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BUSINESS OPPORTUNITIES FOR A GROUND EFFECT VEHICLE - CASE OF CANARY ISLANDS

***Riina Otsason*[1], *Olli-Pekka Hilmola*[2], *Ulla Tapaninen*[3], *Beatriz Tovar*[4]**

[1]*Estonian Maritime Academy, Tallinn University of Technology*
Tallinn, Estonia
riina.otsason@taltech.ee
[2]*Estonian Maritime Academy, Tallinn University of Technology*
Tallinn, Estonia, and Department of Industrial Engineering and Management
University of Gävle, SE-801 76 Gävle, Sweden
olli-pekka.hilmola@taltech.ee
[3]*Estonian Maritime Academy, Tallinn University of Technology*
Tallinn, Estonia
ulla.tapaninen@taltech.ee
[4] *Tourism and Transport Research Unit, Institute of Tourism and Sustainable Economic Development,*
University of Las Palmas de Gran Canaria, Spain
beatriz.tovar@ulpgc.es

The need to decarbonise and reduce pollutant emissions from maritime transport is facilitating the studies of ground effect vehicles. Technical development in recent decade concerning unmanned flights in drones has supported this development. These vehicles could have much higher speed than sea vessels and they are estimated to be less costly compared to air transport. Unmanned operations without passengers enable wider range of transport connections (even in difficult conditions). In this research we analyse prototype vehicle called Airship and its possible use in different routes of intra Canary Islands' transport. We suggest the most lucrative routes and cargo groups. Initial cost and revenue considerations are made over the life-cycle of Airship. As a result, we can point that there are three main factors determine the success of the transport operations. They are: the number of journeys per day, business days operating per year and freight price.

Keywords: Ground effect vehicle, wing in ground (WIG), airship, Canary Islands, routes, cargo, costs, profitability

1. Introduction

The European Union has a strategic interest in ensuring the continuous performance of short sea shipping. According to the European Commission short sea shipping has a strong role in reaching EU transportation goal of reducing 60% of greenhouse gas (GHG) emissions generated by transport and by 2030 the shift of 30% of road freight over 300 km to other modes. On the other hand, the short-sea shipping impact on the local air pollution has led to the several stringent regulations for marine fuels not only in EU (Directives 1999/32/EU, 2005/33/EU, 2012/33/EU, and 2016/802/EU) but also under MARPOL Annex VI (Tichavska *et al.*, 2019).

There are various studies conducted about short sea shipping and their influencing factors and significance (Kelmalis *et al.,* 2023; van den Bos et al. 2018). Nevertheless, shipping is the cheapest mean of transport and therefore all possible alternatives and optimal low emission or carbon free vehicles on sea should be given higher importance.

Unmanned Aerial Vehicles (UAVs; e.g., drones or aircrafts) have increased in popularity, and they could be used simultaneously for planned tasks through one control room or location (Laghari *et al.*, 2023). Development and use of these vehicles started in the early 2000s within defence purposes of USA (Adamski, 2017; Laghari *et al.*, 2023) – currently they are applied in civilian, military and business purposes. It is still an open question, in which routes, weather conditions and in which seasons UAVs can operate reliably for home deliveries of freight (Yowtak *et al*., 2020) – no person on board increases tolerance for severe weather. Key benefit comes from the lack of pilot or personnel on board – this enables much freedom e.g., in the design of "fixed wing" aircrafts and enables better performance for small vehicle.

One sub-class of unmanned vehicles is the wing in the ground crafts (WIG) or ground effect vehicles (Amir *et al.*, 2016). These are classified under jurisdiction of International Maritime Organization (IMO) as long as they have flight altitude capability only up to 150 meters (Amir *et al.*, 2016). Ground pressure in these vehicles creates opportunities for lower emissions (affecting local NOx, SOx, PM, CO and global CO_2 environments), lower maintenance costs, simplified vehicle structures as compared to airplanes and these vehicles do not need airports and/or other larger landing areas (Amir *et al.*, 2016; however, these vehicles need sea area instead of airports). Smallest ground effect vehicles reach some hundred km of operating distance, and typically are estimated to have top speeds of 100-150 km/h (Amir *et al.*, 2016; Papadopoulos *et al.*, 2022). In a case of unmanned vehicles (Papadopoulos *et al.*, 2022), range is leaned to shorter distances (like 300 km; Papadopoulos *et al.*, 2022) as they are typically fuelled by electrical system, while often older technology (combustion engine) reaches distances of 1000 km and longer (Amir *et al.*, 2016).

In the research of Papadopoulos *et al.* (2022) the WIG vehicle was able to carry payload of 300 kg and operate 300 km within range. In the study of Nebylov and Nebylov (2021) the vehicles were traditional airplanes manned with pilots and could have take-off mass of 800 tons.

In this research we are interested in novel unmanned electrical propulsion system vehicles, which can serve 500 nm distance, and are capable of carrying cargo of 1000-4000 kg. In the pilot operating environment of Canary Islands, potential routes are mostly concerned populous islands and their food transportation needs.

To study these aspects an international collaboration project called Airship is executed. Airship aims to lay the foundations of a new class of fully electrical unmanned aircraft system, the UWV (Unmanned WIG Vehicle) that brings together speed, flexibility and energy efficiency. The aim of the research vehicle is to study and develop new technologies in zero-emission energy, on-board AI and in automatic flight control that overcome the challenging technological problems that flying in ground effect poses, allowing such vehicles to become autonomous. The main goal of this study is to focus on actual potential and specific application for this vehicle (Figure 1).

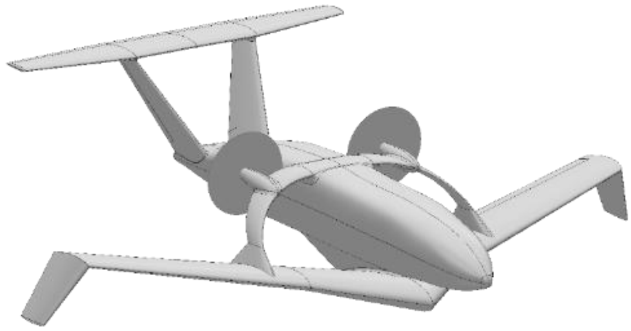

Figure 1. Isometric view for the model of Airship (source: Airship project)

The main research questions of the study are: (i) Which ports in the Canary Islands could potentially be used for inter-island cargo transport by UWV craft Airship?; (ii) Which routes would be the most optimal in respect of potential consumers and shortest distances? And (iii) What would be the minimum feasible annual freight revenue?

This research is structured as follows: In section 2 we introduce the cargo transport environment of Canary Islands for ground effect vehicle. Section 3 presents the methodology and data for assessing the most lucrative routes and ports. As an addition we consider revenue opportunities and evaluate it against number of different cost factors (arising from investments such as depreciation and interest rates, and then different operating expenses). Section 4 presents the main findings. Research is concluded in Section 5.

2. Research Environment of Canary Islands

2.1. Inter-Island Traffic in Canary Islands

The Canary Islands are organised administratively into two provinces with the capital in the central islands of the archipelago. Maritime import/export transport in the archipelago is based on two main ports, located in Tenerife (Santa Cruz) and Gran Canaria (Las Palmas also called as La Luz). Las Palmas is the most important port in the archipelago. It is an international hub, the largest in the Mid-Atlantic Ocean in terms of container handling (Tovar *et al.*, 2015) and the fourth largest port within the Spanish system

(Puertos y Terminales, 2023). However, in terms of inter-island freight traffic, the ports of Las Palmas and Tenerife are of similar importance in the Canary Islands maritime network, which is completed by nine ports administratively grouped in two port authorities, one for each province. There are also 16 autonomous (small) ports managed by the autonomous government.

According to an analysis completed by a logistics company (Rhenus Group, 2022), air transport accounts for barely 0.12 % total trade flow. Sea traffic to Santa Cruz (Tenerife) and Las Palmas (Gran Canaria) ports account for 91 % of the imports from the Spanish mainland. The inter-island freight traffic is characterised by the polarisation that exists around the two ports of the capital islands, which play a distributive role to and from the other ports. Therefore, the smaller islands move rather more modest volumes of goods, in no case exceeding 1.5 million tonnes.

The Canary Islands have highly developed ferry traffic with several route options from one island to another. The routes are operated by different operators and various types of ships.

The sea ports of Canary Islands handle practically all the products imported from the Spanish mainland of which Andalusia region dominates.

An alternative for sea transport in the region is air transport, which accounts for a minor part of the trade flow. This minor part is mainly handled in airports of Gran Canaria and Tenerife Norte. The lively air traffic in Canary Islands is covering inter-island flights and other domestic and international flights. The focus on air transportation is on passengers.

The Canary Islands have traditionally benefited from transport subsidies in order to compensate for the disadvantages of their insularity and distance from mainland Spain. The residents of Canary Islands are supported by the government with 75 % subsidy for domestic and inter-island travel (for buying tickets of both by air and sea transport). There are also subsidies for sea and air transport of industrial or agricultural goods to or from the Canary Islands, including grants to compensate for the additional costs incurred by operators of certain fishery and aquaculture products in the Canary Islands, as provided for in the European Maritime, Fisheries and Aquaculture Fund (European Parliament (2021), for the programming period 2021-2027 (Government of Canary Islands, 2024).

Castanho *et al.* (2020) have carried out a study to assess the transportation sustainability of Canary Islands archipelago. The study was conducted through exploratory tools by using the accessibility and connectivity indicators over the socio-economic impacts. According to the findings of the study, the accessibility is categorized in five main groups (having very high, high, medium, low or very low accessibility). The findings regarding accessibility factors of the islands were included to the study and based on the highest distribution analyse another assessment for suitable ports with significant factor of having also good accessibility were conducted.

2.2. Environmental Issues

The International Maritime Organization (IMO) has set a goal to reach carbon neutrality by 2050 (IMO, 2023). Similarly, the European Union (EU) has set a target in its Fit to 55 package to reduce the net greenhouse gas (GHG) emissions by at least 55% by 2030 and achieve carbon neutrality by 2050 (European Parliament, 2022). On the other hand, IMO and EU maritime regulatory regime also aims to substantially reduce air pollution for coastal areas and port cities (Tichavska and Tovar, 2019).

With these tightening regulations also transportation sector must take effort to reduce their emissions. For shipping the possible ways to minimize exhaust emissions are grouped into three main categories: fuel and energy solutions, ship design and technical development and choices of ship operations (Barreiro *et al.*, 2022).

Transportation sector is responsible for 28.9% of the EU’s total greenhouse gas emissions (European Parliament, 2024). Although aviation and shipping each account for only about 4% of the EU’s total greenhouse gas emissions, it is essential to focus on reducing them significantly, since these means of transport currently also grow the fastest. Sea and air transport are essential for life in the Canary Islands. Having low emissions solutions for these transportation modes are therefore the key factors of meeting the targets of Green Deal (European Commission, 2024).

In December 2020 the European Commission published a strategy to ensure and support the transportation system achieving green transformation (European Environment Agency, 2023). One of the obtainable ways to reach the carbon neutral targets in transportation is using carbon free alternative fuels. Fully electric ships are considered well suited to short-sea shipping (Laasma *et al.*, 2022). On the other hand, ships operate at relatively low speeds, which might be crucial for cargo with short shelf life.

Transportation is affecting environment and nature in several ways. Apart from the direct impact of emitting GHG emissions, there are also other important issues that affect the environment. The Canary

Islands ports are subject to EU air quality legislation, as maritime transport is a major source of air pollution. Tichavska and Tovar (2015a,b) calculated the external costs derived from ship emissions in the port of Las Palmas, showing the type of information needed to inform policy measures that contribute to the internalisation of estimated external costs. In fact, a potential benefit from the implementation of UWV is the external cost derived from cargo vessels that could be avoided.

Canary archipelago is a unique area for its biodiversity of various wildlife species (Escánez *et al.*, 2021). There is evidence of significant disruptions to sea and underwater species caused by the ferry traffic (Ritter, 2010). Due to flying mainly above sea, the alternative environmentally friendly vehicle Airship is having several benefits also to wildlife and sea spices. The fully electrical alternative vehicle has low noise and vibration levels. This aspect is relevant to wildlife, but also to the habited areas, urban planning and tourism, which has the largest share of the economy of Canary Islands.

However, the most significant environmental impact of the Airship is not only low greenhouse gas emissions (GHG), but also the reduction in local air pollutants. The Airship is designed to be fully electric vehicle. While using only green energy for operating the new type of vehicle will be carbon neutral in the whole tank-to-wheel (TTW) section meaning the operating and transporting cargo would be with zero emissions. The significant aspect of this to the Canary Islands is to support filling the European Green Deal and Fit-for-55 goals.

3. Methodology and Data

3.1. Methodology

According to Tapaninen (2020, p 102) the factors affecting profitability of a shipping route are: variable costs (crew, maintenance), fuel and port dues, capital costs and administration. The income depends on the frequency and speed of the vessel, and size of the cargo hold as well as utilisation and fill rate (Tapaninen, p. 79) in addition to freight from transported cargo ton. In this study we focus on capital costs, fuel (electricity) and port dues, and length of the journey as well as frequency per day in addition to freight.

The gravity model has become a standard transportation planning procedure for estimating interzonal trip interchanges. Gravity model of international trade traditionally states that bilateral exports are proportional to economic size and inversely proportional to geographic distance. There are several interpretations to the traditional gravity model (see for example Ravishankar *et al.*, 2014; Kabir *et al.*, 2017.). Gravity models have also been used for dynamic interrelations studies (Seppälä, 1997), but in this case we take only a static approach.

In the case of economics, the trade flow between the countries is generalized according to equation derived from the Newton's law (Pal and Kar, 2021):

$$F_{i,j} = M_i^{\alpha} M_j^{\beta} D_{i,j}^{\gamma},$$

where

m_i - Economic mass for country *i*,
m_j - Economic mass for country *j*,
$D_{i,j}$ - Geographical distance between country *I* and country *j*,
$F_{i,j}$ - Force of trade flow between country *I* and country *j*
α, β, γ - parameters of the model.

Shipping distances between the ports can be assessed according to the following formula:

$$D_{i,j} = \min_{i,j}\{distance(P_i, P_j)\},$$

where

$D_{i,j}$ - distance between the ports,
P_i - a port of the country i,
P_j - a port of the country j.

In this aggregated model, the economic mass of an island was studied in four different ways: 1) populations, 2) tourism, 3) population and tourism together, and 4) island accessibility.

The shipping cost of goods between country *i* and country *j* directly was calculated on the distance $D_{i,j}$ between them. Therefore, the force of trade flow between country *i* and country *j* decreases as the shipping cost increases.

3.2. Ports and distances

First, in this study the analyse for finding best ports to be used by the alternative vehicle was carried out by gravity model simulations with considering the economic mass of the islands and distances between the local ports. The economic mass of an island is represented by the population, tourism or sum of population and tourists.

Distanes from the seaports of Canary Islands are calculated in Table 1 below. Las Palmas (Gran Canaria) and Santa Cruz (Tenerife) are the locations for cargo hubs for the whole archipelago as they are supplied with suitable storing and cooling facilities.

Table 1. Seaport distances (nm) in Canary Islands
GC-Gran Canaria; T-Tenerife; LP-La Palma; L-Lanzarote; F-Fuerteventura; LG-La Gomera; E-El Hierro; SM-Spanish mainland

Distance matrix (nm)	Las Palmas (GC)	Agaete (GC)	Santa Cruz (T)	Los Cristianos (T)	Santa Cruz (LP)	Arrecife (L)	Playa Blanca (L)	Corralejo (F)	Puerto Del Rosario (F)	Morro del Jable (F)	San Sebastian (LG)	Valle Gran Rey (LG)	La Estaca (E)	Cadiz (SM)	Huelva (SM)
Las Palmas (GC)	0	29	54	83	144	113	96	93	104	57	103	123	145	689	698
Agaete (GC)	29	0	39	60	127	131	114	111	129	81	79	91	121	701	710
Santa Cruz (T)	54	39	0	47	108	148	132	129	152	104	67	80	109	704	711
Los Cristianos (T)	83	60	47	0	69	184	167	164	183	139	22	38	69	747	766
Santa Cruz (LP)	144	127	108	69	0	229	212	210	228	193	53	44	57	753	757
Arrecife (L)	113	131	148	184	229	0	20	23	34	81	204	216	246	587	600
Playa Blanca (L)	96	114	132	167	212	20	0	9	26	75	187	200	229	611	624
Corralejo (F)	93	111	129	164	210	23	9	0	18	74	186	196	227	612	625
Puerto Del Rosario (F)	104	129	152	183	228	34	26	18	0	48	201	213	244	620	633
Morro del Jable (F)	57	81	104	139	193	81	75	74	48	0	156	168	199	666	678
San Sebastian (LG)	103	79	67	22	53	204	187	186	201	156	0	16	48	753	758
Valle Gran Rey (LG)	123	91	80	38	44	216	200	196	213	168	16	0	14	767	768
La Estaca (E)	145	121	109	69	57	246	229	227	244	199	48	14	0	794	799
Cadiz (SM)	689	701	704	747	753	587	611	612	620	666	753	767	794	0	50
Huelva (SM)	698	710	711	766	757	600	624	625	633	678	758	768	799	50	0

3.3. Cargo

According to OECD in November 2023, Canary Islands exported cargo for 224 million € and imported for 408 million €. The highest impact to the economics of Canary Islands has by far tourism. Besides tourism, fishing is one of the most important sectors.

Fishing has traditionally been a significant primary activity, while having several roles in reducing poverty, job creation, strengthening and assuring food sufficiency and sovereignty, but also increasing the value of various products. The fishing fleet of the area is almost exclusively artisanal, giving to fishing industry also a social aspect (González *et al.*, 2020). In addition to the fishing in open seas, also fish farming shows growing trends in the industry (Cantillo *et al.*, 2023).

Based on the statistical data collected from the Canary Islands Statistics Institute (ISTAC) the five recent years average of cold fish export from the Canary Islands varies from 2600 to 4600 tons (Table 2). The frozen fish export varies from 245 000 tons to 331 000 tons (Table 3).

Table 2. Export of cold fish from major fishing ports (tons)

	Yearly export in tons				
Port	**2023**	**2022**	**2021**	**2020**	**2019**
Arrecife (L)	443	1097	683	1146	1291
Puerto Del Rosario (F)	3	13	10	14	16
Las Palmas (GC)	86	101	95	120	78
Arinaga (GC)	10	5	9	0	3
Santa Cruz (T)	2115	1702	2112	2825	3230
TOTAL	2657	2918	2909	4105	4618

Table 3. Export of frozen fish from major fishing ports (tons)

	Yearly export in tons				
Port	**2023**	**2022**	**2021**	**2020**	**2019**
Arrecife (L)	8552	10788	9631	10588	12431
Puerto Del Rosario (F)	3179	3153	3409	2033	403
Las Palmas (GC)	231631	270365	228269	204177	195773
Santa Cruz (T)	40328	46665	29385	28061	44267
TOTAL	283690	330971	270694	244859	252874

Fish is a complex type of cargo with short shelf life. This sets the limits and often also additional requirements to its transport as travel time to the customer is crucial. For Airship this, on the other hand, is additional advantage – the costs of transport are significantly lower than with traditional air transport, but also significantly faster than with traditional sea transport. While the average transport of the container ship from the Canary Islands to the Spanish mainland is 7-14 days or 36 hours with the passenger vessels, Airship could cover this within 3-4 hours. However, as the unmanned electrical vehicles, which already operate are mostly in 270 nm range, the focus to this study is kept to inter-island transport of fish and other seafood.

Planning and managing cargo transportation of inter-island traffic it is also relevant phase of the route and vehicle type optimization. This is also the reason, why the study focuses on fish. The most efficient and feasible use of Airship is transporting all other types of cargo with short shelf life by departing from the cargo hubs in Tenerife and Gran Canaria and brining fish and seafood at returning to the from other islands.

3.4. Revenues and Costs

There are numerous different routes in Canary Islands available to be used for Airship/Ground Effect Vehicles, but in our analysis most lucrative is the route between Gran Canaria and Tenerife due to the existence of cargo hubs near their ports. This could be served with two seaports from both islands (Agaete and Las Palmas from Gran Canaria, and Santa Cruz and Los Cristianos from Tenerife). Distances between these seaports differ, but in general they are around 100 nm (shortest is Agaete-Santa Cruz, approx. 39 nm, and longest Arrecife-Los Cristianos, approx. 184 nm). Whichever is the used route from these, it means that this route could be served up to six journeys per day (in one direction). Vehicle needs flight time of 1.5 hours, and then unloading and loading of cargo at seaport takes approx. one hour. If operations start in early morning hours (like 7 am), it is possible to make six journeys until very late evening hours (e.g., 22 pm).

Simulation model of revenue and costs was conducted (see interactive model: InsightMaker, 2024). Revenues are arising from freight operations, and we assume that Airship can carry cargo having weight between 1000 to 4000 kg. In simulation model it is assumed that freight amount on each occasion is random uniform function having minimum of 1000 kg and maximum of 4000 kg (and having then average of 2500 kg of cargo on board). Freight revenues (annual) depend then on journeys made in a day, business days operated in a year, and freight price (together with freight weight). Journeys per day and business days operated are having connection also to costs – port payments and electricity costs (these are dependent on operations volume).

In cost side, we have incorporated Airship fleet price (assumed to be 2 mill. EUR; this is estimate for two vehicles that we are able to achieve needed service level in one route), which is assumed to serve 20 years. In simulation model we assume linear, or fixed, annual depreciation in this period. Charging infrastructure (100 000 EUR) is included in the price of GEV fleet, and it will increase annual depreciation and interests paid (assumed 20 years of usage period). Interest costs of fleet is assumed to follow depreciation programme (loans are paid with depreciation amounts), and these are of course highest in the early years (as depreciation is done only in minor scale). Interest rates (annual) follow random uniform function, where minimum is 3 % and maximum 10 %. Electricity costs are dependent on assumed consumption per one journey (540 kWh), price of electricity (0.3 EUR per kWh) and within annual total amount of journeys (journeys per day times business days operating). Annual maintenance costs are 6 % from original fleet price. Port payments are based on the annual number of journeys and port payment of 200 EUR per visit. In addition to these, there is annual fixed costs of overhead and management (operations and sales) of 200 000 EUR.

4. Results

4.1. Ports and Routes

The results of the study show that there are several possible routes for piloting cargo transport by the Airship. As mentioned in the methodology, we calculated the economic mass in four different ways: 1) residents of the island, 2) nights of the tourists, 3) residents and tourist together and 4) island accessibility.

First: potential ports for cargo transport by Airship were analysed first by potential customers focusing on residents as priority. As a result, the most significant ports for the service are: Arrecife (Lanzarote), Puerto Del Rosario (Fuerteventura) and La Estaca (El Hierro).

Second: Similar analysis was conducted by considering the number of nights at tourist accommodation establishments of the islands. The results are common to previous findings with ports of the highest distribution as follows: La Estaca (El Hierro), Santa Cruz (La Palma) and Valle Gran Rey (La Gomera).

Third: While analysing tourism, population and distances together the calculation resulted to Las Palmas (Gran Canaria), La Estaca (El Hierro) and Santa Cruz (La Palma).

By analysing possible cargo for the fast mean of transport groups with short self-life are prioritized. Las Palmas (Gran Canaria) and Santa Cruz (Tenerife) are the locations for hubs as they are supplied with suitable storing and cooling facilities.

The Canary Islands is a small territory with short distances between various destinations, when the focus is on bird-eye view. On the other hand, while focusing land transportation factors, which are essential for final delivery to the customers and the whole logistics chain, it is important to consider the sustainability of the island land transportation.

For the fourth: focus factors of accessibility from the research of Castanho (2020) were used and included to support the verification. Based on the highest distribution analyse it was found that suitable ports with significant factor of having also good accessibility are: Arrecife (Lanzarote), Puerto Del Rosario (Fuerteventura), Santa Cruz (La Palma) and La Estaca (El Hierro).

Based on the analysis of different aspects from possible consumers and logistics chain potentially suitable ports were found. By having main home ports in Las Palmas port in Gran Canaria and Santa Cruz in Tenerife route alternatives are created by going from the hubs to the western and eastern islands in range and an additional line to connect the hubs is created (Table 4). The route alternatives are calculated by minimizing the distances between the findings from the results of the suitable port analyse. Depending on the cargo capacity it is possible to optimize the routes with round-trip to one island only.

Table 4. Routes and ports of proposed lines

	Origin port	**Destination ports**	**Route total distance [nm]**
Eastern line 1	Las Palmas (GC)	Arrecife (L) - Puerto Del Rosario (F)	254
Eastern line 2	Santa Cruz (T)	Arrecife (L) - Puerto Del Rosario (F)	337
Western line 1	Las Palmas (GC)	La Estaca (E) - Santa Cruz (LP)	274
Western line 2	Santa Cruz (T)	La Estaca (E) - Santa Cruz (LP)	347
Connection line 1	Las Palmas (GC)	La Estaca (E) - Santa Cruz (LP) - Santa Cruz (T)	364
Connection line 2	Santa Cruz (T)	Arrecife (L) - Puerto Del Rosario (F) - Las Palmas (GC)	343

It should be borne in mind that when it comes to the main objective of the Trans-Insular Transport Axis, which is to allow goods to cross from one end of the archipelago to the other in the same day, as reported by (Delgado-Aguiar and Hernandez-Luis, 2019) *"there is currently an inconsistency in the schedule of shipments from Tenerife to Gran Canaria when the goods come from the western islands, and in Fuerteventura when the goods come from Lanzarote. This makes it necessary to spend the night on one of the islands, which significantly increases the cost of the shipments, if not paralysing them*". Therefore, the proposed routes (Table 5) have a good chance of solving this problem by contributing to the cohesion of the territory by improving accessibility, in line with the objective of the Trans-Insular Transport Axis policy.

4.2. Costs and Feasibility

As simulation model was run for several times and with different parameter values, it became evident that three main factors determine the success of operations (see InsightMaker, 2024). They are journeys per day planned, business days operating per year and freight price. It is so that Airship should serve at least four journeys per day, and operating days per year should be 250 days or more. Most sensitive changes are for the freight price. If this falls to 0.3 EUR per kg or below, then it is very difficult to have any profitability left in 20 years observation period. However, if freight rate increases to 0.5 EUR per kg, then running this freight service is clearly profitable. We also added as fourth slider for parameter value of charging infrastructure investments. Based on our simulation runs, it influences profitability, but only marginally and needs to have cost of several hundred thousand EUR to hold real importance.

The study shows that depending on the unit price of freight having profitable new mean of cargo transport is possible. Unit prices for cargo with short shelf life are always higher from the ones with long shelf life. This is mainly due to the speed of transport, but also due to the need of having other special resources (e.g., cooling facilities). The Airship would meet the requirements of fast delivery and it also has the possibility of adding other cargo specific resources as the above-mentioned cooling or freezing facilities.

5. Conclusions

We are witnessing change in transportation logistics from two fronts: one is regulatory as within EU we have numerous agreements and objectives set for future emission reduction, and another one is the opportunity to use new technologies and vehicles within transportation. In this work we have analysed one of the emerging new opportunities, which is ground effect vehicle called Airship. This vehicle is currently at prototype stage, so all the evaluations concerning its technical and economical capability are preliminary, and initial. Based on our analysis, it seems to be the case that used operating environment of Canary Islands fits Airship due to the general distances between islands, and main locations. We were able to identify potential main routes for implementation the pilot project as well. It also seems to be the case that some food items, like fish, could be most potential as main cargo group (due to its daily need, and high enough volume).

While substituting all inter-island cargo carried by air transport with the new green mean of transport would support achieving the environmental targets of becoming carbon neutral by 2050, but also gain a reduction in frequency needs for airplane flights and in addition minimizing and optimizing cargo carried by ferries. As a result, optimizing cargo transportation in inter-island traffic to ferries for goods with long shelf life and to the new vehicle for goods with short shelf life reduces significantly emissions emitted of the whole cargo transportation in Canary Islands. According to the findings of the research, the pioneering and primary ports for piloting the Airship service are Santa Cruz in La Palma island, Arrecife in Lanzarote island, Puerto Del Rosario in Fuerteventura island and La Estaca in El Hierro island. These results are also supported by a relevant finding of being the ports that export fish and seafood. This finding is important as fishing is playing significant role in the life and economy of local inhabitants of these islands. Another relevant finding, while analysing port verification results and local fish export, is that currently the port of La Estaca in El Hierro is a minor fish and seafood exporter. In case the island export focuses only on fish and seafood, La Estaca should be excluded from the results. On the other hand, there are other relevant export articles with short shelf life (e.g., tomatoes) that could possibly be transported and having La Estaca still as one destination ports would support cargo transportation of one additional island and possibly also the whole western lines.

Apart of just examining transportation costs per km for Airship (compare e.g., Papadopoulos *et al.*, 2022; Yowtak *et al.*, 2020), we did put this vehicle to serve some predetermined route (like ferries). We assumed in the simulation model that Airship shall serve two destinations daily (journeys per day between these destinations) and with some given amount of business days from year. Our approach mimicked that of sea ferries or sea vessels used in some route, and all costs were incorporated based on this logic. Results showed that despite very disciplined use of Airship in predetermined route, it is difficult to achieve low transportation costs for cargo. It cannot be said that ground effect vehicle would be impossible to be used in cargo operations, but its cargo groups being served are limited. Possibly the selected fish and seafood could be lucrative as they could tolerate higher transportation costs due to limited sales time.

It should be noted that our results are conservative as there are potential benefits from emission reduction/elimination (global and local) that could be monetised and are not included in our model. If they were included, they would increase the margin on the freight price or allow a more flexible range of freight prices consistent with the benefits. The same could be said of subsidies for sea transport to compensate for the additional costs incurred by operators transporting certain fishery and aquaculture products to or from the Canary Islands.

As for further research in the area, we would be interested to examine specific cargo alternatives and transportation costs in situation, where there is e.g., some investment support for examined vehicles, subsidies are given for its operations (like low cost or free of charge electricity) and/or it is receiving state or EU supported low interest rate loans. These together of using new vehicles in numerous routes instead of one, would be natural further study on cost efficiency of ground effect vehicles. In addition, technologies develop over time, and amount of cargo on board could increase over time too – bringing transportation costs down as well.

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For more information concerning Airship project, please visit: https://airshipproject.eu/

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