

# TAROM'S OPERATIONS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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**ABSTRACT. Tarom's Operations in the Context of Sustainable Development.** Understanding the environmental impact of air transport is an important objective in establishing sustainable transportation, as well as in shaping the future of aviation. In this study, we attempted to determine the greenhouse gas emissions associated with the activities of the Romanian airline TAROM in recent years. The COVID-19 pandemic placed the aviation sector in a critical situation worldwide, and the post-crisis period has also presented numerous challenges for airlines. Improving competitiveness, achieving profitable operations, and, not least, ensuring the most environmentally friendly operation possible pose significant challenges for airlines. A key question is to what extent air transport can become sustainable and what decisions and developments are necessary to achieve this goal. To answer this, it is essential to first map out aviation emissions at both the national and airline levels. The case of TAROM illustrates well that the specific emissions (emissions per passenger) can show considerable variability from year to year, depending on factors such as the types of aircraft used, the routes operated, the average load factor of flights, and the emission reduction measures implemented at the corporate level.

**Key words:** GHG emission, CO<sub>2</sub> emission, TAROM, airline, air transportation impact

## 1. INTRODUCTION

One of the most pressing issues today is the fight against climate change and the achievement of sustainable development. To accomplish this, anthropogenic greenhouse gas (GHG) emissions must be urgently reduced. This challenge affects multiple sectors, including transportation, meaning that reducing transport-related emissions—ideally achieving net-zero emissions—is also mandatory.

According to Nordin et al. (2024), the transport sector currently accounts for 20% of global greenhouse gas emissions. While road transport emissions have

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received significantly more attention in scientific research and policy decisions than other transport sub-sectors, in recent years, the issue of emissions from air (Arul, 2014; Larsson et al., 2018; Miyoshi and Mason, 2009; Scheelhaase, 2019; Scotti and Volta, 2015) and water transport (Pimiä et al., 2024) has rightfully come to the forefront.

In aviation, one of the main challenges is the increasing demand for services—the number of air passengers and the distance traveled per passenger-kilometer have both been rising (Lo et al., 2020; Turgut et al., 2019). Additionally, aircraft operations involve the combustion of significant amounts of fuel (Brueckner and Abreu, 2017), which serves as the primary source of emissions.

Measuring the net GHG emissions of flights performed by aircraft is not a straightforward task (Changxiong Li and Merkert, 2023; Fan et al., 2018; Song and Shon, 2012; Wang et al., 2020), as several variables influence actual fuel consumption, including flight length, weather conditions, aircraft (engine) technology level, possible use of alternative fuels, flight routes, strategies, and the complexity of ground maneuvers. The truly compelling question, however, is how to accurately determine aviation's specific greenhouse gas emissions, as this allows for an objective assessment of its environmental impact. To do this, it is necessary to first calculate the GHG (or CO<sub>2</sub> equivalent) for a specific flight and to know the number of passengers on board. With this information, the GHG emissions per passenger (or per seat) can be determined for a given flight.

Worldwide, every year, a vast number of flights are operated by many airlines (O'Connell, 2016), connecting even the most remote parts of the world. According to IATA data, in 2023, around 37 million jet and turboprop aircraft movements were registered (a 17% increase compared to the previous year), carrying 4.43 billion passengers. Furthermore, it is estimated that by 2025, this number will reach 5.22 billion passengers and approximately 40 million flights (IATA, 2024). Therefore, it is of paramount importance to address the negative environmental impacts of aviation, including efforts to reduce GHG emissions. Strategic decisions and measures made at the airline level (Cui and Li, 2021) play a crucial role in this regard, as do mandatory regulations related to aviation.

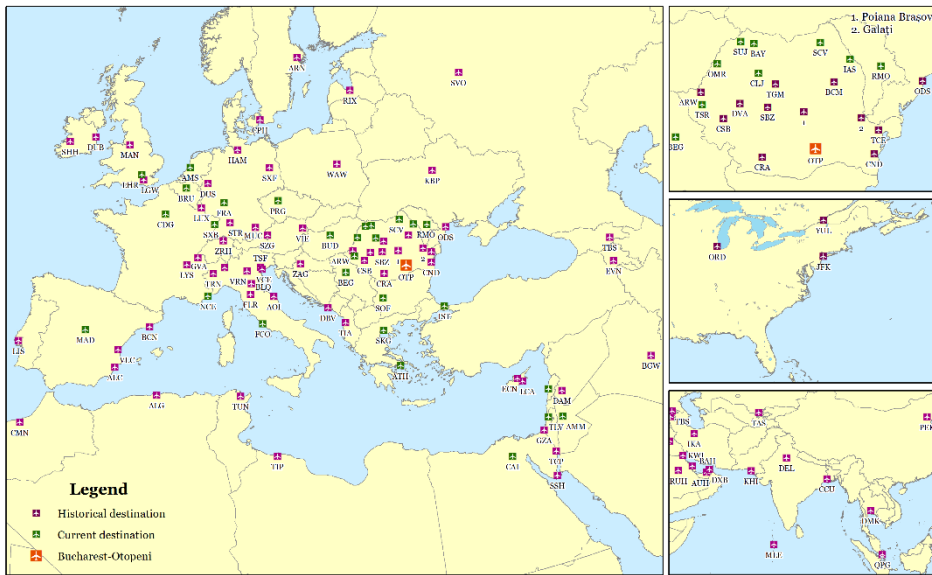
Aviation is not a simple market within the EU, as the Single European Sky (SES) regulations (EC 549/2004, EC 551/2004, EC 550/2004) have opened the door for the rise of low-cost carriers, which intensifies competition even for traditional national airlines such as TAROM. Additionally, the sector is characterized by high entry and operational costs (aircraft purchase/lease, pilot and ground crew salaries, maintenance costs, fuel costs, etc.), and it is sensitive to macroeconomic crises, with demand and supply being highly dynamic and subject to change within even a single year.

The key to long-term success is likely to be achieving the highest possible load factor on the flights served by the company, maintaining a reliable fleet with low operational/maintenance costs, and making sound strategic decisions

(Abdullah et al., 2016; Merkert and Hensher, 2011). In this regard, the pressure for a shift towards more environmentally friendly operations is increasing, driven both by mandatory regulatory guidelines and societal pressure (Chiambaretto et al., 2024). In our opinion, to ensure TAROM's competitiveness and long-term survival, it is essential that, alongside business considerations, the airline also takes steps to reduce greenhouse gas emissions.

## 2. EVOLUTION OF THE TAROM AIRLINE ACTIVITIES

In 1945, the TARS (Transporturi Aeriene Româno-Sovietică) airline was established as a Romanian-Soviet joint venture. In 1954, Romania sought to reduce Soviet influence, the Romanian state bought out the Russian share and, in September of the same year, founded the new Romanian national airline, TAROM (Erdösi, 2007). Between the 1950s and 1980s, its domestic and international route network and fleet underwent continuous expansion, making it a key player in Southeastern Europe (*Figure 1*).



**Fig. 1. TAROM's historical and current\* destinations from Bucharest-Otopeni (\*2024 summer schedule), source: TAROM's historical timetables**

In December 1989, the TAROM fleet consisted of 60 aircraft and operated international scheduled flights to destinations like Bucharest-Singapore, Bangkok, Delhi, Kolkata, Beijing, and New York, many requiring one or more stopovers due to the aircraft's limited range or low passenger numbers. In the early 1990s, TAROM remained Romania's leading airline, with 82% of flights

being international and 13% domestic (Erdősi, 2007). The international network expanded to include new routes to Chicago, Montreal, Milan, Chişinău, Bologna, Thessaloniki, Munich, and Stuttgart.

Between 2000 and 2004, TAROM underwent reorganization, suspending all long-haul flights due to unprofitability, along with several other routes or reduced service frequency. This restructuring led to temporary profitability, with significant changes to the fleet, including the addition of new Airbus A318 and Boeing B737-700 aircrafts.

By the end of 2011, TAROM's international network connected 29 cities across Europe, Africa, and the Middle East with Romania's three airports, primarily Bucharest. Domestic routes steadily declined, leaving only nine by the end of 2011. In 2021, TAROM operated seven domestic and 22 international routes, and by late 2024, it serves seven domestic and 17 international destinations from its main hub in Bucharest (Otopeni).

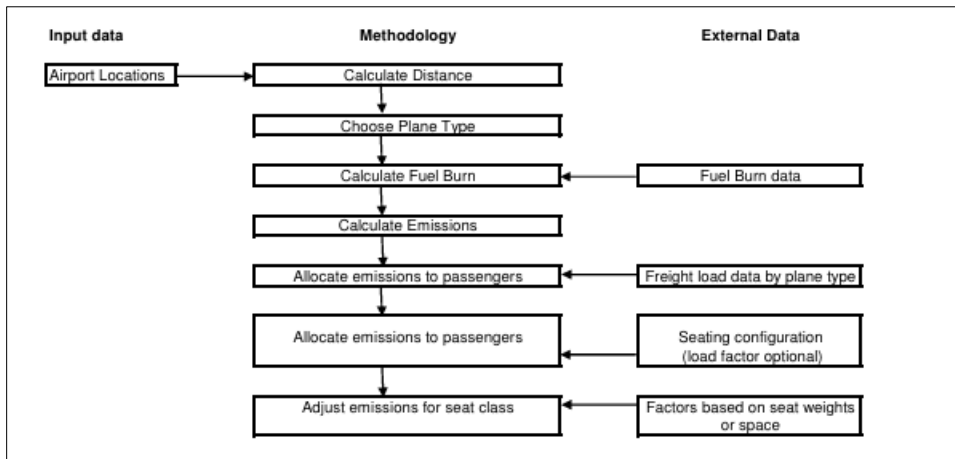
TAROM remains one of Eastern Europe's last state-owned airlines, gradually shrinking due to the pandemic and increasing competition. In 2023, the company's passenger traffic was 2,302,432 passengers, with a 13.3% share in the Romanian market (TAROM). The European Commission has approved in April 2024 a state-aid of €95.3 million for TAROM, to support its restructuring. This decision includes debt cancellation and a capital injection, contingent on TAROM reducing its fleet and routes to improve competitiveness and ensure regional connectivity at the same time.

### 3. METHODOLOGY

To assess TAROM's emissions, we utilized the FEIS (Flight Emissions Inventory System) system. The FEIS employs EUROCONTROL's Advanced Emission Model (AEM), which calculates an aircraft's fuel consumption and the resulting emissions from fuel combustion (EEA, 2019). The FEIS was developed by EUROCONTROL with support from the European Monitoring and Evaluation Programme (EMEP) and the European Environment Agency (EEA).

Specifically, EUROCONTROL provided Annexes 4 and 5 of the Aviation chapter, which include spreadsheet-based emission calculators. These tools estimate emissions for both the landing and take-off (LTO) cycle and the climb-cruise-descent (CCD) phases of flight, covering a wide range of aircraft and engine type combinations. <https://www.eurocontrol.int/database/aviation-fuel-use-and-emission-inventory-system>

All emission calculators use a nearly identical methodology, as illustrated in *Figure 2*.



**Fig. 2. Emission calculator methodology by N. Jardine (2009)**

The distance between the origin and destination can be accurately calculated using a Great Circle method based on a database of airport longitude and latitude coordinates. Some methodologies adjust this distance by a factor to account for deviations from the optimal route (calculated using the Great Circle method), such as avoiding bad weather or stacking around the destination airport (Jardine, 2009).

To more accurately determine the environmental impact, it is advisable to assess aviation-related GHG emissions by taking the number of seats into account. *Figure 3* illustrates the differences between emissions per seat for the airline's different aircraft models flying the same distance. The aircraft type should be taken into account, as well as the seating configuration. Additionally, if occupancy data is available, it should be included in the calculation to ensure the most accurate estimate of emissions per passenger.

The model and calculator developed by EMEP/EEA use the LTO (Landing, Taxi-in and -out, Take-off) and CCD (Climb, Cruise, Descent) flight phases to calculate total emissions. AEM associates each aircraft from the input traffic sample with an engine listed in the ICAO Engine Exhaust Emissions Data Bank or another emissions database.

The performance modeling of different aircraft types over the same route introduces minor variations in stage lengths. To account for these discrepancies, the model applies CCD adjustments using the following formula:

$$\text{Fuel burnt (Ref. Stage Length)} = \frac{\text{Fuel burnt (CCD Distance)} \times \text{Ref. Stage Length}}{\text{CCD Distance}}$$

Fuel consumption calculated with AEM can then be converted into CO<sub>2</sub> emissions by applying an emission factor of 3.157 kg CO<sub>2</sub> per kg of fuel (EMEP/EEA air pollutant emission inventory guidebook, 2016).

### **3.1. Calculating CO<sub>2</sub> emissions of TAROM**

In this study, we examined pollutants including carbon dioxide, nitrogen oxides, sulfur oxides, and water vapor, based on the airline's fuel consumption. Before the calculation, we gathered all the aircraft movements of TAROM, including both scheduled and non-scheduled (charter) flights, broken down by month. We categorized them by aircraft type; for 2022, we have a daily breakdown of the flights, and for 2023, we have a monthly breakdown. We calculated the emissions by flight type (charter, domestic and international flights) to present the TAROM's operations more accurately. In the next phase, using the calculator developed by the EEA, we calculated the emissions for each flight, depending on the aircraft type, and then we obtained the emission values, which we later aggregated. The calculator requires the aircraft type and the flight distance (in nautical miles) for the calculations.

During 2022-2023, TAROM operated with 6 aircraft types, but the calculator does not recognize one aircraft type, the ATR 72-600, separately. In 2022, 31.38% of the flights were operated with this aircraft type, while in 2023, it was 34.28%. Therefore, for flights with this type of aircraft, we used the ATR 72-500 in the calculator, as its data most closely approximated the actual emission values. This is why TAROM's emissions are not totally accurate, but our main goal was to estimate roughly the airline's emissions for these years.

### **3.2. Data**

The research examines the operations of the Romanian national carrier between 2022 and 2023, for which data was obtained from two sources. The first source is CNAB (National Company for the Administration of Bucharest Airports), and this data was supplemented with datasets obtained from the Flightradar24 flight tracking website. We obtained data from CNAB on flights departing from and arriving at Bucharest "Henri Coandă" International Airport, categorized by aircraft type, while through Flightradar24, we gained access to data on TAROM's aircraft movements at Romanian regional airports. In addition, we obtained the past fuel consumption and emissions data from the airline.

#### 4. DISCUSSION - TAROM'S FLEET AND ITS ROUTE NETWORK

By the late 1970s, TAROM had 59 aircraft, making its fleet the largest in Southeast Europe after the Soviet Aeroflot (Erdósi, 2007). The airline's fleet, just like its number of flights, has significantly decreased in recent years.

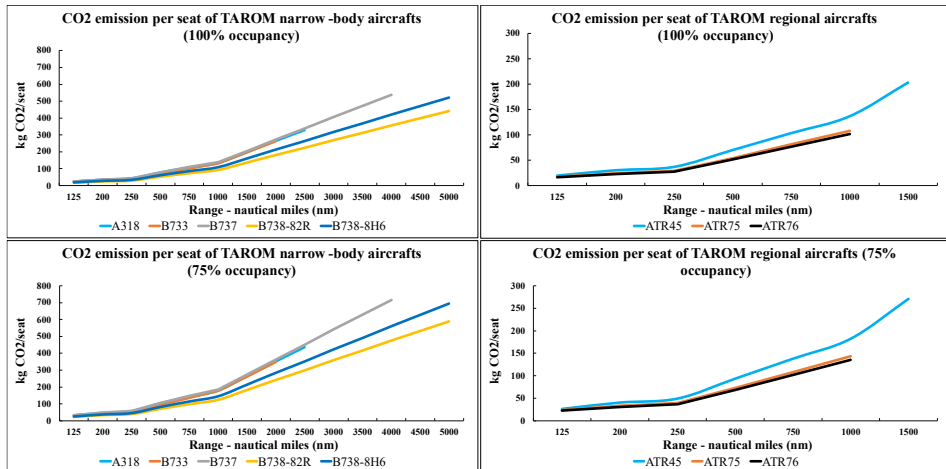
*Table nr. 1. TAROM active and inactive fleet in 2022-2023, source: own data*

Manufacturer	Type	Nr.	Capacity (seats)	Total capacity 2022	Total capacity 2023	22vs23 (%)
Airbus	318	4	113	508.613	415.614	-18,3%
ATR	42-500	7	48	-	-	Inactive
ATR	72-500	2	68	151.504	232.424	53,4%
ATR	72-600	4	72	580.392	631.008	8,7%
Boeing	737-300	4	134	57.218	-	-
Boeing	737-700	4	116	633.012	580.696	-8,3%
Boeing	737-8H6	2	160	478.926	436.800	-8,8%
Boeing	737-82R	2	189	396.800	642.033	61,8%
<b>TOTAL SEATS</b>				<b>2.806.465</b>	<b>2.938.575</b>	<b>+4,7%</b>

*Figure 3* illustrates how the aircraft in TAROM's fleet (*Table 1*) generate carbon dioxide as their range increases. The diagrams are ideal for showing which aircraft in the fleet are the most environmentally friendly and the most polluting, based on operating at maximum capacity. TAROM's most environmentally friendly aircraft are the ATR 72-600 and the Boeing 737-800, while the most polluting is the Boeing 737-700 and the Airbus A318. The B733 with registration number YR-BGD only operated flights (427 in total) between April and August 2022. In *Figure 3*, we included not only active aircraft but also the inactive ATR 42-500 model to provide a basis for comparison of progress. Through the modernization of the regional fleet, the aging ATR 42s were replaced by the more environmentally friendly ATR 72-600s, enabling TAROM not only to rejuvenate its fleet but also to standardize it.

TAROM will operate with a reduced fleet in the coming years, with a maximum capacity of 14 aircraft, according to its restructuring plan [1]. Eight of

the current 18 aircraft will be withdrawn from commercial service and sold. The airline also plans to expand its fleet by acquiring up to four Boeing 737 MAX 8 aircraft. Leasing agreements have already been signed for two of these planes, with delivery expected in the second half of 2025.



**Fig. 3. Emissions per seat based on distance for TAROM current and historical aircraft models, source: FEIS calculator, self-made diagram**

## 5. RESULTS

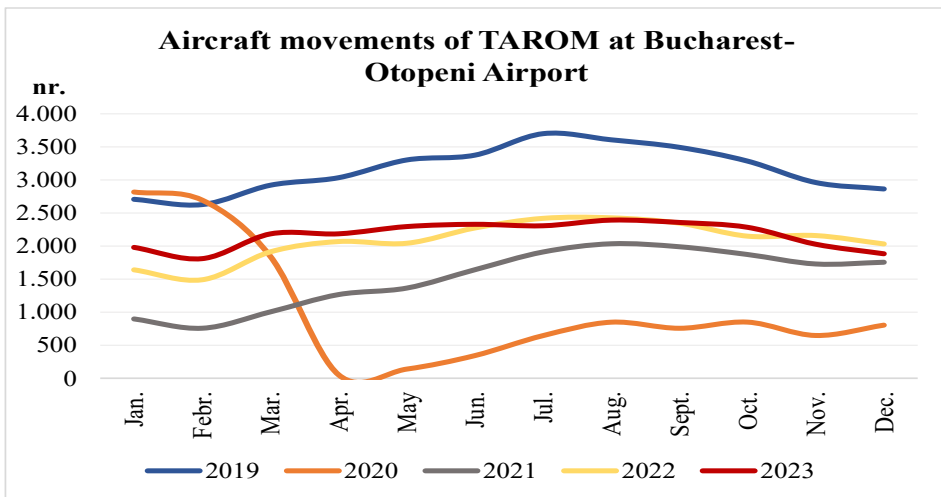
TAROM is an airline that primarily operates scheduled flights. Its scheduled flight network has been continuously shrinking since the covid pandemic, which is in stark contrast to the steadily growing trend of other European airlines' networks. Over the past few years, the airline has gradually shut down its heavily loss-making routes, resulting in its complete withdrawal from the air travel markets of several countries. TAROM's decline is mainly caused by the increasing competition (low-cost carriers: Blue Air, Wizz Air, Ryanair) that intensified after joining the EU.

The COVID-19 pandemic significantly impacted TAROM's air network. Numerous routes were temporarily suspended, and fewer aircraft operated on several routes due to reduced travel demand and higher ticket prices. *Figure 4* shows how TAROM's aircraft movements from Bucharest H. Coandă Airport evolved between 2019 and 2023.

Before the pandemic, the national airline operated 37,893 flights from its Bucharest hub, but this number decreased by 203% due to the pandemic. As a result of the pandemic, TAROM closed its other domestic bases (Suceava, Iași) and suspended numerous important domestic and international destinations,

including routes from Cluj-Napoca, Timișoara, Chișinău, Satu Mare, and routes from its main base in Bucharest.

Between 2020 and 2021, the number of flights increased by 31%, and between 2021 and 2022, it grew again by 27%. By the end of 2021, TAROM operated 7 domestic and 22 international routes. In 2022, the network underwent further changes, with the airline discontinuing its Vienna and Barcelona routes from the end of October. However, between 2022 and 2023, the growth was minimal, with only a 4% increase in TAROM's aircraft movements from the country's largest airport. In 2023, TAROM ceased its Munich route, and from the 2024 winter schedule, it also discontinued its London-Heathrow route. Until the end of 2024 summer schedule, TAROM was operating flights on 7 domestic and 17 international routes.

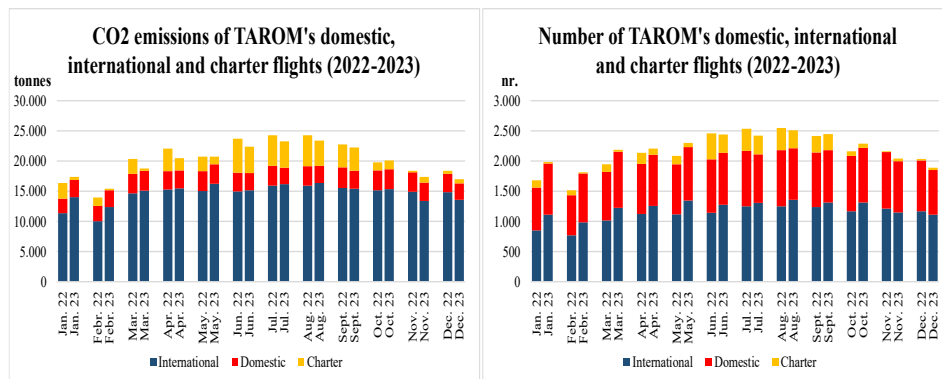


**Fig. 4. TAROM aircraft movements to/from Bucharest H. Coandă Airport, source: CNAB, self-made diagram**

The Romanian flag-carrier, like many other airlines, not only operates scheduled flights but also runs charter flights. Charter flights are non-scheduled (irregular) flights operated by airlines upon request, typically arranged by tour operators and governments, following predetermined routes and schedules (Tetyana et al., 2020).

To accurately measure emissions, we analyzed all TAROM flights in recent years. This allowed us not only to determine total emissions but also to assess the share of domestic, international, and charter flights in the overall emissions (Figure 5).

In 2022, TAROM flights burned 77,825 tons of fuel, emitting 245,148 tons of CO<sub>2</sub>. In 2023, fuel consumption and emissions decreased by 2.7%, with the airline producing 238,701 tons of CO<sub>2</sub>. Fuel consumption and emissions (CO<sub>2</sub>, H<sub>2</sub>O, NO<sub>x</sub>, SO<sub>x</sub>) are directly proportional.



**Fig. 5. TAROM monthly CO<sub>2</sub> emissions and aircraft movements by type of flight, source: own data, self-made diagram**

In 2022, international flights generated 173,597 tons of CO<sub>2</sub>. This figure increased by 3% in 2023, reaching 178,951 tons, reflecting a rise in flight numbers. In contrast, domestic flight numbers decreased, leading to lower emissions. Domestic flights produced 37,156 tons of CO<sub>2</sub> in 2022, which dropped by 4.1% to 35,687 tons in 2023.

The most significant change was observed in charter flights. A sharp decline in flight numbers led to reduced passenger numbers and emissions. In 2022, TAROM's charter flights carried 284,855 passengers, but this dropped by 34.7% to 211,522 passengers in 2023. While charter flights generated 34,395 tons of CO<sub>2</sub> in 2022, emissions fell by 40.8% in 2023, totaling 24,423 tons.

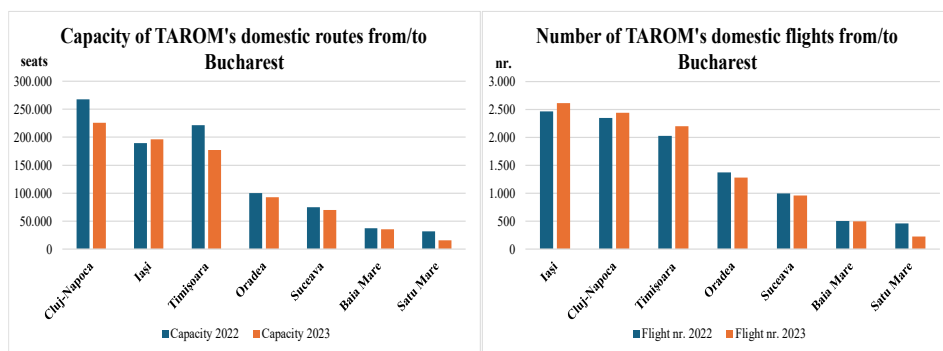
In 2022, charter flights emitted 120,7 kg of CO<sub>2</sub> per passenger, decreasing to 115,5 kg in 2023 due to the increased use of more environmentally friendly aircraft (B737-800). In 2022, scheduled flights emitted 105,7 kg of CO<sub>2</sub> per passenger, whereas this decreased to 102,5 kg per passenger in 2023. The difference in the number of passengers between 2022 and 2023 was 96,523 passengers.

In 2022, TAROM's international flights accounted for 70.8% of the airline's total emissions, domestic flights for 15.2%, and charter flights for the remaining 14%. According to *Figure 5*, international flights were responsible for the largest share of CO<sub>2</sub> emissions, with approximately 74.8% of the emitted carbon dioxide in 2023 originating from the operation of scheduled international flights. Domestic flights followed with 15%, while charter flights accounted for

10%. It is worth noting that while charter flights represented only 6% of TAROM's traffic, their CO<sub>2</sub> emissions nearly matched the percentage contribution of domestic flights, which accounted for 38.5% of the traffic.

In 2022, based on *Figure 6.*, the highest-capacity domestic route was Cluj-Napoca, followed by Timișoara and Iași. In 2023, Cluj-Napoca remained the domestic route with the highest capacity. However, Iași surpassed Timișoara in terms of capacity that year.

TAROM gained a monopoly on the Bucharest-Iași route in September 2022 following the bankruptcy of Blue Air. This shift explains why the airline began expanding connections between the two cities. In contrast, in 2022-2023 Baia Mare and Satu Mare had the lowest-capacity flights. Regarding the distribution of domestic flights, Iași, and not Cluj-Napoca, had the highest number of flights, totaling 2,464 (2022) and 2,615 (2023).



**Fig. 6. Capacity and number of TAROM's domestic air network to/from Bucharest-Otopeni in 2022-2023, source: own data, self-made diagram**

This discrepancy can be explained by the fact that TAROM predominantly operated small ATR 72-500/600 turboprop aircrafts on the Iași route, accounting for 89.3% of the flights in 2022, and 91.3% in 2023. In comparison, on the Cluj-Napoca route, only 39.3% (2022) and 52.6% (2023) of the flights were operated with these small regional aircraft. However, this also explains why Cluj-Napoca offered the highest capacity, as larger aircraft were used more frequently on this route. While in 2022 an average domestic flight of TAROM offered 84 seats for sale, this number dropped to 76 in 2023. During the research, we employed a similar methodology to analyze international and charter flights as we did for domestic flights.

*Table 2* illustrates the aircraft types used by TAROM to operate different domestic flights in 2023. To calculate the CO<sub>2</sub> emissions for that year, we determined the emissions for each flight based on the aircraft type used. This table

shed light on how the CO<sub>2</sub> emissions from TAROM's aircraft vary across different routes.

The „2022” and „2023” columns represent the aircraft movements during those years, while the last column reflects the difference between the two years. There was a significant decrease in aircraft movements on the Bucharest – Satu Mare (-51.7%), Bucharest – Oradea (-6.6%), Bucharest – Suceava (-3.8%), and Bucharest – Baia Mare (-3.1%) routes. Meanwhile, on the remaining routes, TAROM operated more flights in 2023 compared to the previous year, although with smaller capacity. The airline's drastic reduction in Bucharest – Satu Mare flights was a response to declining travel demand and low passenger numbers.

**Table nr. 2. TAROM's domestic routes from H. Coandă International Airport – Number of flights and the CO<sub>2</sub> emissions by aircrafts, data expressed in kilograms (2023), source: own data, CNAB**

Destinations	A318		ATR 72-5/600		B737		B738		Difference		
	CO2	Nr.	CO2	Nr.	CO2	Nr.	CO2	Nr.	2022	2023	22-23%
Baia Mare	6.377	2	2.532	485	7.028	4	7.620	5	512	496	-3.1%
Cluj-Napoca	5.574	216	2.229	1.286	6.182	287	6.693	653	2.345	2.442	4.1%
Iasi	5.601	114	2.239	2.388	6.211	86	6.725	27	2.464	2.615	6.1%
Oradea	6.625	14	2.623	1.243	7.277	14	7.885	7	1.369	1.278	-6.6%
Satu Mare	-	-	2.633	222	-	-	-	-	460	222	-51.7%
Suceava	5.899	92	2.354	908	6.533	24	7.082	6	998	960	-3.8%
Timișoara	6.377	392	2.532	1.039	7.028	164	7.620	606	2.028	2.201	8.5%

The domestic routes operated primarily by ATR 72-500/600 aircraft have a maximum passenger capacity of 68–72, while routes served mainly by A318s and B737-78Js can carry a maximum of 113–116 passengers. Routes with a higher presence of B738 aircraft generally achieve higher load factors compared to other routes.

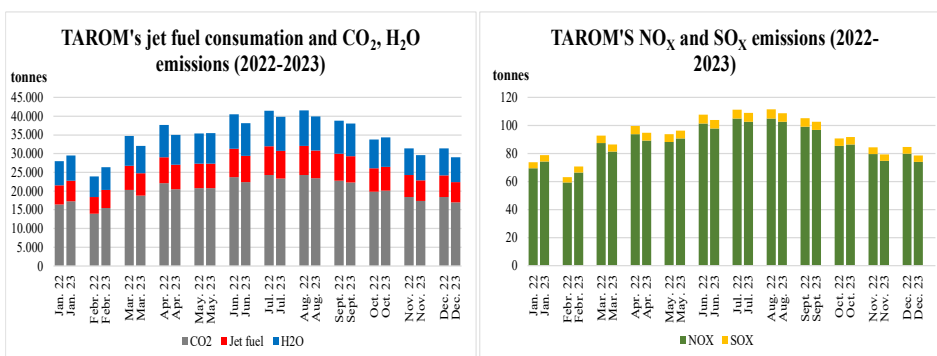
Table 3 presents the aircraft types operated by TAROM on various international routes in 2023. The table also includes destinations that have since been suspended, such as Barcelona, Munich, and Vienna.

In 2023, several routes from Bucharest saw reduced operations compared to the previous year. On the Bucharest – Thessaloniki route, the number of flights fell by 21.7%, accompanied by a 20.5% decline in capacity. The Bucharest – Tel-Aviv service saw a 16.1% reduction in flight frequency and an 11.4% decrease in available capacity. On the Bucharest – Amman route, the airline operated 9.6% fewer flights, with capacity down by 14.2% year-on-year. Meanwhile, the Bucharest – Frankfurt route experienced a 5.8% decline in flight numbers, while capacity dropped only slightly, by 2.1%. Conversely, the number of flights on the Bucharest – Belgrade route increased by 3.1%, although capacity decreased by 1.2%, as the airline operated smaller aircraft in 2023 compared to 2022.

**Table nr. 3. TAROM's international routes from H. Coandă International Airport – Number of flights and the CO<sub>2</sub> emissions by aircrafts, data expressed in kilograms (2023), source: own data, CNAB**

Destinations	A318		ATR 72-5/600		B737		B738		Nr. Flights		Capacity			
	CO <sub>2</sub>	Nr.	CO <sub>2</sub>	Nr.	CO <sub>2</sub>	Nr.	CO <sub>2</sub>	Nr.	2022	2023	22-23%	2022	2023	22-23%
Amman	16.065	36	-	-	17.368	160	18.752	2	217	198	-10%	25.830	22.628	-14%
Amsterdam	16.895	808	-	-	18.268	214	19.731	430	1.432	1.452	1%	189.976	189.714	0%
Athens	9.495	130	3.850	78	10.247	314	11.062	134	582	656	11%	72.324	79.086	9%
Barcelona	-	-	-	-	-	-	-	-	258	-	-	31.606	0	-
Belgrade	-	-	2.745	322	-	-	-	-	312	322	3.1%	22.482	22.208	-1.2%
Beirut	14.535	62	-	-	15.708	182	16.948	114	337	358	6%	40.428	46.532	15%
Brussels	16.698	94	-	-	18.054	282	19.499	268	431	644	33%	52.469	87.274	40%
Budapest	8.301	4	3.329	1080	9.005	4	-	-	705	1.088	35%	54.422	78.140	30%
Cairo	16.093	38	-	-	17.397	116	18.785	257	357	411	15%	47.362	65.438	27%
Chişinău	5.855	24	2.337	1787	6.486	60	7.030	18	1.195	1.889	37%	90.868	137.156	34%
Frankfurt	14.630	136	-	-	15.811	788	17.060	92	1.075	1.016	-6%	124.870	122.278	-2%
Istanbul	6.625	266	2.623	446	7.277	798	7.886	36	868	1.546	44%	103.412	160.714	36%
London	19.363	658	-	-	20.878	12	22.548	8	642	678	5%	76.048	77.142	1%
Madrid	22.141	4	-	-	23.821	12	25.696	716	724	732	1%	109.028	128.758	15%
München	12.669	34	-	-	13.658	72	14.731	10	652	116	-40%	76.562	13.852	-45%
Nice	15.018	36	-	-	16.232	76	17.517	4	70	116	40%	8.048	13.582	41%
Paris	17.362	82	-	-	18.773	674	20.280	626	1.124	1.382	19%	150.854	189.234	20%
Prague	12.026	80	5.086	2	12.949	272	13.965	38	368	392	6%	43.372	47.338	8%
Rome	12.605	118	-	-	13.588	262	14.655	12	314	392	20%	36.514	45.384	20%
Sofia	-	-	2.198	512	6.097	4	-	-	406	516	21%	28.154	35.544	21%
Tel-Aviv	15.548	34	-	-	16.807	76	18.143	388	578	498	-16%	86.568	77.741	-11%
Thessaloniki	7.454	4	2.959	328	-	-	-	-	404	332	-22%	28.154	23.364	-21%
Vienna	-	-	-	-	-	-	-	-	204	-	-	14.552	0	-

In 2023, the airline significantly increased its operations on several international routes from Bucharest. On the Bucharest – Istanbul route, the number of flights rose by 43.9% compared to 2022, resulting in a 35.7% increase in seat capacity. The seasonal Bucharest – Nice route experienced a 39.7% growth in flight frequency, accompanied by a 40.7% rise in available capacity. On the Bucharest – Brussels route, TAROM operated 33.1% more flights, which led to a 39.9% increase in capacity. Lastly, services on the Bucharest – Chişinău route were also expanded, with flight numbers up by 36.7% and capacity growing by 33.7%.



**Fig. 7. TAROM's jet fuel consumption and CO<sub>2</sub>, H<sub>2</sub>O, NO<sub>x</sub> and SO<sub>x</sub> emissions, source: own data, self-made diagram**

*Figure 7.* illustrates our final results – the amount of emissions generated by the aircraft operated by TAROM during the analyzed period. TAROM is implementing various procedures aimed at reducing aviation fuel consumption and, consequently, CO<sub>2</sub> emissions. These include:

- **Continuous Descent Approach (CDA)** – In collaboration with AIRBUS and the Aviation and Environment Research Center in Manchester (UK), TAROM conducted a pilot project for Airbus A318 aircraft to implement the "Continuous Descent Approach" (CDA). The main objective was to reduce fuel consumption, with results showing a reduction of up to 350 kg of CO<sub>2</sub> per flight. Following the success of the project, TAROM adopted the CDA procedure for all aircraft in its fleet.
- **Single Engine Taxi Procedure** – This method allows aircraft, after landing, to shut down one engine while taxiing to the parking area, significantly reducing fuel consumption on the ground. This procedure is applied to all types of aircraft in TAROM's fleet, including the A318, ATR, and Boeing 737, achieving an emissions reduction of approximately 0.4%.
- **Winglet System** – TAROM has equipped its Boeing 737-700 fleet with Winglets, which are widely used in the aviation industry for their ability to enhance fuel efficiency. Winglets help reduce fuel consumption by up to 3.5% and lower emissions by up to 6.5%.
- **Carbon Brakes** – To minimize CO<sub>2</sub> emissions, TAROM has replaced traditional steel brakes with carbon brakes on aircraft such as the A318, ATR 72, and Boeing 737-700. These carbon brakes reduce the aircraft's weight by approximately 200-400 kg, directly contributing to lower fuel consumption.

It is important to highlight that, although TAROM takes the above elements into account when assessing its own emissions, we are unable to consider these factors in our research. In the methodology section of our study, we have thoroughly discussed how the data was processed and how TAROM's emissions for the years 2022-2023 were determined.

## CONCLUSION

The central focus of the paper is the examination of TAROM's emissions and sustainability. In the study, we reviewed and calculated the extent of TAROM's emissions. Additionally, we analyzed how the flight numbers of the Romanian national airline evolved at Henri Coandă International Airport between 2022 and 2023, as well as the trends in scheduled and charter flights during the pandemic.

In 2022, TAROM's flights consumed 77,825 tons of fuel, resulting in the release of 245,148 tons of carbon dioxide. By 2023, the airline had achieved a

2.7% reduction in both fuel usage and emissions, bringing its CO<sub>2</sub> output down to 238,701 tons.

In 2022, international flights accounted for 173,597 tons of CO<sub>2</sub> emissions. This figure rose by 3% in 2023, reaching 178,951 tons, mirroring an increase in flight frequency. Conversely, domestic flights saw a decline in both numbers and emissions. Domestic operations produced 37,156 tons of CO<sub>2</sub> in 2022, but this figure fell by 4.1% to 35,687 tons in 2023.

TAROM's charter flights carried in 2022 a number of 284,855 passengers, but this dropped by 34.7% to 211,522 passengers in 2023. While charter flights generated 34,395 tons of CO<sub>2</sub> in 2022, emissions fell by 40.8% in 2023, totaling 24,423 tons.

The Romanian flag carrier recorded CO<sub>2</sub> emissions of 107.6 kg per passenger in 2022, which decreased to 102.5 kg per passenger in 2023, while the average CO<sub>2</sub> emissions per flight were 9,543 kg in 2022, which decreased by 6.1%, reaching 8,992 kg in 2023. During the analyzed period, TAROM's emissions per passenger and per flight were shown to decrease. This was due to the operation of shorter flights, fewer charter flights, reduced use of older aircraft, and higher passenger load factors.

Following the sudden restart of tourism and the operation of charter flights after the pandemic, significant emissions were generated compared to the pre-pandemic period. Due to the shrinking market of TAROM, the airline has significantly downsized its route network in recent years, which has resulted in the temporary suspension or cancellation of numerous routes. Furthermore, the national airline also scaled back its domestic flight network due to low travel demand caused by the COVID-19 pandemic.

While TAROM operated 0.45% more domestic flights, the company offered 13.4% fewer seats in 2023 compared to 2022.

TAROM is still a significant player in the Romanian aviation market — not only in terms of emissions but also in the flight numbers and passenger traffic. The airline significantly contributes to the CO<sub>2</sub> emissions of national level; however, despite its financial instability, it is striving to modernize its fleet as soon as possible and to implement more environmentally friendly methods in its operations. The airline is making considerable efforts to achieve net-zero greenhouse gas emissions by 2050.

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(EC) 549/2004 Regulation – The Single European Sky framework regulation, which governs the integration of EU airspace, promoting more efficient and cost-effective air transport, which is particularly important for low-cost carriers.

(EC) 550/2004 Regulation – This regulation pertains to air traffic services and aims to reduce management costs, which indirectly supports the competitiveness of low-cost carriers.

(EC) 551/2004 Regulation – This regulation deals with airspace organization, helping low-cost carriers achieve shorter and more efficient routes.

EUROCONTROL - Annex 4 – Master emission calculator

[1] <https://boardingpass.ro/tarom-va-opera-zboruri-cu-maximum-14-avioane-pana-in-2027/> accessed on April, 28, 2025.