CIRIUM
aviation analytics

FLIGHT EMISSIONS REVIEW

OFFICIAL AIRLINE REPORT

JULY 2025

emerald sky

CONTENTS

THE CIRIUM FLIGHT EMISSIONS REVIEW

by **Jeremy Bowen**, Chief Executive Officer, Cirium

Welcome to the **Cirium Flight Emissions Review** — the trusted benchmark for flight emissions calculations for the global aviation sector.

As the industry faces continued pressure to decarbonize, accurate and independent emissions data is no longer a nice-to-have — it's essential. At Cirium, we believe progress starts with visibility. That's why we've developed this Review: to give stakeholders across aviation a clear, data-backed view of emissions performance, built on the most accurate information available.

The results in this Review are powered by **EmeraldSky,** Cirium's emissions intelligence solution. EmeraldSky combines the most complete aviation data available with advanced data modeling and emissions science. It enables airlines, airports, lessors, and aviation sustainability stakeholders to measure and understand flight carbon emissions with confidence and clarity.

In 2025, EmeraldSky's methodology achieved **ISAE 3000 Reasonable Assurance** following independent review by **PricewaterhouseCoopers** (PwC) — the highest level of assurance available under the International Standard on Assurance Engagements. This verification sets a new bar for emissions data reliability and makes EmeraldSky a foundation stakeholders can trust for everything from benchmarking and operational insights to Scope 3 disclosures.

Additionally, Cirium's EmeraldSky is officially accredited by the Rocky Mountain Institute (RMI) as a qualified flight emissions data provider under the Pegasus Guidelines — the first climate-aligned finance framework tailored for aviation. This accreditation validates EmeraldSky's methodology for use by banks, financiers, and other stakeholders aligning with net-zero emissions targets by 2050.

What's included in this Review

This Review takes a broader and deeper look into flight emissions performance than ever before. We've focused on four different views which we thought you would find useful and compelling:

- **Global Airline Rankings** — A comprehensive comparison of CO_2 emissions per ASK across the world's largest carriers, featuring the top 20 major airlines and the 10 largest global carriers for clearer peer benchmarking.
- **Intra-Region Rankings** — These rankings focus on average CO_2 per ASK for flights that take place entirely within a single region.
- **Inter-Region Rankings** — The inter-region rankings focus on average CO_2 per ASK for flights that span two different global regions.
- **Improvement by Route** — Highlighting specific airport pairs with the greatest year-over-year reductions in CO_2/ASK, giving insight into where operational decisions and fleet changes are delivering results.

This isn't just about publishing a leaderboard. The Cirium Flight Emissions Review is built to show how accurate and precise data and analytics will inform better decisions, support transparency, and accelerate aviation's transition to more sustainable operations.

Why this Review matters

Today, emissions reporting across aviation is still inconsistent — often hard to compare and rarely comprehensive. This Flight Emissions Review addresses that by applying a consistent methodology to flight-level data, enabling meaningful and fair comparisons across operators, markets, and routes.

A foundation built on trusted data

Cirium brings together the most authoritative aviation data sets in the world, enriched with inputs from leading industry partners. We don't just gather data—we connect it, validate it, model it, and make it actionable.

That same principle guides our emissions work. By building on EmeraldSky and ensuring third-party assurance, we're delivering a new standard for accuracy, transparency, and reliability in aviation sustainability reporting.

We hope you find the insights in this report both valuable and thought-provoking. As the dataset grows and the methodology evolves, we're committed to refining how this information is presented. Quarterly updates are planned, and future editions will be shaped by your feedback.

Let us know how we can make it even more useful to you.


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aviation analytics
Better Performance.
Lower Emissions.
We are here to help us all fly sustainably.
Cirium EmeraldSky is empowering the aviation
to accurately measure and monitor CO_2 emissio
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industry
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sky

GLOBAL AIRLINE RANKINGS

8

GLOBAL AIRLINE RANKINGS

by **Mike Malik**, Chief Marketing Officer, Cirium

Which Airlines Minimize Environmental Impact

With aviation facing unprecedented scrutiny over emissions and new regulatory frameworks taking shape globally, the industry finally has concrete data on which carriers are truly leading the efficiency race. After analyzing the world's 100 largest scheduled passenger airlines, we can put hard numbers behind performance rather than relying on marketing claims.

The headline:

Wizz Air of Hungary tops our rankings for Major Airlines with just 53.9 grams of CO_2 per available seat kilometer (ASK), followed closely by Frontier Airlines at 54.4 grams and Turkey's Pegasus at 57.1g.

The story behind these numbers reveals where aviation efficiency really comes from—and what it means for airlines, investors, and passengers alike.

Building a Fair Comparison Framework

We chose grams of CO_2 per ASK, which we call **"Emissions Intensity,"** as our core metric because ASKs capture what airlines can actually control: aircraft efficiency, seating density, and route optimization. Under our methodology, carriers flying newer, fuel-efficient aircraft with higher-density configurations naturally perform better.

We are publishing a list of the top 20 airlines from our total analysis. While we analyzed top 100 carriers, we're focusing on the efficiency leaders and their best practices rather than highlighting those with higher emissions intensity. This approach provides actionable insights the industry can adopt, rather than simply creating headlines about underperformance. The goal is to showcase what works and drive improvement through demonstrated success.

Equally important, we examined the world's 10 **Largest Airlines** by ASK to show how scale affects Emissions Intensity—a critical component of understanding industry performance.

Airlines may have their own internal calculations, and ours may differ slightly. However, because we're using the same methodology for every airline, and we have more data globally, this provides better comparisons overall. An individual airline cannot calculate another airline's CO_2 per ASK—you need consistent standards applied across the industry.

The Results: Efficiency Follows a Clear Pattern

The top performers share unmistakable characteristics.

Wizz Air leads through high seat density and newer fleets—strategies that create real efficiency advantages.

The carriers dominating the lowest Emissions Intensity rankings operate some of the youngest fleets in the industry and use high-density cabin configurations to spread their emissions across more seats.

Among the largest operators by total ASK—the airlines moving the most passengers the greatest distances globally—

Ryanair leads with similar efficiency principles.

Southwest Airlines ranks second at 68.9g CO_2 per ASK, while Delta, despite its complex mix of long-haul, short-haul, and varied aircraft types, achieves 74.4g per ASK.

My Take

Here's what makes this data both encouraging and sobering: while these airlines excel at reduced emissions intensity, total emissions continue rising with demand growth. Even the most efficient operators can't offset demand growth through operational improvements alone yet.

The data confirms what many in the industry suspected: seat density and fleet age matter more than almost any other factor airlines can control. While industry leaders are succeeding through these operational strategies, it also highlights how limited the levers for emissions reduction really are compared to the scale of the challenge.

The broader industry trend is encouraging—efficiency improvements are happening across different carrier types and business models, not just low-cost carriers. However, the efficiency variations between airlines are wider than many expected, suggesting significant room for industry-wide improvement.

What This Means for Different Stakeholders

For airlines: The efficiency leaders show a clear playbook—invest in fleet renewal, maximize seat density where market allows, and optimize operations. But the real competitive advantage lies in executing these strategies consistently while regulatory frameworks like EU ETS and CORSIA are already imposing carbon costs.

For investors: These rankings provide the first standardized framework for comparing environmental performance across carriers. Airlines in the top quartile are better positioned as existing carbon pricing mechanisms expand and intensify globally.

For passengers: Your choice of carrier increasingly matters. Flying with the most efficient carriers versus those emitting significantly higher CO_2 per ASK can mean your personal carbon footprint varies significantly on the same route.

Looking Ahead

We expect these efficiency variations to narrow as existing regulatory frameworks intensify and fleet renewal accelerates industry-wide. The carriers already leading in our rankings have a head start, but the real test will be maintaining efficiency advantages as they scale and as competitive and regulatory landscapes evolve.

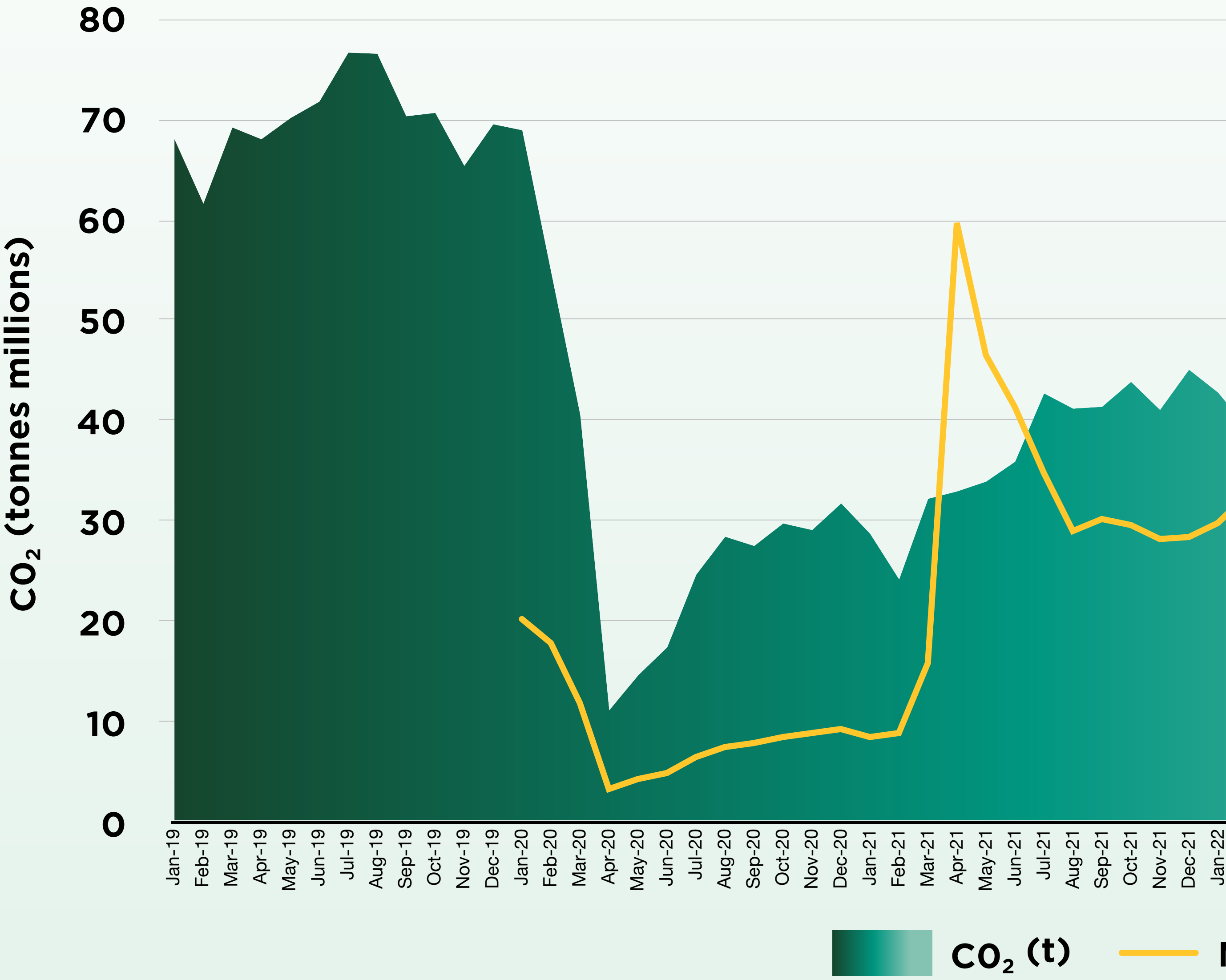
Worth noting: we haven't factored Sustainable Aviation Fuel (SAF) into this analysis. While SAF will undoubtedly have a positive impact on emissions, current production covers only 0.53% of fuel demand[1] and scaling requires massive infrastructure investment and years of development. Until airlines have consistent access to meaningful volumes, operational efficiency remains the primary lever they can pull today.

What makes this ranking valuable isn't just identifying efficiency leaders—it's creating a standardized framework for measuring performance. With intensifying regulatory requirements and growing passenger awareness, airlines need credible metrics to demonstrate progress. Airlines optimizing accordingly will find themselves better positioned as environmental transparency becomes essential rather than optional.

[1]International Air Transport Association (IATA), 2024 projections

GLOBAL CO_2

FROM PASSENGER F

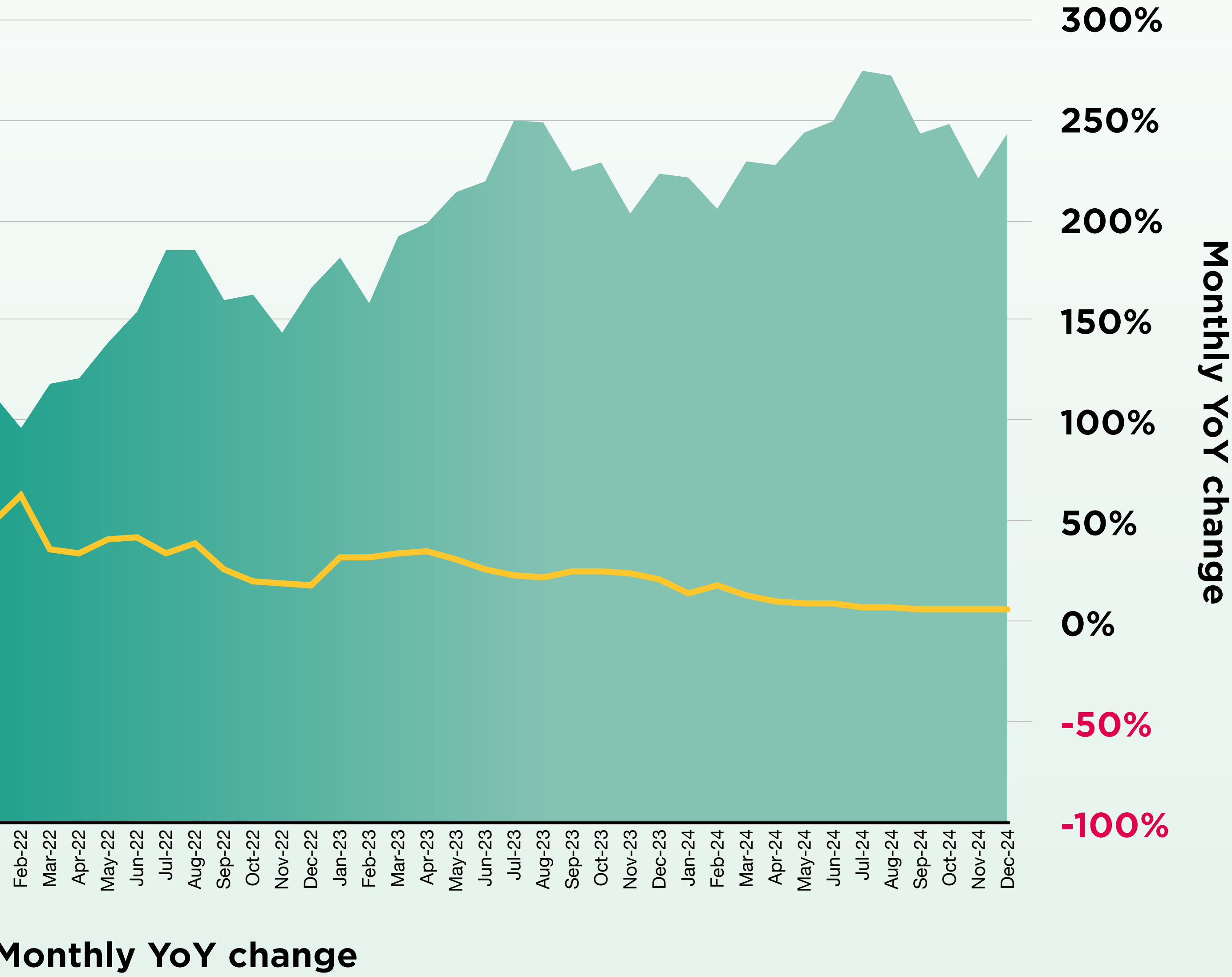


Global trend

Global monthly passenger CO_2 peaked in July 2019 prior to the dran
pandemic-induced decline in operations experienced from early 202
Flight activity progressively recovered to exceed 2019 levels, but Jul
emissions remained approximately 2.4% below 2019's peak.

2 EMISSIONS

FLIGHTS (2019–2024)



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20.
ly 2024

This translated to a

6% reduction

in average passenger CO_2/ASK over the five-year period.

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Ranked by Lo

Rank	Operator (group)	Country	CO_2/ASK (g)	
			2024	% change vs 23
1	**Wizz Air**	Hungary	53.9	+0.0%
2	**Frontier Airlines**	USA	54.4	-1.0%
3	**Pegasus**	Turkiye	57.1	-2.5%
4	**Volaris**	Mexico	57.9	+1.6%
5	**IndiGo**	India	58.2	+1.6%
6	**Jetstar**	Australia	58.4	-0.9%
7	**Spirit Airlines**	USA	58.4	-2.0%
8	**Scoot**	Singapore	58.7	+0.9%
9	**SunExpress**	Turkiye	59.4	+1.1%
10	**Air India Express**	India	60.5	+1.0%
11	**Viva**	Mexico	60.7	+5.1%
12	**VietJet Air**	Vietnam	60.8	-0.2%
13	**Transavia**	Netherlands	61.3	-0.7%
14	**Flynas**	Saudi Arabia	61.5	-1.6%
15	**Air Transat**	Canada	61.5	+1.9%
16	**Aegean Airlines**	Greece	61.7	+1.1%
17	**Flydubai**	UAE	61.7	+0.5%
18	**Cebu Pacific**	Philippines	62.4	+4.1%
19	**Lion Air**	Indonesia	62.6	-4.5%
20	**Ryanair**	Ireland	63.0	-1.9%
	Global:		**74.8**	**0.0%**

AIRLINES

west CO_2/ASK

CO_2 Emissions (mt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
2024	2024	% change vs 23	2024	2024	2024
5.9	314	+4.0%	222	5.1	1,551
3.5	219	+13.8%	204	4.5	1,432
3.3	204	+9.9%	209	4.5	1,362
3.0	166	-14.5%	196	6.9	1,578
8.8	747	+9.2%	181	4.1	1,036
2.9	125	+12.5%	199	11.4	1,745
5.1	289	-3.3%	192	6.3	1,560
2.2	59	+8.9%	245	7.4	2,275
2.1	94	+17.3%	189	10.3	1,981
1.8	93	+150.7%	180	6.9	1,779
2.3	161	+13.9%	200	8.7	1,165
3.2	138	+3.2%	225	7.9	1,607
2.8	147	+6.8%	189	11.5	1,637
1.5	99	+25.2%	177	3.1	1,314
1.6	27	+4.9%	239	10.4	3,887
1.3	95	+5.9%	185	9.7	1,143
2.7	120	+10.4%	172	4.9	2,174
1.9	121	+15.8%	217	6.2	984
1.6	100	-17.0%	215	12.3	1,002
13.7	905	+7.8%	191	9.1	1,250
815.6	**34,964**	**+5.5%**	**168**	**11.1**	**1,527**

WORLD'S LARGEST

Ranked by

Rank	Operator (group)	CO_2/ASK (g)		C Emis (m
		2024	% change vs 23	20
1	Ryanair	63.0	-1.9%	13
2	Southwest Airlines	68.9	-1.5%	19
3	Delta Air Lines	74.4	-0.5%	32
4	American Airlines	74.6	-0.2%	31
5	United Airlines	75.4	-0.7%	35
6	Turkish Airlines	76.9	-0.8%	19
7	China Southern Airlines	78.2	-1.4%	18
8	Qatar Airways	79.7	-0.8%	20
9	Air China	83.3	-0.1%	16
10	Emirates	84.9	+0.9%	30

T AIRLINES BY ASK

/ CO_2/ASK

O_2 sions nt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
24	2024	% change vs 23	2024	2024	2024
.7	905	+7.8%	191	9.1	1,250
.7	1,450	-1.0%	159	11.9	1,224
.0	1,145	+3.2%	171	15.1	1,924
.4	1,202	+4.2%	173	13.8	1,843
.7	975	+5.8%	176	15.7	2,405
.6	522	-0.3%	202	10.4	2,021
.4	758	+2.8%	185	10.0	1,566
.4	201	+7.9%	275	9.2	4,204
.3	525	+6.0%	193	10.2	1,719
.3	172	+4.1%	414	10.6	4,881

INTRA-REGIONAL HIGHLIGHTS:

CO_2 EFFICIENCY BY GEOGRAPHY

18

INTRA-REGION RANKINGS

by **Kevin O'Toole**, Chief Strategy Officer, Cirium

Alongside our global view, we've also broken down emissions intensity within key regions to give a more regional perspective. These intra-region rankings focus on average CO_2 per ASK for flights that take place entirely within a single region—providing a closer look at how airlines are performing on short- and medium-haul networks.

To be included, an airline must have operated at least 10 intra-region flights per day on average in 2024. We've also included average distance per flight to help put the emissions intensity in context—because, as we know, route length plays a big role in overall efficiency.

Why does this matter?

Emissions performance looks different depending on where—and how—you fly. These regional breakdowns give a more nuanced view, helping users see patterns and benchmarks that might not be obvious from global averages alone. And while this is just one cut of the data, it shows the kind of insight that's possible when you have both scale and detail.

NORTH AMER

Rank	Operator (group)	CO_2/ASK (g)		C Emis (m
		2024	% change vs 23	20
1	**Frontier Airlines**	55.3	+0.1%	2.
2	**Flair Airlines**	55.5	+3.9%	0
3	**Spirit Airlines**	59.0	-2.1%	4
4	**Sun Country Airlines**	62.2	-0.2%	0
5	**Alaska Airlines**	64.0	-0.2%	6
6	**WestJet**	65.4	-1.6%	2
7	**Allegiant Air**	66.3	-1.3%	2.
8	**Air Canada**	68.1	+1.1%	3
9	**Southwest Airlines**	69.1	-1.4%	18
10	**Breeze Airways**	70.0	-5.2%	0
	All North America:	**74.1**	**-0.5%**	**12**

RICA REGION

O_2 sions nt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
24	2024	% change vs 23	2024	2024	2024
.9	193	+15.9%	203	4.6	1,354
.4	23	-10.1%	189	3.4	1,706
.2	247	+0.0%	192	6.3	1,499
.7	37	+9.2%	186	15.9	1,663
.1	246	-0.6%	169	10.4	2,237
.2	119	+14.9%	161	11.9	1,746
.0	120	+0.6%	177	15.5	1,432
.2	130	+3.2%	174	11.5	1,979
.9	1,409	-1.2%	159	11.9	1,207
.6	46	+41.7%	132	4.3	1,441
22	**8,465**	**+3.9%**	**135**	**13.2**	**1,261**

WESTERN EU

Rank	Operator (group)	CO_2/ASK (g)		CO Emis (m
		2024	% change vs 23	20
1	**Wizz Air**	54.0	-1.9%	3.
2	**Azores Airlines**	61.4	-2.9%	0
3	**Aegean Airlines**	61.6	+1.2%	1
4	**Transavia**	62.1	-1.3%	1.
5	**Ryanair**	63.2	-1.9%	12
6	**Buzz**	63.4	-0.1%	2.
7	**TAP Air Portugal**	63.7	+1.2%	1
8	**Norwegian**	64.6	-1.3%	1
9	**Finnair**	65.9	-0.1%	0
10	**SAS**	66.9	-5.7%	1.
	All Western Europe:	**67.3**	**-1.3%**	**7**

ROPE REGION

O_2 sions nt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
24	2024	% change vs 23	2024	2024	2024
.6	205	+4.3%	223	4.8	1,456
.1	8	+22.5%	177	11.6	1,577
.1	84	+6.3%	185	9.7	1,134
9	107	+5.1%	189	12.0	1,500
.6	841	+6.5%	191	9.2	1,237
.0	129	+14.9%	190	7.9	1,296
.1	63	-2.4%	182	12.5	1,439
.1	83	+2.0%	187	9.9	1,107
.9	46	+13.1%	192	15.7	1,529
2	146	-11.0%	141	8.5	783
71	**5,720**	**+5.6%**	**163**	**11.5**	**1,048**

SOUTHEAST

Rank	Operator (group)	CO_2/ASK (g)		CO Emis (m
		2024	% change vs 23	20
1	**Scoot**	64.4	+2.0%	0
2	**VietJet Air**	67.2	+0.5%	1.
3	**Lion Air**	67.6	-5.8%	1
4	**Royal Brunei Airlines**	67.8	+3.4%	0
5	**Indonesia AirAsia**	68.5	-1.3%	0
6	**Jetstar Asia**	69.0	-1.7%	0
7	**Philippine Airlines**	69.8	+2.1%	0
8	**Cebu Pacific**	70.8	+3.7%	1.
9	**AirAsia**	71.0	+1.2%	1.
10	**Thai Lion Air**	71.7	+1.1%	0
	All Southeast Asia:	**75.5**	**+0.4%**	**2**

ASIA REGION

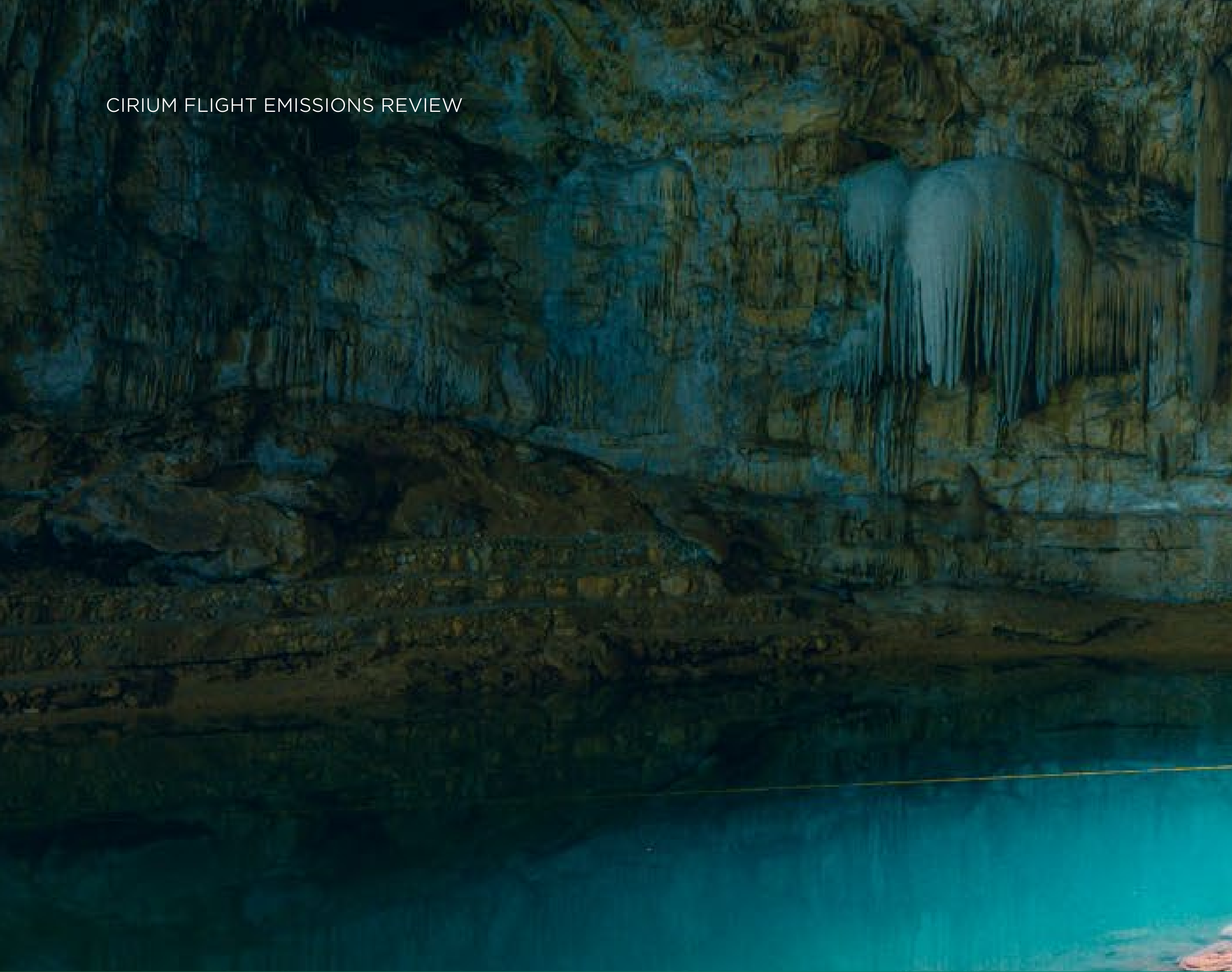
O_2 sions nt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
24	2024	% change vs 23	2024	2024	2024
.6	34	+8.5%	209	7.4	1,177
3	95	-5.5%	219	8.5	947
.1	97	-15.9%	209	12.4	825
.1	6	+17.4%	157	6.2	1,172
.6	38	+1.0%	180	13.9	1,232
.2	14	+17.4%	180	12.7	1,265
.4	13	-5.0%	231	9.5	1,886
2	104	+17.0%	205	6.7	746
6	148	+6.7%	183	9.7	853
.3	27	+13.9%	194	9.7	709
0	**1,736**	**+0.9%**	**173**	**10.6**	**803**

LATIN AMER

Rank	Operator (group)	CO_2/ASK (g)		C Emis (m
		2024	% change vs 23	20
1	**Arajet**	51.9	+0.5%	0
2	**Sky Airline**	54.9	-1.2%	0
3	**JetSmart**	56.6	-2.4%	0
4	**Volaris**	59.1	+3.5%	2.
5	**VivaAerobus**	61.4	+6.0%	2.
6	**Gol**	64.7	-3.9%	2
7	**Azul**	64.8	-3.2%	2.
8	**Flybondi**	66.2	+7.2%	0
9	**Copa Airlines**	66.5	-1.7%	2
10	**Aeromexico**	70.0	+1.2%	1.
	All Latin America:	**67.5**	**-1.3%**	**2**

ICA REGION

O_2 sions nt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
24	2024	% change vs 23	2024	2024	2024
.2	7	+64.8%	185	2.5	2,694
.7	58	+6.3%	195	4.0	1,186
.8	61	+22.8%	193	3.3	1,200
.0	127	-20.5%	197	6.9	1,340
.0	145	+12.6%	200	8.8	1,106
.7	210	-5.2%	180	9.4	1,101
.5	292	+2.6%	132	6.9	860
.3	24	+0.4%	184	15.8	1,203
.1	96	+4.2%	159	10.5	2,064
6	101	+3.2%	173	6.4	1,258
2	**2,245**	**+3.4%**	**165**	**9.9**	**1,053**



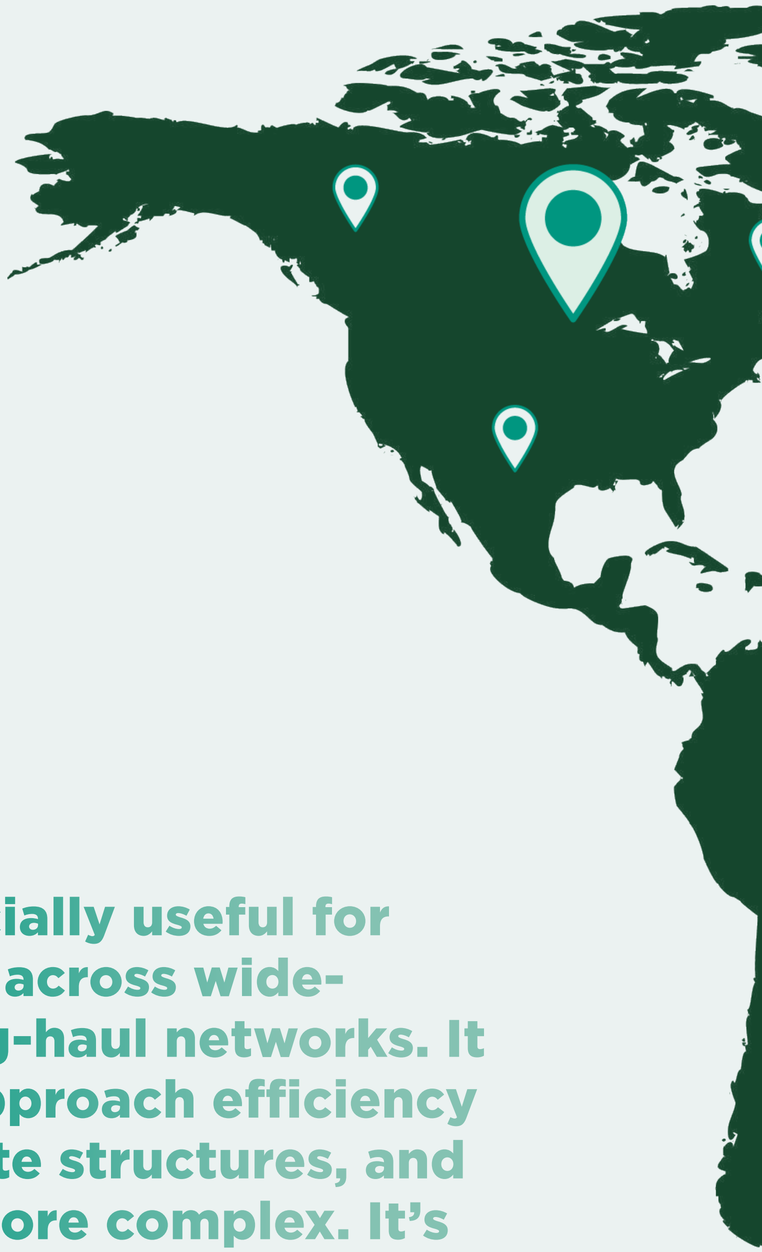
INTER-REGIONAL HIGHLIGHTS:
CO_2 EFFICIENCY BY GEOGRAPHY

30

INTER-REGION RANKINGS

To complement the regional view, we've also examined how airlines perform on longer routes crossing between regions.

These inter-region rankings focus on average CO_2 per ASK for flights that span two different global regions.



To be included here, an airline must have operated at least 300 inter-region flights during 2024. As with the intra-region section, we've provided the average great circle distance per flight to help give the emissions numbers context—longer flights come with different efficiency profiles, and that matters when comparing operators.

This kind of view is especially useful for understanding emissions across wide-body operations and long-haul networks. It highlights how airlines approach efficiency when fleet decisions, route structures, and fuel burn dynamics are more complex. It's another example of how a more granular approach—powered by the right data—can surface deeper insights.

NORTH A

Rank	Operator (group)	CO_2/ASK (g)			
		2024	% change vs 23	Westbound	Eastbou
1	French Bee	55.0	+4.7%	58.3	51.6
2	Azores Airlines	56.3	-5.7%	60.8	51.8
3	Norse Atlantic Airways	60.1	+0.9%	63.9	56.3
4	WestJet	60.5	-2.4%	62.6	58.5
5	TAP Air Portugal	65.6	+1.0%	71.1	60.1
6	Air Tahiti Nui	67.3	+2.5%	70.2	64.4
7	Aer Lingus	67.6	+1.1%	72.6	62.6
8	JetBlue	68.3	-1.1%	73.2	63.4
9	Air Canada	70.1	+0.5%	74.2	66.0
10	LOT Polish Airlines	71.5	+1.2%	75.7	67.3
	All North Atlantic:	**78.8**	**+0.2%**	**83.8**	**73.7**

ATLANTIC

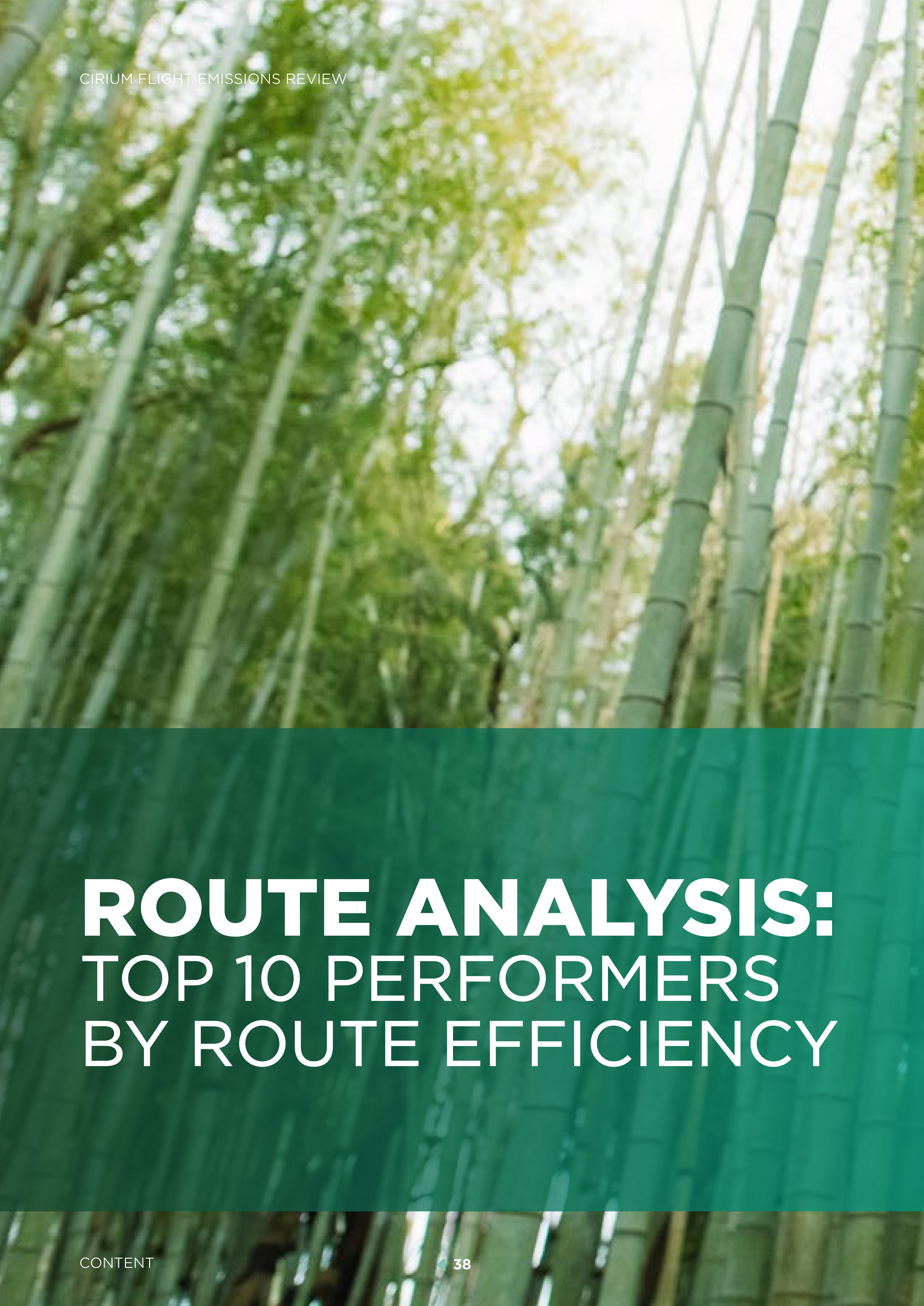
CO_2 Emissions (mt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
2024	2024	% change vs 23	2024	2024	2024
0.3	1.6	+0.9%	411	6.3	7,384
0.1	2.4	+24.4%	195	5.1	4,180
0.6	4.5	+22.4%	339	5.9	6,900
0.4	3.6	+56.7%	268	4.2	6,442
0.7	8.7	+11.0%	211	4.3	5,855
0.1	0.6	+5.7%	294	5.3	8,772
1.2	12.5	+3.3%	254	9.2	5,723
0.4	7.2	+62.4%	143	1.6	5,488
3.3	24.0	+6.9%	323	13.0	6,105
0.6	4.2	-3.3%	273	8.0	7,419
57	**384.3**	**+6.3%**	**275**	**12.8**	**6,715**

TRANS

Rank	Operator (group)	CO$_2$/ASK (g)			
		2024	% change vs 23	Westbound	Eastbou
1	Zipair Tokyo	63.9	+0.5%	70.1	57.6
2	Fiji Airways	65.0	-1.2%	67.4	62.6
3	LATAM Airlines	66.2	+0.0%	71.1	61.4
4	Air Premia	69.1	-4.5%	75.4	62.7
5	Air Canada	74.4	+0.1%	80.0	68.9
6	Delta Air Lines	76.2	-0.0%	82.3	70.0
7	Hawaiian Airlines	76.4	+0.1%	84.2	68.6
8	Aeromexico	78.1	-0.4%	86.6	69.8
9	Philippine Airlines	78.6	+0.2%	85.3	71.9
10	Hainan Airlines	79.0	+6.9%	84.0	74.6
	All Transpacific:	**86.1**	**-0.9%**	**92.8**	**79.4**

PACIFIC

	CO_2 Emissions (mt)	Flights (thousands)		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)
und	2024	2024	% change vs 23	2024	2024	2024
5	0.4	2.6	+32.9%	290	9.5	8,007
6	0.3	1.7	+3.2%	299	5.3	8,006
1	0.2	1.1	+36.4%	314	8.4	10,244
7	0.3	1.5	+75.5%	319	3.3	9,861
9	2.1	8.4	+20.8%	332	10.4	10,270
0	2.3	10.5	+29.5%	291	6.1	9,880
5	0.6	4.3	+6.8%	278	11.1	6,761
3	0.2	1.0	+83.0%	251	8.8	11,489
	1.3	4.1	+0.7%	354	9.8	11,254
5	0.2	0.8	+493.3%	290	7.3	10,141
4	**33.1**	**132.0**	**+19.1%**	**288**	**8.8**	**10,090**



ROUTE ANALYSIS:
TOP 10 PERFORMERS BY ROUTE EFFICIENCY

38

IMPROVEMENT BY ROUTE RANKINGS

This section takes a closer look at where real progress is being made—on individual routes. Here, we've ranked specific airport pairs flown by individual airlines based on their year-on-year reduction in CO_2 per ASK.

To make comparisons meaningful, we've grouped routes into three distance bands:

Short-haul under 1,500km

Medium-haul 1,500–3,999km

Long-haul 4,0

While these bands are defined by great circle distance for categorization, Cirium's emissions estimates go further. Rather than relying purely on distance, we factor in real-world operating data like tracked air time and taxi time, giving a more accurate reflection of flight-level emissions.

To qualify, a route must have been flown at least 300 times in 2024 by a single airline—roughly equivalent to 82% of a daily schedule. That means we're focusing on consistent, high-volume routes where meaningful efficiency gains are visible. In fact, about 77.4% of global flights last year fell into this qualifying category.

The most significant drops in emissions intensity tend to come from two areas: the introduction of new-generation aircraft and seat densification strategies. To help interpret the changes, we've included an equipment trend column that highlights key fleet updates on each route. While not exhaustive, it gives a useful snapshot of what's driving the improvement.

This view helps pinpoint where airlines are making operational decisions that lead to measurable environmental benefits—route by route. It's another example of how detailed tracking can uncover the small changes that, when scaled, add up to a big impact.

00km or more

LONG-HAU

Rank	Operator, route	CO_2/ASK (g)		CO_2 Emissions (kt)	
		% change vs 23	2024	2024	2024
1	**LATAM Airlines Peru, LIM - MEX**	-27.5%	51.7	13.8	360
2	**British Airways, LHR - PHL**	-21.5%	82.4	53.4	361
3	**Jetstar, BNE - DPS**	-20.2%	47.1	25.5	508
4	**SriLankan Airlines, CMB - KWI**	-20.1%	56.9	14.7	333
5	**United Airlines, LAX - BOS**	-16.9%	59.2	35.0	792
6	**United Airlines, EWR - FRA**	-16.9%	64.3	48.7	404
7	**Turkish Airlines, ISL - BOG**	-15.4%	74.8	90.5	364
8	**United Airlines, SFO - BOS**	-15.4%	58.9	73.7	1,618
9	**Etihad Airways, AUH - IAD**	-14.9%	79.1	92.2	363
10	**Thai Airways Int., BKK - SYD**	-14.6%	66.1	104.3	641
	All long haul:	**+0.1%**	**79.8**	**230,850**	**1,433,3**

UL ROUTES

Flights		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)	Equipment trend
4	% change vs 23	2024	2024	2024	
	-1.1%	174	6.4	4,246	767-300s to A320neos
	+4.0%	315	6.7	5,690	777s to A350-1000s
	+39.6%	238	1.3	4,488	787-8s to A321neos
	-2.6%	187	7.3	4,143	A330-200s to A321neos
	+10.3%	178	12.4	4,192	757-200s to 737 Max 9s
	-41.6%	302	5.9	6,211	767s & 777s to 787-10s
	-0.3%	310	4.7	10,729	777-300ERs to 787-9s
	-11.4%	178	12.5	4,341	757-200s to 737 Max 9s
	0.0%	282	3.3	11,386	226-seat 787-9s to 290-seat 787-9s
	+75.1%	327	7.2	7,515	777-300ERs to A350-900s
37	**+14.6%**				

MEDIUM-HA

Rank	Operator, route	CO_2/ASK (g)		CO_2 Emissions (kt)	
		% change vs 23	2024	2024	2024
1	Xiamen Airlines, CAN - PKX	-24.3%	62.2	10.6	505
2	Air China, PEK - KHG	-23.2%	67.2	16.9	408
3	Spirit Airlines, MCO - MCI	-21.9%	61.7	11.0	547
4	Spirit Airlines, MCO - STT	-21.6%	50.9	9.5	534
5	Air Canada, YVR - ORD	-21.1%	56.9	9.0	351
6	Delta Air Lines, ATL - BTV	-20.1%	71.5	6.0	364
7	Spirit Airlines, ACY - PBI	-18.9%	63.2	6.4	356
8	Spirit Airlines, MIA - SJU	-18.8%	50.0	7.1	400
9	China Eastern Airlines, TFU - HGH	-18.5%	74.8	7.7	414
10	Hainan Airlines, PEK - BKK	-18.2%	63.0	23.1	627
	All medium-haul:	**-0.3%**	**66.4**	**190,708**	**6,715,2**

AUL ROUTES

Flights		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)	Equipment trend
4	% change vs 23	2024	2024	2024	
	+10.0%	186	7.2	1,816	767-300s to A320neos
	+23.3%	179	6.0	3,436	777s to A350-1000s
	+35.4%	189	6.9	1,726	787-8s to A321neos
	+25.4%	175	5.7	2,007	A330-200s to A321neos
	-2.5%	160	8.6	2,831	757-200s to 737 Max 9s
	-0.5%	148	24.1	1,546	767s & 777s to 787-10s
	-1.1%	189	9.1	1,509	777-300ERs to 787-9s
	-2.0%	211	5.1	1,681	757-200s to 737 Max 9s
	-3.7%	161	11.2	1,534	226-seat 787-9s to 290-seat 787-9s
	+40.9%	177	6.5	3,316	777-300ERs to A350-900s
218	**+9.6%**				

SHORT-HAU

Rank	Operator, route	CO_2/ASK (g)		CO_2 Emissions (kt)	
		% change vs 23	2024	2024	2024
1	**Austrian, VIE - KLU**	-29.7%	101.5	1.1	566
2	**Azul, CNF - IOS**	-27.1%	67.0	3.4	508
3	**Azul, SLZ - BEL**	-26.8%	76.8	2.5	392
4	**JetBlue, JFK - BNA**	-26.6%	77.6	6.3	484
5	**Azul, VCP - PFB**	-24.9%	69.2	3.3	364
6	**China Eastern Airlines, HGH - SZX**	-24.3%	96.8	6.5	344
7	**Azul, FOR - BEL**	-24.1%	58.4	7.5	670
8	**JetBlue, JFK - BUF**	-24.1%	116.5	10.2	1,411
9	**JetBlue, JFK - ROC**	-23.9%	124.8	4.9	736
10	**China Eastern Airlines, TFU - CAN**	-23.3%	85.2	11.7	736
	All short-haul:	**+0.3%**	**83.8**	**191,827**	**18,888,**

UL ROUTES

Flights		Avg. Seats	Weighted Avg. Age (y)	Avg. Flight Distance (km)	Equipment trend
4	% change vs 23	2024	2024	2024	
	+11.2%	81	8.8	235	E195s to ATR 72-600s
	+20.1%	135	3.8	749	E195s to E195 E2s & ATR 72-600s
	-2.7%	172	5.3	490	E195s to A320neos
	-3.0%	137	4.0	1,228	E190s to A220-300s
	-25.7%	166	5.8	781	E195s to A320neos
	-1.1%	183	9.5	1,071	A330-200s to A321s
	+0.4%	169	5.5	1,135	E195s to A320neos
	-17.2%	129	6.1	482	E190s to A220-300s
	-17.1%	126	6.6	423	E190s to A220-300s
	+3.5%	160	11.6	1,167	A330-200s to A320/A321s
623	**+4.7%**				


emerald
sky

EMERALDSKY: ADVANCING FLIGHT EMISSIONS MEASUREMENT IN AVIATION

by **Andrew Doyle**, Senior Director, Market Development, Cirium

The aviation industry's path to decarbonization requires accurate emissions quantification, yet the sector has historically relied on fragmented methodologies that produce inconsistent results across operators and flight operations.

The Emissions Measurement Challenge

Current industry practices for flight emissions calculation often rely on overly simplistic fuel burn models or simplified distance-based approximations that fail to capture the complexities of real-world operations. This methodological inconsistency creates several operational challenges:

- **Regulatory Compliance Gaps:** Different calculation approaches can yield varying results for the same flight, complicating environmental reporting and regulatory submissions
- **Fleet Optimization Limitations:** Without granular, accurate data, industry stakeholders struggle to identify the most effective aircraft deployment strategies for emissions reduction
- **Benchmarking Difficulties:** Industry-wide performance comparisons become unreliable when operators use different measurement standards
- **Investment Decision Support:** Capital allocation decisions for fleet renewal, route optimization, or operational efficiency programs require robust baseline data

EmeraldSky's Technical Approach

EmeraldSky addresses these challenges through a comprehensive, data-driven methodology that leverages actual flight operations data coupled with sophisticated fuel burn models. The system integrates multiple data sources to produce emissions calculations that reflect real-world operational conditions.

Calculation Methodology

EmeraldSky's emissions calculations are built on a multi-layered data integration approach that combines several critical data sources:

- **Flight Operations Data:** The system ingests actual flight tracking data, including gate and runway departure and arrival times. This real-world operational data replaces the theoretical great circle distance calculations used by many existing tools.

- **Aircraft Performance Models:** EmeraldSky incorporates detailed aircraft-specific fuel consumption models that account for individual aircraft characteristics, engine types, and configuration variables. These models consider factors such as aircraft age and operational weight that significantly impact fuel burn rates.

- **Operational Context Integration:** The system accounts for operational factors such as taxi times, ground delays, air traffic control routing changes, and holding patterns that contribute to taxi/flight times and therefore total flight emissions but are often excluded from simplified calculation methods.

- **Real-Time Data Processing:** EmeraldSky processes this multi-source data through advanced algorithms that weight and correlate different variables to produce fuel consumption estimates. The system then applies standardized emissions factors to convert fuel burn data into CO_2.

- **Validation and Calibration:** The platform continuously validates its calculations against actual reported fuel consumption data where available, using machine learning techniques to refine its models and improve accuracy over time.

Strategic Applications

EmeraldSky's comprehensive emissions data serves multiple critical applications across the aviation ecosystem:

- **ESG Reporting and Compliance:** Airlines can improve environmental disclosure reporting related to travel programs and enhance investor appeal through improved ESG performance and reporting. EmeraldSky achieves an independently calculated unrivalled >99% accuracy on emissions for a specified set of mission, aircraft and payload inputs, providing the data integrity required for credible sustainability reporting to stakeholders and regulatory bodies.

- **Competitive Benchmarking:** Airlines can benchmark flight emissions across owned and leased aircraft, as well as comparisons with partners and competitors. This enables carriers to understand their relative environmental performance and promote differentiated sustainable flight offerings in the marketplace.

- **Carbon Offset Accuracy:** The precision of EmeraldSky's seat-by-seat emissions tracking enables accurate carbon offset calculations. The data enables seat-by-seat emissions to be precisely tracked by management companies, corporate travel departments, aircraft finance firms and airlines, ensuring that offset purchases correspond to actual emissions rather than theoretical estimates.

- **Passenger Flight Selection:** EmeraldSky enables travellers to make more informed decisions about sustainable flight options by providing accurate CO_2 emissions data for specific flights. This supports the growing demand for environmental transparency in travel booking platforms and helps passengers choose lower-emission alternatives when available.

- **Operational Optimization:** Airlines can use EmeraldSky's granular data for route planning and fleet deployment strategies, identifying opportunities to reduce emissions through operational improvements and aircraft utilization optimization.

BUILDING CONFIDENCE IN EMISSIONS DATA: THE IMPORTANCE OF ISAE 3000 ASSURANCE

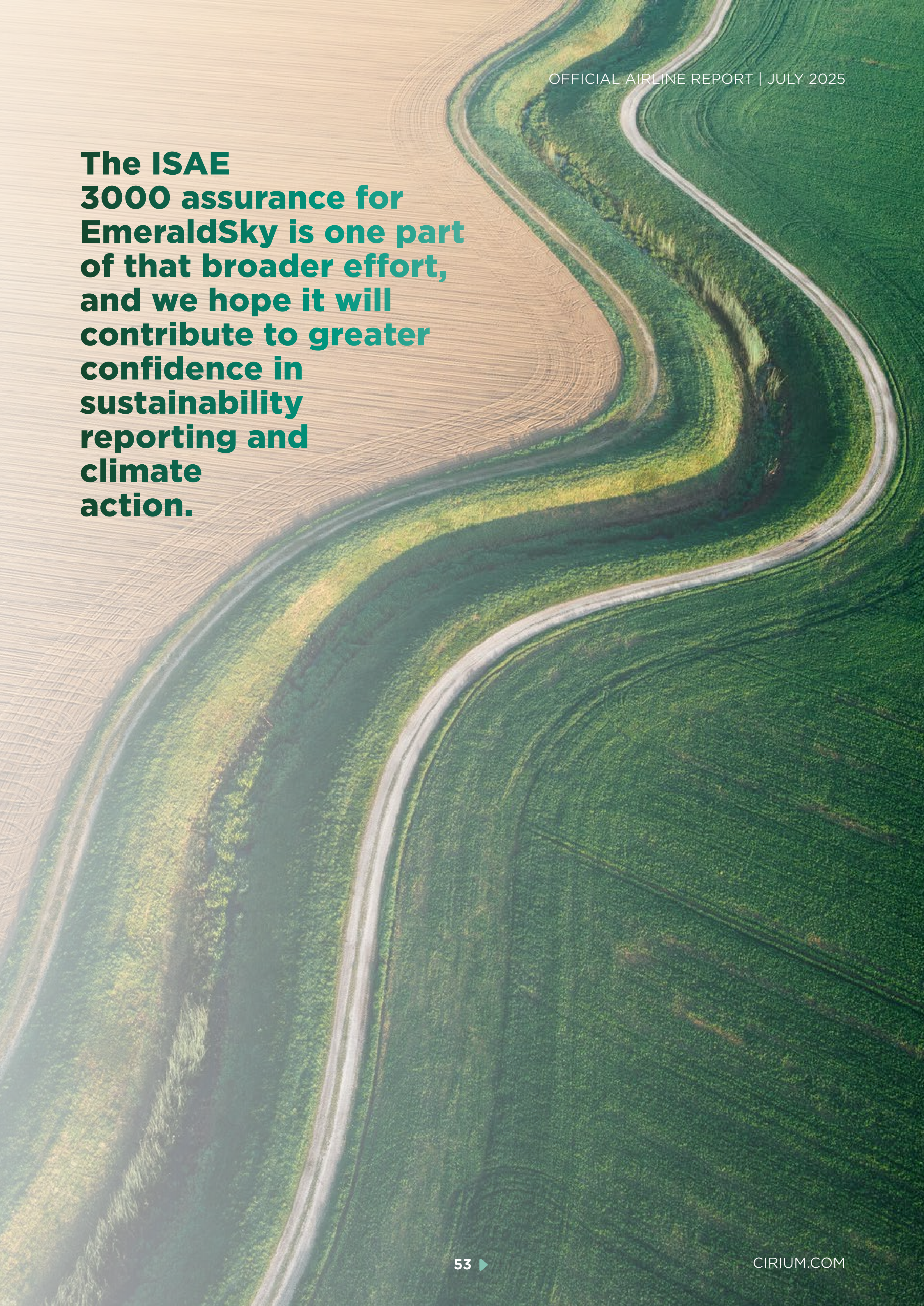
Accurately measuring aviation's carbon footprint is a complex challenge—but it's also essential. That's why Cirium sought independent validation of its EmeraldSky Flight Emissions methodology. The recent achievement of ISAE 3000 Reasonable Assurance, following a detailed review by PricewaterhouseCoopers LLP (PwC), is an important step in helping the industry rely on data it can trust.

ISAE 3000 is a globally recognized standard for assurance of non-financial information. Achieving Reasonable Assurance—the highest level available—means that EmeraldSky's methodology, internal controls, and data processes have been thoroughly assessed and found to meet the standard's rigorous requirements. For those using the data, it brings greater confidence in how emissions are modeled and reported.

EmeraldSky is built on a combination of robust modeling and detailed aviation data. It accounts for a wide range of variables, including aircraft type, engine specifications, payload, taxi times, and fuel burn. These factors are not based on broad assumptions but are tied to operational data, including verified airline inputs where available. The result is a methodology designed to reflect actual performance as closely as possible.

For airlines, airports, and corporate sustainability teams working to report Scope 3 emissions, evaluate environmental performance, or support carbon reduction efforts, reliable data is essential. While no model is perfect, the assurance provided by ISAE 3000 offers added transparency and accountability. It also supports broader industry goals—such as improving decision-making and progressing toward long-term emissions reduction targets.

At Cirium, the aim has always been to provide the aviation industry with tools that are practical, grounded in data, and independently verified wherever possible. The ISAE 3000 assurance for EmeraldSky is one part of that broader effort, and we hope it will contribute to greater confidence in sustainability reporting and climate action.



The ISAE 3000 assurance for EmeraldSky is one part of that broader effort, and we hope it will contribute to greater confidence in sustainability reporting and climate action.

APPENDIX


54

AIRLINE CODES

Aegean Airlines	A3
Aeromexico	AM
Aeromexico Connect	5D
Aer Lingus	EI
Air Canada	AC
Air China	CA
Air Corsica	XK
Air Europa	UX
Air Europa Express	X5
Air France	AF
Air India	AI
Air New Zealand	NZ
Air Premia	YP
Air Swift	T6
Alaska Airlines	AS
American Airlines	AA
Asiana Airlines	OZ
ASL Airlines France	5O
Austrian	AU
Avianca	AV
Avianca Ecuador	2K
Avianca El Salvador	TA
Azores Airlines	S4
Azul	AZ
Batik Air	ID
Binter Canarias	NT
British Airways	BA
Brussels Airlines	SN

Bulgaria Air	FB
Capital Airlines	JD
Cathay Pacific	CX
Cebu Pacific	5J
China Eastern Airlines*	MU
China Southern Airlines	CZ
Copa Airlines	CM
Condor	DE
Contour Aviation	LF
Croatia Airlines	OU
Delta Air Lines	DL
EasyJet Group**	U2
Edelweiss Air	WK
EgyptAir	MS
Emirates	EK
Enter Air	E4
Etihad Airways	EY
Eurowings	EW
Finnair	AY
Flynas	XY
Frontier Airlines	F9
GOL	G3
GX Airlines	GX
Hawaiian Airlines	HA
Iberia	IB
Iberia Express	I2
IndiGo	6E
Indonesia AirAsia	QZ

ITA Airways	AZ
JAL	JL
JetSmart Peru	JZ
Jetstar	JQ
Jetstar Asia	3K
Jettime	JP
Juneyao Air	HO
Korean Air	KE
Kuwait Airways	KU
Lao Airlines	QV
LATAM Airlines Brasil	JJ
LATAM Airlines Colombia	4C
LATAM Airlines Group**	LA
Lion Air	JT
Loganair	LM
Loong Air	GJ
LOT Polish Airlines	LO
Lufthansa CityLine	CL
Malaysia Airlines	MH
Norwegian Air Sweden	D8
Pegasus	PC
Pelita Air Service	IP
Qantas	QF
Qatar Airways	QR
Ryanair***	FR
SAS	SK
SAS Link	
Saudia	SV

Scoot	TR
Shandong Airlines	SC
Shanghai Airlines	FM
Shenzhen Airlines	ZH
Sichuan Airlines	3U
Singapore Airlines	SQ
Sky Express	GQ
Southwest Airlines	WN
Spring Airlines	9C
Sunclass Airlines	DK
Super Air Jet	IU
Swiss	LX
TAP Air Portugal	TP
Thai Airways International	TG
TransNusa	8B
TUIfly Netherlands	X3
United Airlines	UA
US-Bangla Airlines	BS
Vietravel Airlines	VU
Virgin Atlantic	VS
Virgin Australia	VA
Vietnam Airlines	VN
Volaris	Y4
WestJet	WS
Wizz Air	W6
Wizz Air UK	W9
Xiamen Airlines	MF

AIRPORT CODES

Aarhus Airport	AAR
Atlantic City International Airport	ACY
Hartsfield-Jackson Atlanta International Airport	ATL
Zayed International Airport – Abu Dhabi	AUH
Belem/Val-de-Cans International Airport	BEL
Grantley Adams International Airport	BGI
Suvarnabhumi Airport	BKK
Kempegowda International Airport Bengaluru	BLR
Nashville International Airport	BNA
Brisbane Airport	BNE
El Dorado International Airport - Bogota	BOG
Chhatrapati Shivaji Maharaj International Airport	BOM
Boston Logan International Airport	BOS
Patrick Leahy Burlington International Airport	BTV
Buffalo Niagara International Airport	BUF
Baltimore/Washington International Airport	BWI
Cairo International Airport	CAI
Guangzhou Baiyun International Airport	CAN
Netaji Subhash Chandra Bose International Airport	CCU
Charles de Gaulle Airport	CDG
Marechal Rondon Cuiaba International Airport	CGB
Charlotte Douglas International Airport	CLT
Colombo Bandaranaike International Airport	CMB
Belo Horizonte/Confins-Tancredo Neves Intl Airport	CNF
Copenhagen Airport	CPH
Cam Ranh International Airport	CXR
Denver International Airport	DEN
Dallas/Fort Worth International Airport	DFW

Doha Hamad International Airp
I Gusti Ngurah Rai Internationa
Dubai International Airport
Newark Liberty International A
Pinto Martins – Fortaleza Intern
Frankfurt Airport
Hangzhou International Airpor
Dulles International Airport
George Bush Intercontinental A
Incheon International Airport
Bir Tikendrajit International Air
Ilheus/Bahia-Jorge Amado Air
Istanbul Airport
John F. Kennedy International
Kashgar Airport
Klagenfurt Airport
Kualanamu International Airpo
Kuala Lumpur International Air
Kuwait International Airport
Los Angeles International Airp
London City Airport
London Heathrow Airport
Jorge Chavez International Air
Milan Linate Airport
Murtala Muhammed Internation
Chennai International Airport
Kansas City International Airpo
Orlando International Airport

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	DXB
irport	EWR
national Airport	FOR
	FRA
t	HGH
	IAD
Airport	IAH
	ICN
rport	IMF
port	IOS
	ISL
Airport	JFK
	KHG
	KLU
rt	KNO
rport	KUL
	KWI
ort	LAX
	LCY
	LHR
port	LIM
	LIN
nal Airport	LOS
	MAA
rt	MCI
	MCO

Muscat International Airport	MCT
Benito Juarez Mexico City International Airport	MEX
Miami International Airport	MIA
Mitiga International Airport	MJI
Munich International Airport	MUC
Chicago O’Hare International Airport	ORD
Palm Beach International Airport	PBI
Beijing Capital International Airport	PEK
Passo Fundo Airport	PFB
Pacific Harbour Airport	PHR
Phoenix Sky Harbor International Airport	PHX
Beijing Daxing International Airport	PKX
Frederick Douglass Greater Rochester Intl Airport	ROC
El Salvador International Airport	SAL
San Francisco International Airport	SFO
Shenyang Taoxian International Airport	SHE
Singapore Changi Airport	SIN
Luis Munoz Marin International Airport	SJU
Sao Luis-Marechal Cunha Machado Intl Airport	SLZ
Cyril E. King Airport	STT
Shenzhen Bao’an International Airport	SZX
Sydney International Airport	SYD
Syracuse Hancock International Airport	SYR
Qingdao Jiaodong International Airport	TAO
Chengdu Tianfu International Airport	TFU
Vienna International Airport	VIE
Vancouver International Airport	YVR
Zurich Airport	ZHR

DEFINITION OF TERMS

A · B · C · D · **E** · F · **G** · H · **I** · J · K · **L** · **M**

A

AVAILABLE SEAT KILOMETERS (ASKs)

The number of seats available multiplied by the number of kilometers between origin and destination.

E

ESG REPORTING

The disclosure of information by companies regarding their performance and impact across three key areas: Environmental, Social, and Governance. It's a way for organizations to communicate their commitment to sustainability and responsible business practices to various stakeholders, including investors, customers, employees, and regulators.

G

GLOBAL AIRLINE RANKINGS

Comparing the world's 100 largest carriers by CO_2 per ASK, split into 'Major' and 'Mainline' categories for clearer peer benchmarking.

I

INTER-REGION RANKINGS

The interregion rankings focus on average CO_2 per ASK for flights that span two different global regions.

INTRA-REGION RANKINGS

These rankings focus on average CO_2 per ASK for flights that take place entirely within a single region—providing a closer look at how airlines are performing on short- and medium-haul networks.

· N · O · P · Q · R · **S** · **T** · U · V · W · X · Y · Z

ISAE 3000

These rankings focus on average CO_2 per ASK for flights that take place entirely within a single region—providing a closer look at how airlines are performing on short- and medium-haul networks.

L

LONG-HAUL ROUTE

Typically intercontinental flights (e.g., across the Atlantic or Pacific, from Europe to Asia, North America to South America). Distances are usually greater than 4,000 km (around 2,200 nautical miles).

M

MEDIUM-HAUL ROUTE

Can be transcontinental within large countries or international flights to neighboring continents (e.g., within Europe, or between Europe and North Africa/ Middle East). Distances often range from 1,500 km to 4,000 km (around 800 to 2,200 nautical miles).

S

SHORT-HAUL ROUTE

Typically domestic or regional flights, often within the same country or to very close neighboring countries. Distances are usually less than 1,500 km (around 800 nautical miles).

SUSTAINABLE AVIATION FUEL (SAF)

An alternative fuel made from non-petroleum feedstocks that reduces emissions from air transportation.

T

TAXI TIME

The period an aircraft spends moving on the ground at an airport, either before takeoff or after landing, under its own power.

CIRIUM HISTORY

Cirium brings together powerful data and analytics to keep the world moving. Delivering insight, built from decades of experience in the sector, enabling travel companies, aircraft manufacturers, airports, airlines and financial institutions, among others, to make logical and informed decisions which shape the future of travel, grow revenues and enhance customer experiences. Cirium is part of RELX PLC, a global provider of information-based analytics and decision tools for professional and business customers.

1909

Launched the world's first weekly aerospace magazine.

1985

Launched airline-specific insights to airline C-suite with the title Airline Business.

2016

The pioneer in global, real-time flight status data, FlightStats, brought into the group.

Expanded the group's offering with Diio's fares, traffic and schedules analysis tools.

2019

New aviation analytics brand Cirium launched showcasing the industry's largest data store and an advanced solutions portfolio.

1997

Created online news and data service for aerospace and airports (formerly known as ATI).

2004

Expanded in aerospace with the most comprehensive technical fleet database (known previously as ACAS).

2011

Grew portfolio with the addition of aircraft finance services with historical fleet and valuations data with acquisition of Ascend.

2014

Added historical airline schedules data to business with acquiring Innovata.

2020

Added live flight and navigational data to the Cirium portfolio, bringing in initiatives for System Wide Information Management (SWIM), with Snowflake Software.

2023

Introduced new aviation analytics tools to accelerate digital transformation and support the industry's sustainability goals under five product brands

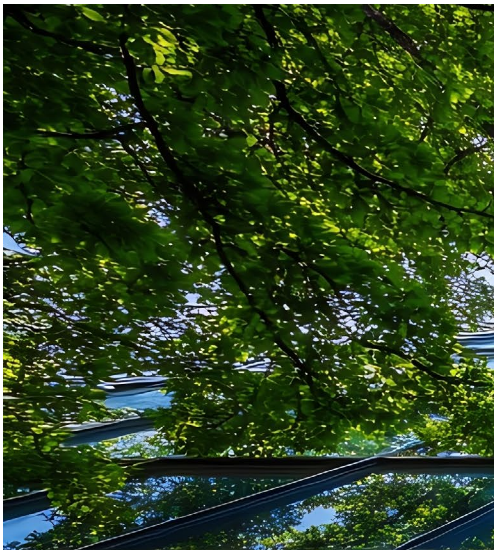
Extended partnership with Aireon to offer satellite-based aircraft positional analytics.

2024

Launched EmeraldSky with a unique and unparalleled methodology, data and analytics to provide the world's most accurate measure of aircraft and flight emissions.

Introduced the On-Time AI Assistant, designed to enhance exploration of on time performance data, streamline data discovery, uncover insights, and answer operational questions.

CIRIUM GLOBAL OFFICES



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