share of operating costs, investors could use information about fuel efficiency to make better investment decisions. Finally, business and leisure travelers with access to information on airline fuel efficiency could use it to select less carbon-intensive travel options.

In September 2013, the International Council on Clean Transportation (ICCT) released a benchmark study comparing the fuel efficiency of major U.S. airlines on domestic operations in 2010 (Zeinali, Rutherford, Kwan, & Kharina, 2013). The study was subsequently updated for 2011 and 2012 (Kwan, Rutherford, & Zeinali, 2014) and then again for 2013 (Kwan & Rutherford, 2014). The studies apply a methodology developed by the National Center of Excellence for Aviation Operations Research (NEXTOR) at the University of California, Berkeley, to compare the relative fuel efficiencies of airlines irrespective of size, operational structure, and business model (Zou, Elke, & Hansen, 2012).

This paper updates those earlier reports with new data on the fuel efficiency of U.S. domestic operations in 2014. Key findings include:

1. Alaska, Spirit, Frontier, and Southwest Airlines remained the top four most fuel-efficient airlines on U.S. domestic operations in 2014. On average, Alaska has operated the most efficient U.S. domestic flights for five years running since 2010.
2. The fuel efficiency gap between the most and least efficient airlines narrowed slightly to 25% in 2014, compared with 27% in 2013.

3. On a passenger mile per fuel metric, overall industry fuel efficiency improved by 1.7% from 2013 to 2014. Operational improvements, including a 1% gain in passenger load factor and 1.6% increase in seating density (seats available per unit floor area), accounted for most of the observed fuel efficiency gains. Fleet renewal programs and reduced usage of older aircraft also helped reduce airline fuel consumption.
4. A steady increase in seats available per flight, driven by upgrading to larger aircraft and adding more seats to aircraft of a given size, has been observed over the past five years. These changes, which allow airlines to move the same number of passengers on fewer flights, translate to increased fuel efficiency but at the cost of reduced passenger comfort and access (fewer airports served and/or longer wait times between flights).
5. All major airlines were profitable in 2014. A stronger correlation between fuel efficiency and profitability was observed in 2014 than in 2013, despite a sharp fall in oil prices in the latter half of the year.

2. METHODOLOGY

This section provides a brief overview of the approach used to evaluate relative airline fuel efficiencies in this study. Additional detail regarding the methodology can be found in Appendix A of Kwan, Rutherford, & Zeinali (2014).

2.1 FRONTIER APPROACH

This update, like previous studies, uses a frontier model to evaluate and compare the fuel efficiency of U.S. airlines on domestic routes. This approach enables an equitable comparison of airline fuel efficiency, regardless of business model, through the use of primary fuel burn data and an inclusive metric for transport service—a combination of mobility, measured by revenue passenger miles (RPM), and access, measured by departures (or the flight frequency). Quarterly 2014 traffic and fuel data from Data Base Products, a reseller of Form 41 U.S. air carrier data from the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS), was used to develop a statistical frontier model that normalizes each airline's fuel consumption by the transport service it provides. The model relates the input, fuel, of an airline *i* at time *t* to its output, RPMs, and departures (dep):

$$fuel_{it} = f(RPM_{it}, dep_{it}) + \eta_{it} \quad \text{[Eq. 1]}$$

where η_{it} represents the airline's true inefficiency.

Assuming that a log-linear function best describes the dataset, Equation 1 is transformed into the following functional form:

$$ln(fuel)_{it} = \beta_0 + \beta_1 ln(RPM)_{it} + \beta_2 ln(dep)_{it} + \xi_{it} \quad \text{[Eq. 2]}$$

where β_0, β_1, and β_2 are the coefficients estimated from a single year's quarterly dataset of fuel consumption, RPMs, and departures.

The approach recognizes the need to account for regional carriers, which operate a significant portion of flights for some mainline airlines. Regional carriers were incorporated through the apportionment of their RPMs, departures, and fuel to corresponding mainline carriers using BTS Airline Origin and Destination Survey (DB1B) data (see the Appendix for the mainline-affiliate RPM distribution in 2014). Circuity, the degree to which airlines deviate from direct flight paths due to one or more layovers that require extra distance traveled, was also accounted for. The resulting frontier model representing 2014 airline fuel consumption, with standard error in parentheses, was:

$$ln(fuel) = -1.342 + 0.752*ln(RPM) + 0.261*ln(dep) \quad \text{[Eq. 3]}$$

$$(0.920) \quad (0.067) \qquad (0.054)$$

Number of observations: 52 $\qquad R^2 = 0.996$

A unitless fuel efficiency score (FES), measuring the transport service (combination of mobility and access) an airline provides per unit of fuel consumed, is calculated by normalizing each airline's inefficiency value (based on Eq. 3) by the simple average across all airlines. A higher FES indicates relatively higher fuel efficiency—that is, a high-scoring airline consumes less fuel per unit of transport service than airlines with lower FES.

3. FINDINGS

The fuel efficiency scores for each airline's 2014 U.S. domestic operations are shown in Table 1. An FES of 1.00 represents the industry average fuel efficiency in 2014 (Hawaiian Airlines, in red). A higher FES denotes a better fuel efficiency, and a score lower than 1.00 indicates an airline with below average efficiency on U.S. domestic operations.

Table 1. Fuel Efficiency Scores (FES) by airline for U.S. domestic operations in 2014

Rank	Airline	FES	Excess Fuel Per Unit Transport Service
1	**Alaska**	1.14	**—**
2	**Spirit**	1.13	**+1%**
3	**Frontier**	1.10	**+4%**
4	**Southwest**	1.08	**+6%**
5	**United**	1.01	**+13%**
6	**Hawaiian**	**1.00**	**+14%**
7	**US Airways**	0.97	**+17%**
8	**Allegiant**	0.96	**+19%**
9	**JetBlue**	0.95	**+20%**
9	**Sun Country**	0.95	**+20%**
11	**Delta**	0.94	**+21%**
12	**Virgin America**	0.93	**+22%**
13	**American**	0.91	**+25%**

The Fuel Efficiency Score (FES) is a unitless fuel efficiency metric that indicates the transport service provided by an airline per unit fuel consumed relative to other airlines. A higher FES denotes higher fuel efficiency and an FES of 1.00 represents the average airline in 2014.

In 2014, Alaska Airlines operated the United States' most fuel-efficient domestic flights with an FES of 1.14. Alaska regained its sole first-place ranking after tying for first in fuel efficiency with Spirit and Frontier Airlines in 2013. Spirit and Frontier consumed 1% and 4% more fuel, respectively, to provide a comparable level of transport service (RPMs and departures) in 2014. Southwest Airlines, the largest low-cost carrier in the United States with more than 134 million passengers and 1.2 million domestic flights in 2014 (Data Base Products, 2015), came in fourth place with an FES of 1.08, burning 6% more fuel on average than Alaska on equivalent operations.

While the fuel efficiencies of these four carriers were similar in 2014, the remaining nine airlines were notably less efficient, burning at least 13% more fuel than Alaska Airlines to provide the same level of transport service. United Airlines ranked fifth in 2014 with an FES of 1.01, just slightly above the industry-average airline (Hawaiian) but behind Southwest by about 7%. US Airways, Allegiant Air, JetBlue, Sun Country Airlines, Delta Air Lines, Virgin America, and American Airlines — collectively responsible for 53% of total revenue passenger miles and 56% of fuel consumed — all demonstrated below-average fuel efficiencies in 2014.

American Airlines is now the largest airline in the domestic market after its merger with US Airways. American was still operating separately from US Airways throughout 2014, but the airline received its single operating certificate from the Federal Aviation

Administration in April of this year (Mouawad, 2015) and is set to begin branding all flights as American in October 2015 (American Airlines, 2015). In contrast to US Airways' near-average efficiency, American Airlines came in last place with an FES of 0.91. The efficiency gap between the least and most efficient airlines in 2014 narrowed to 25%, compared with 27% in 2013 and 26% in 2012.

3.1 KEY AIRLINE FINDINGS

The airline fuel efficiency rankings for 2010 to 2014 are shown in Table 2, which also highlights the shifts in ranking over time. As a result of the United-Continental and Southwest-AirTran mergers (as indicated by the arrows), the total number of airlines analyzed dropped from 15 in 2010 to 13 in 2012.

Table 2. Airline fuel efficiency rankings, 2010–2014

RANK	2010	2011	2012	2013	2014	RANK
1	Alaska	Alaska	Alaska	Alaska*	Alaska	1
2	Spirit*	Spirit	Spirit	Spirit*	Spirit	2
3	Hawaiian*	Southwest*	Southwest*	Frontier*	Frontier	3
4	Continental	Hawaiian*	Hawaiian*	Southwest	Southwest	4
5	Southwest	Frontier	Frontier	Hawaiian	United	5
6	Frontier	Continental →	United	United	Hawaiian	6
7	JetBlue	JetBlue	JetBlue	JetBlue	US Airways	7
8	United	United	Virgin*	Delta	Allegiant	8
9	Virgin	Delta	Delta*	Virgin*	JetBlue*	9
10	Sun Country	Sun Country*	US Airways*	US Airways*	Sun Country*	10
11	Delta	US Airways*	Sun Country	Sun Country	Delta	11
12	US Airways	Virgin*	Allegiant*	Allegiant	Virgin	12
13	AirTran	AirTran	American*	American	American	13
14	American	American	—	—	—	
15	Allegiant	Allegiant	—	—	—	

* Denotes ties between airlines in a given year → Denotes mergers

In 2014, Alaska Airlines continued renewing its fleet, including the addition of 10 new efficient Boeing 737-900 aircraft. In addition, Alaska has added split-scimitar winglets, expected to improve aircraft fuel efficiency by 1.5%, to 48 of its planned deliveries (Alaska Airlines, 2015). Meanwhile, its main regional affiliate, Horizon Air, flew 36% of Alaska's flights (which accounts for 7% of Alaska's RPMs) with its fuel-efficient all-Dash 8 turboprop fleet. Alaska continues to lead in domestic fuel efficiency by providing a combination of mobility (passenger miles traveled) and access (destinations reached and/or flight frequency) in a fuel-efficient manner.

Spirit Airlines, an ultra-low-cost carrier, operates all of its flights with Airbus A320 family aircraft (A319, A320, and A321), which were among the most efficient aircraft types serving the U.S. domestic market. Spirit has adopted various operational practices to boost the efficiency of its A320 aircraft, notably the installation of more seats than most of its rivals. For example, an average Spirit A320 includes 178 standard seats, 28 more than the typical two-class, 150-seat configuration used on JetBlue, US Airways, and Delta (Table 3).

Table 3. Airline efficiency on the A320 in 2014

Carrier	Efficiency (passenger miles/lb fuel)	Difference from top performer	Average seat count	Average load factor	Average fleet age (years)
Spirit	11.3	—	178	86%	2
Allegiant	11.0	-2%	178	88%	14
Frontier	10.6	-6%	171	89%	6
United	9.2	-18%	148	87%	16
Virgin America	9.1	-20%	147	83%	5
JetBlue	8.9	-21%	150	86%	9
US Airways	8.8	-22%	150	86%	15
Delta	8.1	-29%	150	85%	19

Source: Data Base Products (2015); Ascend Flightglobal Consultancy (2015)

Table 4. Airline efficiency on the A319 in 2014

Carrier	Efficiency (passenger miles/lb fuel)	Difference from top performer	Average seat count	Average load factor	Average fleet age (years)
Allegiant	11.4	—	156	92%	10
Spirit	9.4	-17%	146	88%	8
Frontier	9.3	-18%	139	90%	10
United	7.8	-31%	123	85%	14
American	7.1	-37%	128	81%	1
Virgin America	7.1	-37%	119	78%	7
US Airways	6.8	-40%	124	84%	14
Delta	6.6	-42%	124	83%	12

Source: Data Base Products (2015); Ascend Flightglobal Consultancy (2015)

In 2013 Frontier Airlines tied with Alaska and Spirit for first place in overall efficiency, but fell to third place in 2014. Beginning in 2012, Frontier changed its business model significantly from a low-cost carrier to an ultra-low-cost carrier (Johanson, 2014). Frontier eliminated almost all flights from regional partners in the past few years: in 2010, Chautauqua Airlines and Republic Airlines flew about 21% of Frontier's revenue passenger miles, but that share had dropped to 3% in 2013 and almost zero in 2014. Frontier's passenger load factor dropped by 1% from the previous year, and its overall fleet age went up with the addition of only one new A320 aircraft in 2014. While Alaska and Spirit experienced significant gains in fuel efficiency in 2014, Frontier's fuel efficiency did not change very much from 2013.

US Airways climbed from tenth place in 2013 to seventh place in 2014. US Airways, which had an average fleet age of about 10 years in 2014, removed smaller Boeing 737-400 aircraft (144-seat; average age 24 years) and added 11 larger Airbus A321 (186-seat; average age 5 years) and 3 A330-200 (265-seat; average age 3 years) aircraft to its fleet in 2014 (Ascend Flightglobal Consultancy, 2015). While upgrading to larger airplanes, US Airways was able to maintain an 84% load factor. This combination of increased capacity and high load factor allowed US Airways to improve its efficiency rank from ninth in 2013 to seventh last year.

Allegiant Air also climbed up significantly in the ranking, from twelfth in 2013 to eighth in 2014. Allegiant improved its efficiency by improving the use of its existing fleet. In 2013, Allegiant flew 82% of its passenger miles on MD-80 aircraft, a legacy model brought into

service in the 1980s, but reduced that share to 69% in 2014. Meanwhile, Allegiant increased its use of more efficient, though second-hand, A320 and A319 aircraft. Despite being a relatively new operator of the A320 family, Allegiant is already first or second in fuel efficiency for those aircraft types on U.S. domestic operations, mainly because of higher seating capacity and passenger load factors similar to that of Spirit (Table 3 and Table 4).

Delta Air Lines and Virgin America's overall fuel efficiencies worsened considerably in 2014, causing them to lose ground relative to their peers. Although both airlines experienced a 2% increase in overall passenger load factor from 2013, Delta burned 2% more fuel per RPM and 8% more fuel on a typical flight in 2014 than in 2013, while Virgin burned 3% more fuel per RPM and 5% more fuel per flight. Operational changes for Delta last year included reduced use of its B757-200, the predominant aircraft flown on domestic operations on an RPM basis, and a small increase in average circuity to the highest level (1.08) of any U.S. carrier in 2014. Virgin America had no changes to its fleet in 2014, which consisted of 43 A320 aircraft, averaging 5 years old, and 10 A319 aircraft, averaging 7 years old. Virgin may be experiencing the effects of an aging fleet—aircraft become 1–5% less fuel-efficient over time due to degradation in engine and aerodynamic performance (Zeinali, Rutherford, Kwan, & Kharina, 2013).

Despite the fact that American Airlines operated the least efficient U.S. domestic flights once again in 2014, its absolute fuel efficiency improved substantially from 2013. In 2014, American Airlines phased out its Boeing 767-200 aircraft and removed 17 of its older MD-80 aircraft from its fleet. On average, American consumed 5% less fuel per RPM and 3% less fuel on a typical flight in 2014 than in the previous year. These improvements helped close the efficiency gap between American and the industry's best performer, Alaska, to 25% compared with 27% in 2013.

Other notable carriers include Hawaiian Airlines, whose relative fuel efficiency has slipped in recent years as other airlines improve. Hawaiian continued renewing its fleet by adding newer, larger A330-200 aircraft in 2014. The share of Hawaiian's domestic RPMs carried by A330-200 aircraft rose from 49% in 2013 to 64% in 2014, while the airline's average load factor dropped from 87% to 85% in 2014. In terms of Hawaiian's overall efficiency, its fuel consumption increased on both a per RPM (+3%) and a per flight (+5%) basis. United Airlines reduced its fuel consumption per RPM by 3% relative to 2013 partly due to the addition of more seats on its aircraft (Jones, 2015). United surpassed Hawaiian in overall fuel efficiency for the first time since 2010.

3.2 AIRLINE INDUSTRY FINDINGS

3.2.1 Overall Fuel Efficiency

Industry-wide fuel efficiency improvements on U.S. domestic passenger operations have slowed in recent years and showed no net improvement from 2012 to 2013 (Kwan & Rutherford, 2014). However, from 2013 to 2014, the industry overall had an efficiency gain of 1.7% on an RPM per fuel basis, due in large part to a 1% increase in average passenger load factor to 84% in 2014 (Data Base Products, 2015) and higher seating densities on domestic flights. Airlines also implemented fleet renewal programs that reduced the average age of aircraft used on U.S. domestic flights modestly for the first time since at least 2010.

3.2.2 Aircraft Upgauging

One clear trend in the airline industry is the slowly but steadily increasing number of seats per aircraft, or upgauging. In 2010, there were 145 seats on an average U.S. domestic flight flown by the mainline carriers. In 2013 this number rose to 149, and

reached 150 in 2014. From 2013 to 2014, the overall seating density (seats per unit floor area) increased by 1.6%. Aircraft upgauging is evident in U.S. domestic operations. For example, United Airlines added "new, slimmer seats" to about 300 of its jets, enabling it to increase its per-seat fuel efficiency (Jones, 2015). Likewise, Frontier increased the number of seats on an average flight from 145 in 2013 to 151 in 2014, an increase of about 4% in a single year. Moreover, the popular A320 aircraft carried on average 153 passengers in 2014, up from 148 passengers in 2010 (Table 5).

Table 5. Average number of seats on the A320 aircraft for U.S. domestic operations (mainline carriers only), 2010-2014

Year	Seats (millions)	Flights (thousands)	Seats per flight
2010	69.1	468	148
2011	74.1	499	148
2012	77.7	520	149
2013	80.6	535	151
2014	82.2	536	153

Source: Data Base Products (2015)

According to Boeing, over the next 20 years "the average twin-aisle, or widebody, jetliner will grow by about 20 seats, and the average single-aisle will grow by about 10 seats, as planes both get longer and are packed more densely" (Wall & Ostrower, 2014b). Airlines and manufacturers alike are discovering ways to "pack seats in [the] smallest planes" (Wall & Ostrower, 2014a). In Europe, Airbus aims to reach 189 seats on its A320 aircraft—the same as the maximum for the Boeing 737-800—up 9 seats from the current maximum seat configuration. This could be done by moving and redesigning doors or reconfiguring restrooms and galleys. Meanwhile, Boeing is seeking to add 10 more seats to its new Boeing 737 MAX 8 aircraft. While airlines previously maintained a mix of economy and higher-cost (and roomier) business-class seating on their aircraft to maximize sales, the growth of budget carriers has led the manufacturers to focus on maximizing the number of seats on short- and medium-distance planes.

While there is a gain in both sales, lower fares, and fuel efficiency from aircraft upgauging, there is also an inevitable cost to consumers: comfort. Reduced seat pitch and cushion sizes have led to discontentment among fliers, with some industry observers now advocating for minimum airline seat standards (Elliot, 2014). Higher load factors and seating density allow airlines to move the same number of passengers on fewer flights, which increases fuel efficiency but also reduces access to transport services, in the form of fewer airports served and/or longer wait times between flights. Overall, U.S. airlines increased domestic RPMs by 2% in 2014 while reducing the number of departures by 3% (Data Base Products, 2015).

3.2.3 Fleet Renewal

The U.S. domestic fleet for the 13 airlines was found to be slightly younger in 2014 (average 11.5 years old, weighted by passenger-miles flown) than in 2013, while previous years showed an aging fleet. From 2013 to 2014, most of the mainline carriers' fleet either aged by less than one year or became younger on average. Notably, American Airlines' fleet was on average 1.7 years younger than in 2013 and Hawaiian Airlines 1.5 years younger. Virgin America and Allegiant were the only carriers that did not make any changes to their fleets.

Table 6 shows a comparison of 2013 and 2014 single-aisle aircraft count by type for the 13 major U.S. airlines and their regional affiliate domestic fleets. It can be clearly seen that some newer and more efficient aircraft types—the Boeing 737-800 and 737-900, Airbus A321, Canadair RJ-900, and Embraer 175—were added to the fleet in large numbers. The types that went out of service in the largest numbers were the Boeing 717-200 and 757-200, Canadair RJ-200, and McDonnell Douglas MD-80.

Table 6. U.S. domestic single-aisle aircraft count by type in 2013 and 2014

Aircraft Type	2013 Count	2014 Count	2013-2014 Change
Airbus A320-100/200	456	466	+10
Airbus A319	297	307	+10
Airbus A321	97	153	+56
Boeing 717-200	106	58	-48
Boeing 737-300	124	119	-5
Boeing 737-400	41	35	-6
Boeing 737-500	15	12	-3
Boeing 737-700/LR	503	492	-11
Boeing 737-800	554	607	+53
Boeing 737-900	125	183	+58
Boeing 757-200	377	339	-38
Boeing 757-300	37	37	—
Canadair RJ-200ER/RJ440	489	436	-53
Canadair RJ-700	266	267	+1
Canadair RJ-900	169	212	+43
DeHavilland DHC8-100	32	32	—
DeHavilland DHC8-200	16	16	—
DeHavilland DHC8-300	16	16	—
DeHavilland DHC8-400	82	82	—
Douglas DC-9-50	7	0	-7
Embraer EMB-120 BRAS	43	44	+1
Embraer ERJ-135	9	9	—
Embraer ERJ-140	74	69	-5
Embraer-145	444	432	-12
Embraer E-170	78	78	—
Embraer E-175	109	150	+41
Embraer E-190	87	85	-2
MD-80,1,2,3,8	348	323	-25
MD-90	67	65	-2

Source: Ascend Flightglobal Consultancy (2015)

3.2.4 Profitability

All airlines remained profitable on U.S. domestic operations in 2014 (Figure 1). There was a moderate correlation (R^2~0.5) between profitability and fuel efficiency for the 13 major

airlines in 2014, compared to almost no correlation in 2013. This finding is surprising given the dramatic drop in fuel prices in the fourth quarter of 2014 (U.S. Energy Information Administration, 2015), which could weaken the link between fuel efficiency and profitability. Significant changes in fuel hedging strategies by U.S. carriers in 2014 (Maxon, 2014) complicate efforts to explain this change.

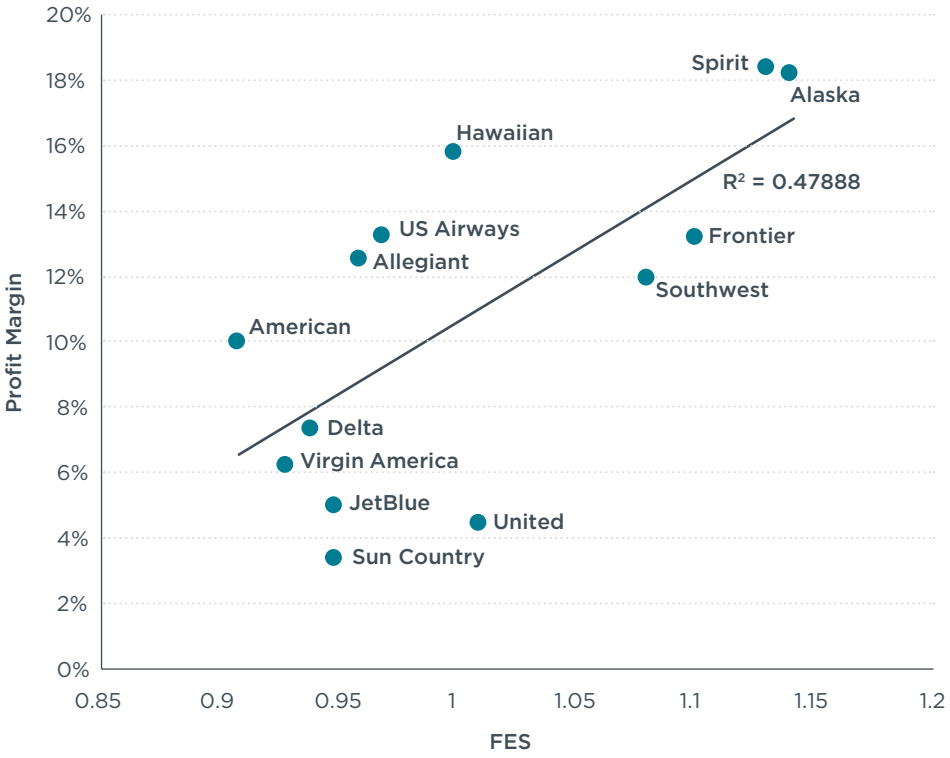

Figure 1. Net operating profit margin on U.S. domestic operations and FES in 2014 for mainline carriers
Source: Data Base Products (2015)

Alaska and Spirit, the top two efficient carriers, have had the most profitable U.S. domestic operations since 2011. Carriers such as American and Virgin America were still able to remain profitable despite having more fuel-intensive operations. Frontier, which was barely profitable in 2013 (Kwan & Rutherford, 2014), experienced a turnover in its 2014 business. As it completely transformed to an ultra-low-cost carrier, Frontier fully adopted an "unbundled fare + ancillary fees" fare structure (Johanson, 2014) and added more seats to its aircraft, though at the cost of legroom for its passengers (Nicas, 2015). An average Frontier flight offered six more seats in 2014 than in 2013. Frontier's 2014 operating revenue increased by 20% from 2013, while its operating expenses increased only 4%. Its operating profit grew from $3 million in 2013 to $187 million in 2014, a 60-fold increase.

United Airlines had a net profit margin of 4.5% in 2014 on domestic operations—an increase of more than 2% from 2013. Its parent company, United Continental Holdings, experienced a net profit gain of 98% from 2013 (Karp, 2015). Southwest and Delta both experienced profits that were higher than estimated at the end of 2014. For Southwest, this was due to lower jet fuel prices (plus fuel hedging) and solid demand on its domestic routes (Bloomberg Business, 2015).

4. CONCLUSIONS

This study analyzed the fuel efficiency of U.S. domestic operations in 2014 and described how the efficiencies of individual airlines have changed since 2010. Alaska Airlines continued to lead in fuel efficiency for the fifth year in a row. Spirit Airlines, Frontier Airlines, and Southwest Airlines followed closely behind Alaska and maintained their positions as the top four most fuel-efficient airlines on domestic operations. In contrast, American Airlines, although still ranked the least efficient in domestic operations, was able to close the efficiency gap from the previous year's 27% to 25% in 2014 through phasing out Boeing 767-200 aircraft and removing some older MD-80 aircraft from its fleet. Meanwhile, the fuel efficiency of carriers such as Delta Air Lines and Virgin America declined compared to 2013.

Overall in 2014, the industry saw a 1.7% improvement in fuel efficiency on a passenger mile per fuel basis, due to higher load factors, adding more seats to the average flight, and to a lesser extent, fleet renewal programs. Regardless of their fuel efficiency, all major U.S. domestic carriers were profitable in 2014, and increasingly so. A stronger correlation was found between fuel efficiency and profitability in 2014 than in 2013.

In future work assessing airline fuel efficiency in 2015, we will investigate the effects of the American-US Airways merger, which created the single largest U.S. domestic airline, as well as ongoing trends influencing fuel efficiency in the U.S. domestic airline industry.

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APPENDIX

Table A. Mainline-affiliate revenue passenger miles distribution, 2013 and 2014

Mainline carrier	Affiliated carriers	Apportioned RPMs (millions)		% RPMs carried by affiliates	
		2013	2014	2013	2014
Alaska	Alaska	24,147	25,818		
	American Eagle (Envoy)	39	30		
	Chautauqua	<0.5	1		
	Compass	1	<0.5		
	ExpressJet	1	<0.5		
	Horizon	2,098	2,159		
	Endeavor (Pinnacle)	2	2		
	SkyWest	569	821		
	Mesa		1		
	Republic		6		
		Total 26,858	**Total 28,839**	**10%**	**10%**
American	American	75,219	75,828		
	American Eagle (Envoy)	8,610	6,567		
	Chautauqua	337	174		
	ExpressJet	407	441		
	Horizon	15	10		
	Republic	108	1,975		
	SkyWest	425	524		
	PSA		65		
	Piedmont		18		
	Trans States		3		
	Mesa		328		
	Air Wisconsin		81		
		Total 85,121	**Total 86,015**	**12%**	**12%**
Delta	Delta	94,486	94,468		
	Chautauqua	767	951		
	Compass	2,830	2,931		
	ExpressJet	5,925	5,323		
	GoJet	934	871		
	Horizon	23	14		
	Endeavor (Pinnacle)	6,013	6,020		
	Shuttle America	1,300	1,425		
	SkyWest	4,760	4,522		
		Total 117,039	**Total 116,524**	**19%**	**19%**

Mainline carrier	Affiliated carriers	Apportioned RPMs (millions)		% RPMs carried by affiliates	
		2013	2014	2013	2014
Frontier	Frontier	8,635	9,866		
	Chautauqua	<0.5			
	Republic	297	11		
		Total 8,932	Total 9,877	3%	0.1%
Hawaiian	Hawaiian	9,082	9,549		
	SkyWest	<0.5	<0.5		
		Total 9,082	Total 9,549	~0	~0
United	United	92,912	92,262		
	Air Wisconsin	8	<0.5		
	Chautauqua	463	92		
	Commutair	261	238		
	ExpressJet	9,452	9,238		
	GoJet	1,553	1,695		
	Mesa	1,158	1,290		
	Piedmont	25	<0.5		
	PSA	40	<0.5		
	Republic	643	810		
	Shuttle America	2,397	2,424		
	SkyWest	8,057	8,745		
	Trans States	871	897		
		Total 117,838	Total 117,693	21%	22%
US Airways	US Airways	49,442	50,079		
	American Eagle (Envoy)		568		
	Air Wisconsin	2,133	2,162		
	Chautauqua	107	4		
	ExpressJet	158	19		
	GoJet	41	1		
	Mesa	2,823	2,901		
	Piedmont	496	486		
	PSA	1,805	1,911		
	Republic	3,666	3,421		
	Shuttle America	63	1		
	SkyWest	793	586		
	Trans States	45	27		
		Total 61,573	Total 62,165	20%	19%