# Travel Impact Model (TIM)
ADVISORY COMMITTEE

**TECHNICAL MEMO**

# Rationale for the apportionment of emissions to belly cargo

**Revised 22 April 2025**

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## SUMMARY

Currently, the Travel Impact Model (TIM) does not account for belly cargo in its emissions calculation, meaning that the model overestimates the passenger share of carbon dioxide ($CO_2$) on aircraft that carry both passengers and cargo ("belly cargo"). At its second meeting, the TIM Advisory Committee (AC) agreed to incorporate belly cargo into the TIM by apportioning a share of the $CO_2$ to belly cargo using a mass-based approach. In addition to an assumed weight of a passenger and their baggage of 100 kilograms, the agreed approach adds a further 50 kilogram per seat correction factor to account for the mass of passenger cabin furnishings and service equipment. Subsequently, ISO 14083 ("Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations") was updated to recommend the use of an equal mass approach of 100 kilograms per passenger. While the AC stands by its recommendation for a furnishings correction factor, the ISO approach will be implemented as an interim solution in the TIM to support industry standardization. In parallel, the TIM Secretariat and Google will coordinate with industry standards such as ISO to develop a freight allocation approach that supports real-world GHG emission reductions through the use of spare belly cargo capacity.

## RATIONALE

The AC agreed first to use payload mass as the basis for apportioning fuel to passengers and belly cargo on passenger flights. Two variations for mass-based apportionment were then investigated by the AC:

1. Equal mass basis—apportion fuel equally to passengers and belly cargo using an assumed mass of 100 kg/passenger including baggage (IATA RP 1726, EcoTransIT/EN16258 and GLEC)

2. With furnishings correction—as above, but adding a correction factor (e.g., +50 kg/seat) to take into account the mass of seats, service equipment, gallies, lavatories etc. used to provide passenger service for apportioning fuel (ICAO ICEC, SBTi).

Both the equal mass basis approach and the furnishings correction approach are used in existing transportation standards. IATA RP 1726 recommends an equal mass approach and requires airlines to disclose if they add a furnishings correction factor in order to comply with local regulatory requirements.[1] EcoTransIT/EN16258 and the GLEC framework both endorse the equal mass approach. In contrast, the +50 kg/seat furnishings adjustment is used by ICEC (ICAO's carbon calculator) and the Science-Based Targets initiative pathway.[2] Accordingly, it is impossible to align TIM with a single industry standard.

One motivation behind approach 2) is that aircraft empty weights vary between passenger and freighter variants of the same aircraft type, with implications for fuel burn and estimated carbon intensity. For example, a simple average of Operating Empty Weights (OEWs) of aircraft with both passenger versus freighter variants in the Piano-5 database[3] generates an average mass of 42 kg/seat of service equipment. This means that, without correcting for furnishings weight, the same kilogram of cargo carried in the belly of a passenger flight will appear more $CO_2$ intensive than that kilogram of cargo carried on a freighter variant of the same aircraft type.

As shown in Figure 1, the carbon dioxide ($CO_2$) intensity of dedicated cargo operations by aircraft type averaged 480 grams of $CO_2$ per freight tonne kilometer (FTK) in 2019, as estimated by a linear regression of $CO_2$ vs. FTKs by aircraft type (red dots and dotted line). Belly cargo's average carbon intensity without a furnishings correction factor was 790 $gCO_2$/FTK (blue dots and line), or 65% higher than that of dedicated cargo. In contrast, a +50 kg per seat adjustment factor generates an estimate of 540 $gCO_2$/FTK (green dots and line), better aligning the carbon intensity of belly and dedicated cargo.

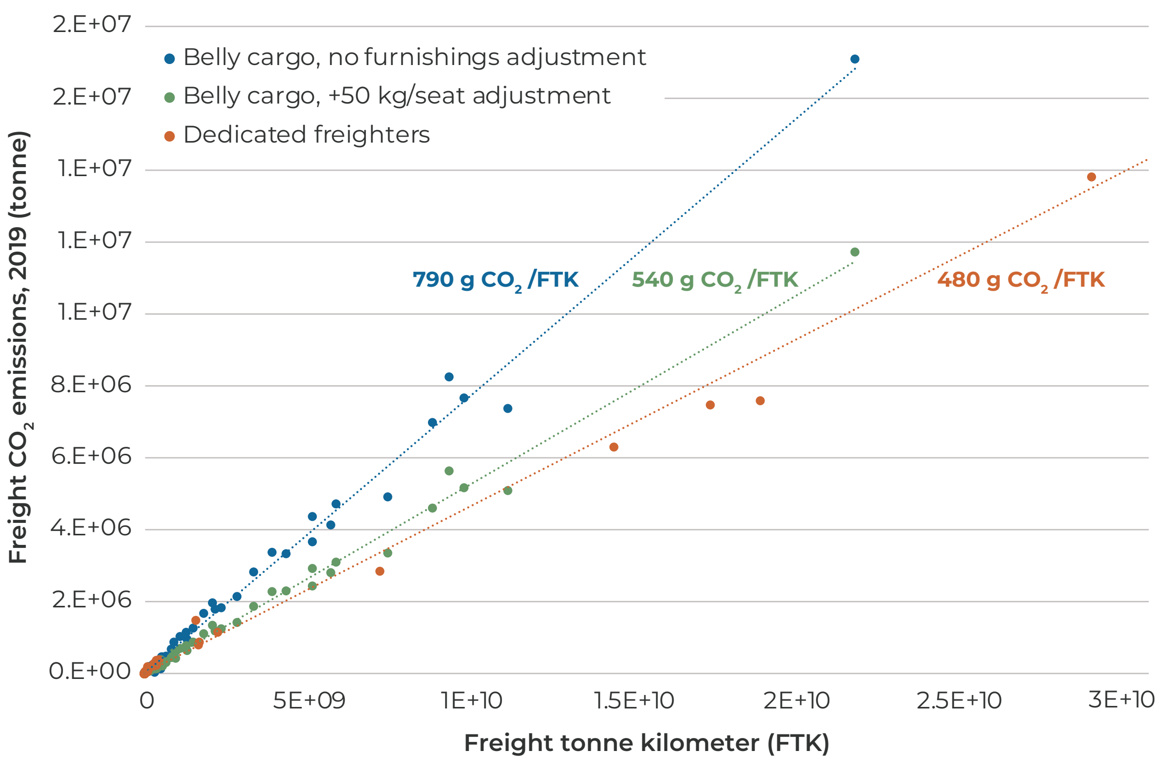


**Figure 1: Freight $CO_2$ emissions, freight tonne kilometers, and $CO_2$ intensity of air freight in 2019 (Source: ICCT analysis using GACA model)**

1 https://www.iata.org/contentassets/139d686fa8f34c4ba7a41f7ba3e026e7/iata-rp-1726_passenger-co2.pdf

2 https://applications.icao.int/icec; https://sciencebasedtargets.org/resources/files/SBTi_AviationGuidanceAug2021.pdf

3 https://www.lissys.uk/Piano5.html

A lack of consistency between belly and dedicated cargo can result in operational hurdles. For example, airlines would be selling the same service (transport of one tonne of freight) at different carbon intensities, which then discourages belly cargo carriage and hurts the overall fuel efficiency of passenger flights. For this reason, ICAO uses a +50 kg/seat correction factor in ICEC, and the Science-Based Targets Initiative (SBTi) also adopted the +50 kg/seat correction factor based on the principle that the pathway should reward airlines that fly their planes as full as possible and avoid incentivizing a shift to dedicated freight.

Table 1, derived from ICCT's 2019 global aviation inventory[4], summarizes how each mass-based approach is expected to influence overall apportionment of $CO_2$ emissions to passengers vs. cargo at a global level. As shown, an equal mass approach would apportion an additional 33 million tonnes (Mt) of $CO_2$ (3.6%) to belly cargo compared to a +50 kg/seat adjustment factor, while the dedicated cargo share of $CO_2$ would be unaffected. About three-quarters of that $CO_2$ would be shifted from widebody passenger service. Larger differences would be seen across individual flights carrying substantial belly cargo. For example, on a Shanghai to Sydney (PVG-SYD) flight, an equal mass approach would allocate 605 kg $CO_2$ to the average passenger, while applying a +50 kg/seat furnishings correction factor would assign 670 kg $CO_2$ per passenger, or a 10% increase.[5]

**Table 1: Estimated apportionment of global aviation $CO_2$ in 2019, equal mass basis and with furnishings correction factor (Source: ICCT, 2020)**

| | | Global $CO_2$ allocated (million tonnes) | | |
|---|---|---|---|---|
| **Service** | **Type** | **Equal mass approach** | **+50 kg/seat adjustment** | **Change in total share** |
| **Passenger** | Narrowbody | 385 (42%) | 393 (43%) | +1% |
| | Widebody | 312 (34%) | 336 (37%) | +3% |
| | Regional | 55 (6%) | 56 (6%) | 0% |
| **Cargo** | Belly cargo | 102 (11%) | 69 (8%) | -3% |
| | Dedicated cargo | 66 (7%) | 66 (7%) | 0% |
| **Total** | **Total** | **920** | **920** | **—** |

Finally, the 50 kg/seat adjustment factor better aligns fuel apportionment with the contribution of each payload type to aircraft revenue (Table 2). As shown, in 2007 cargo (freight plus mail) accounted for about 30% of revenue tonne kilometers in 2007, but

4 https://theicct.org/wp-content/uploads/2021/06/CO2-commercial-aviation-oct2020.pdf

5 2019 flights, Boeing 777-300 flight modelled using PIANO-5

only 13% of revenue. Total $CO_2$ apportioned to cargo (both belly and dedicated) with the +50 kg/seat adjustment factor tracks revenue closely (15% of global $CO_2$ from Table 1 vs. 13% of revenue from Table 2), while an equal mass approach apportions relatively more $CO_2$ to cargo (18% of global total) than the revenue generated.

**Table 2: Breakdown of 2007 airline operations by payload, market, and revenue, plus implied apportionment with +50 kg/seat correction factor (Source, Douganis, Flying Off Course, Fourth Edition)**

| | Tonne km performance in 2007 | | | Revenue split, 2007 |
|---|---|---|---|---|
| **Type** | **Intl** | **Domestic** | **All** | **All** |
| **Passengers** | 63.9% | 84.4% | 70.5% | 87.4% |
| **Freight** | 35.3% | 14.9% | 28.7% | 12.0% |
| **Mail** | 0.8% | 0.7% | 0.8% | 0.6% |
| **Total** | 100% | 100% | 100% | 100% |

For these reasons, the AC agreed to incorporate belly cargo into the TIM and to apportion $CO_2$ to cargo using the +50 kilogram per seat correction factor to account for the mass of passenger service equipment. The decision will be implemented as an interim solution in TIM and may be revised if a single international standard is developed in the future.