Building More Accurate and Granular Flight Emissions Estimates

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The need for more granular estimates

Post-trip reporting vs. pre-trip flight choices

Flight emissions estimates typically serve two use cases: (a) post-trip reporting that measure aggregate impacts in order to drive policy, and (b) pre-trip estimates to drive traveler choices at the point of sale.

At Lumo, we believe that the business travel industry so far has placed too much focus on reporting – aiming solutions at travel sustainability managers – and not enough on influencing buying behavior at the point of sale.

One reason for this is that widely-available emissions estimates today aren't granular enough to differentiate between a traveler's flight choices.

This white paper describes Lumo's method for calculating aircraft carbon emissions to help drive **consistent estimates before, during, and after a trip.**

Why influencing point-of-sale behavior is key

Many organizations have committed to travel carbon footprint reductions of 25%+ in the short term. If the only data available to decision-makers is post-trip reporting, the only lever available to reduce carbon emissions is to reduce travel. Influencing point-of-sale behavior provides a second, equally powerful, lever to drive travelers toward more efficient options, helping achieve carbon reduction targets in the short term.

Widely-used methods today: Defra and ICAO

Defra, a calculation method published by the UK government, is the most commonly used framework for post-trip reporting. It is easy to calculate, is easy to understand, and requires very little data. It is a good methodology for consistent aggregate reporting, but is unsuited to driving changes in behavior.

ICAO, a methodology published by the International Civil Aviation Organization, is more granular than Defra in that it considers adjustments for aircraft type, but is too coarse to drive changes in behavior at the point of sale.

Current methods are acceptable for measuring aggregate impacts, but are not suited to helping travelers make better individual choices, which are key to meeting short-term carbon reduction targets

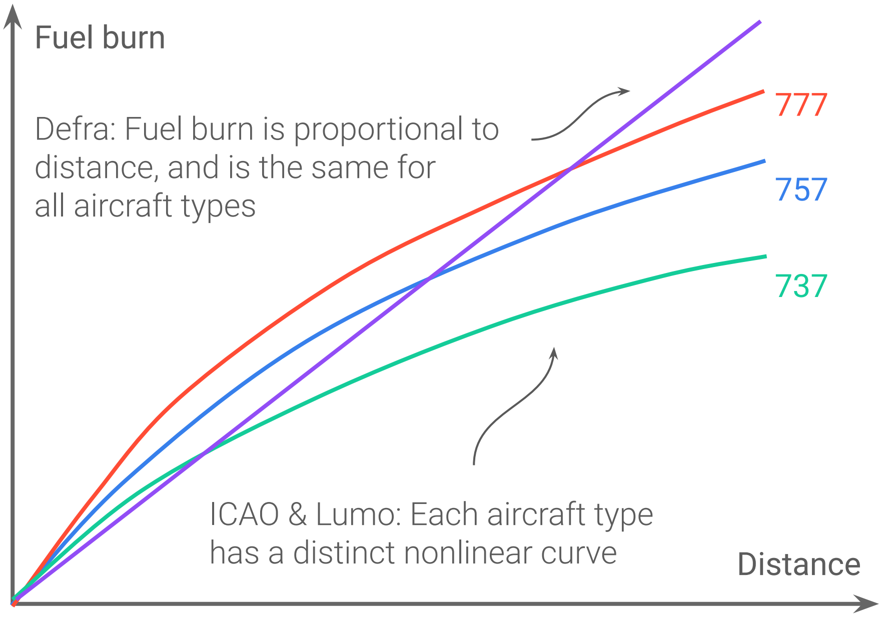
Impact of aircraft type and distance

Factoring distance into the calculation

The distance covered by a flight is the primary driver of fuel burn, and consequently emissions. Both Defra and ICAO take trip distance into account, albeit in slightly different ways: Defra assigns a constant emissions per kilometer estimate to the trip, irrespective of the aircraft type (with some small adjustments for short-haul vs long-haul flights), while ICAO relies on nonlinear curves that compute fuel burn as a function of distance and aircraft type.

Lumo's calculations use ICAO's fuel burn curves, with modifications for newer aircraft types (since the last ICAO publication was in 2018 and does not contain fuel burn curves for newer aircraft types such as the A320neo). Fuel burn curves for newer aircraft were compiled by taking an existing ICAO fuel burn curve, and scaling it based on estimated efficiency improvements published by the CAA, aircraft manufacturers, and other public sources. For example, the curve for an A320neo was generated by scaling the curve for the A320 down by approximately 25%.

Illustrative distance vs fuel curves

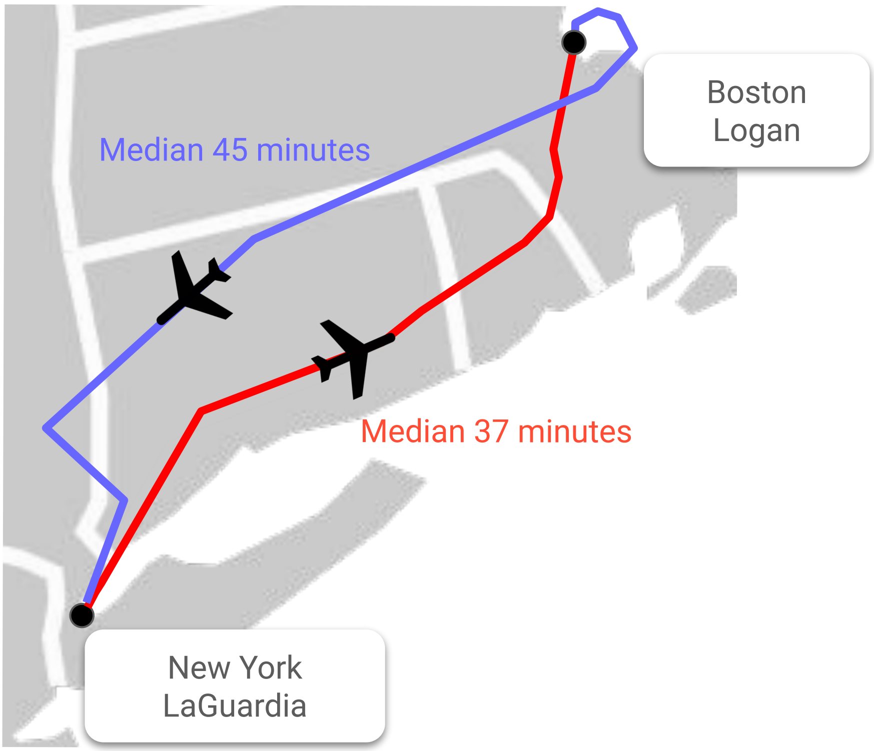


Newer aircraft types such as the Boeing 737 MAX and the Airbus A320neo are up to 25% more efficient than previous generation aircraft; using aircraft-type specific distance vs. fuel curves lead to more accurate and actionable estimates

Seasonality and jetstreams

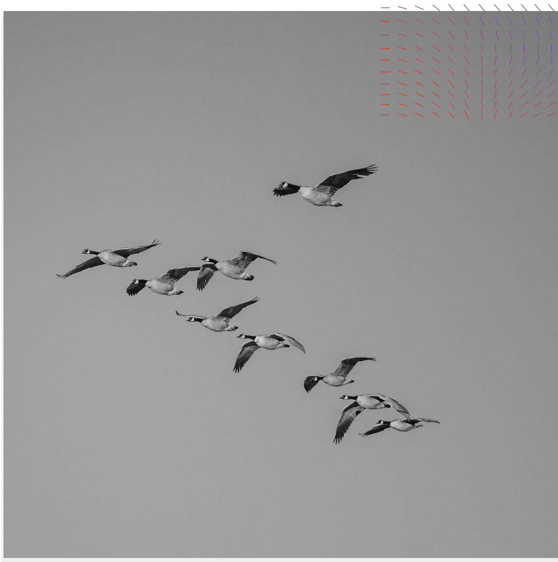
Variance in fuel burn by route

The Defra and ICAO methods assume that the fuel burn between a pair of cities is independent of the direction, and is the same across a year, which is often not an accurate assumption. For example, the flight time from Boston to New York is approximately 20% longer on average than the reverse (and therefore generates 20% greater emissions), driven by flight path and airport configuration constraints. Lumo's calculations account for these differences for every pair of cities in the world.



Seasonal patterns

An average transatlantic flight going East-to-West burns around 15% more fuel than a West-to-East flight between the same airports. However, this difference is as low as 10% in April, and as high as 20% in October due to differences in jetstreams over the year. We analyzed millions of flights over 5 years to estimate seasonal variations by route for all airports globally, and incorporate seasonal adjustments into our emissions estimates.



The fuel burn of a flight between two airports can differ by up to 20% from a flight in the reverse direction, and the time of year can add an additional 10% of variance to the numbers across a year; ignoring seasonality and directionality can lead to inaccurate estimates

Accounting for cabin configuration

Impact of cabin configuration

Cabin configuration refers to the layout of the cabin and number of seats in each class of service. For example, consider two flights from Boston to Fort Lauderdale on a Boeing 737-800:

# Seats by cabin class		
First	32	32
Premium Economy		36
Economy	156	102

The two flights have different cabin configurations, with the American Airlines cabin having a slightly more efficient use of space, leading to 5% lower emissions per economy seat.

While Defra ignores cabin configuration, and ICAO assumes a single configuration for a given aircraft type irrespective of airline and route, Lumo's method accounts for differences in cabin configurations by airline and route, allowing travelers to choose flights with more efficient configurations.

Cabin choice and CO_2 impact

In general, a seat should be allocated emissions that are proportional to the area it takes up on the flight. Since this data is not readily available, Derfa assumes that a premium economy, business, and first class seat have emissions of 1.6, 2.9, and 4.0 times that of an economy class seat. ICAO restricts its analysis to only two cabin classes – economy and non-economy – with the non-economy cabin having emissions of 2 times that of an economy seat.

Lumo follows the Defra approach, with one small adjustment. Oftentimes, seats that are in business class may be marketed as first class seats on certain routes (for example, on US domestic routes as in the example above). Our method normalizes this data to assign such seats the business class multiplier instead of the first class multiplier to ensure consistency.

The seating configuration of the aircraft and cabin class of the seat determine how to allocate a flight's total fuel burn to a specific passenger; taking into account the seat layout by aircraft type, route, and airline leads to more precise estimates of emissions per seat

Passenger and freight load factors

Two factors that drive emissions allocation

Since many aircraft carry both passengers and cargo, two factors go into the calculations to fairly allocate a flight's emissions to its passengers: (a) the freight factor which is the fraction of freight weight relative to the total weight carried by the aircraft, and (b) the passenger load factor which is the fraction of actual seats filled vs available seats.

Defra assumes constant multipliers irrespective of airline or region, while the ICAO method uses factors that are constant between geographical regions (e.g., a constant freight factor for all flights between North American and Europe for all carriers). Furthermore, the ICAO data was last updated in 2018, which may not be representative of current operations.

ICAO TFS and ACT data sets

Most carriers report their freight and passenger loads to ICAO. These data sets – TFS and ACT – contain raw data by origin, destination, carrier, aircraft type, domestic vs international, and other factors, reported annually.

More granular estimates

Lumo aggregates and standardizes the TFS and ACT data sets by origin and destination countries, carrier, and year, which are then fed into the emissions calculations.

For example, in 2019, for Delta flights from France to the United States, passengers accounted for 80% of the weight, and flights had an average load factor of 84%, while the numbers were 72% and 83% respective for American Airlines.

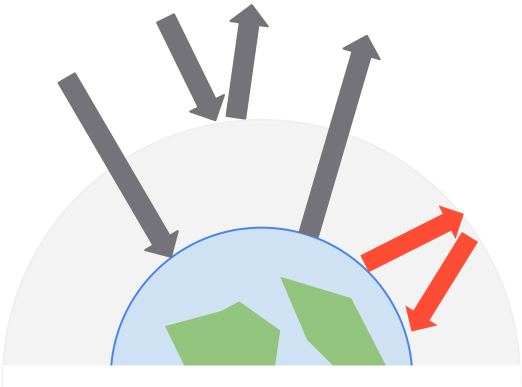
This unprecedented level of detail allows Lumo to provide far more granular emissions estimates than previously possible.

Passenger and freight load factors are used to allocate total flight emissions to each passenger; accounting for these factors by route and airline delivers more granular estimates

CO_2 equivalents and Radiative Forcing

Radiative forcing

Radiative forcing refers to the phenomenon by which the Earth receives more energy from sunlight than it radiates back into space. Since emissions from aviation occur higher in the atmosphere and could cause heat from the earth to be reflected back (the red arrows below), its effect on warming could be greater than that of equivalent emissions on the ground.



Radiative Forcing Index (RFI)

To account for radiative forcing, emissions from aviation must be multiplied by some factor that magnify their impact. The Intergovernmental Panel on Climate Change (IPCC) recommends an index of 2.7, Defra uses a factor of 1.9, while ICAO does not adjust for radiative forcing. Lumo's method uses a factor of 1.9 to maintain consistency with Defra, but we recognize that this is an area of ongoing research, and could change over time.

CO_2 vs CO_2e

Burning aviation fuel releases not only CO_2 but other Greenhouse Gases as well. To account for the impact of these additional emissions, the CO_2 emissions are multiplied by a factor to provide CO_2 equivalents, usually denoted by CO_2e, which is usually a few percentage points higher than raw CO_2 data.

Lumo uses Defra's conversion factors, while the ICAO method does not consider equivalents.

While there is debate on the magnitude of the impact of Radiative Forcing & non-CO_2 emissions, there is broad consensus at this time that these effects are real and need to be accounted for

Putting it all together

The bottom line

No method is "right" in any absolute sense as they all make certain assumptions. The correct way to think about emissions calculations methods is whether the estimates are right within the context of decisions they drive.

If the goal is to provide high-level aggregate reporting across a large organization that has fairly consistent travel patterns (i.e., similar travel year over year), Defra may be an acceptable choice. However, **if the goal is to drill down to individual travelers or flights in order to drive carbon reductions in the short-term or provide with travelers greater visibility and control over their choices, Lumo's data delivers enough granularity to help influence traveler behavior.**

Whether you are looking to integrate Lumo's emissions into a reporting suite or display the information in a booking tool or itinerary management app, Lumo's APIs deliver carbon emissions estimates and more at scale, providing a single consistent experience before, during, and after a trip.

	DEFRA	ICAO	LUMO
Trip Distance	● green	● green	● green
Aircraft Type	● red	● green	● green
Seating Configuration	● red	● orange	● green
Passenger Load Factors	● red	● orange	● green
Freight Factors	● red	● orange	● green
Class of Service	● green	● orange	● green
Radiative Forcing & CO_2 Equivalents	● green	● red	● green
Seasonality and winds	● red	● red	● green

Lumo's emissions calculation methodology has been independently reviewed and verified by https://www.carbonfootprint.com/.