

AIRSHIP TECHNOLOGY FOR AIR CONNECTIVITY AND HUMANITARIAN AID IN THE CARIBBEAN AND THE PACIFIC

Transport and trade connectivity in the age of pandemics

UN solutions for contactless, seamless and collaborative transport and trade

Technical note

26 July 2021



Note: images on this front page showcase a variety of Airship models with illustrative purpose, and not necessarily on scale. These represent a portion of the output of the industry in the recent years which involves many different developing companies and engineering approaches; they represent models that may be in varying stages of development, testing and production, which may apply to prototypes or models.

EXECUTIVE SUMMARY

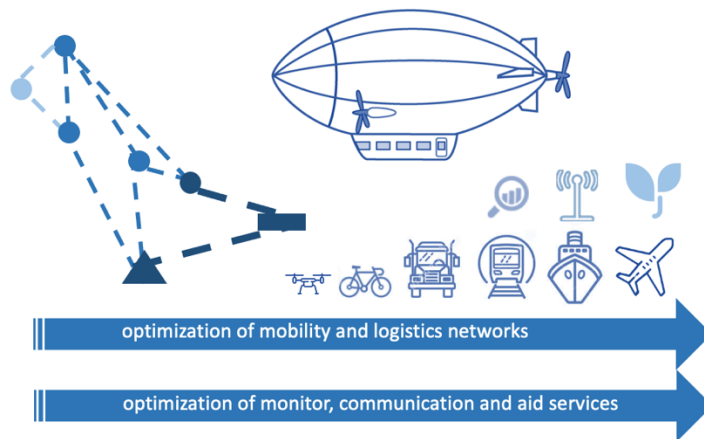
The Hybrid Airship transport alternative has the potential to be a game changing technology with significant development in recent years. It offers the technical capabilities to make a broad contribution to the optimization of mobility and logistics networks in isolated communities and territories, especially but not only in Small Island Developing States. This innovative mode should be incorporated into the transport matrix (both nationally and regionally), for the latter to move towards more efficient, sustainable and resilient networks. Airships do not necessarily compete with other means of transport, instead they provide a complement to traditional modes that improves co-modality / synchro-modality and also performs social functions, achieving a clear improvement in connectivity -accessibility- both interior and regional. There is a diversity in Airship technology and in the functions, both in commercial and in non-commercial operations (such as humanitarian aid), as will be showcased in the following sections, along with the logistics and connectivity standards that it has the potential to raise. Besides transporting cargo and passengers for scheduled or rescue flights, Airships can provide communication and monitoring services to remote and vulnerable locations.

This topic is of significant importance in the context of the ongoing COVID-19 pandemic. In the event of a disaster, different aid agencies are deployed with support in the distribution and logistics of perishable cargo, essential cargo, equipment and assistance personnel. The economic capacity and the transport accessibility -connectivity- of the regions directly influence countries' capacity to face a disaster. Disasters usually have local effects and the area affected depends on the type of the natural hazard. Some of them, such as the COVID-19 pandemic, have a global impact, presenting a significant challenge for the transport and logistics industry.

Remote areas, such as the *Small Islands Developing States* (SIDS) in the Pacific and the Caribbean, have certain common features of vulnerability. The distance to demographic centers and markets translates to a decreased connectivity. Besides distance, there are implicit transport costs related to logistics services that may be diminished as a result of a series of developmental, economic and environmental circumstances. Likewise, small islands are subject to natural disasters, which demands for resilient transport infrastructures. The airships, in combination with other traditional and new technologies, bring to these remote islands a new transport system that promotes sustainable and resilient logistic services and infrastructures and contributes to the implementation of the Sustainable Development Goals.

The aim of this technical note is to help raise awareness on Airships as an innovative mobile services technology that presents a series of competitive advantages for improving connectivity in SIDS and to serve as a response for humanitarian, sanitary and environmental challenges across the local, regional and global scales, as a resilient and sustainable logistics solution (as illustrated on Figure 1). Airship technology as an air transportation and service provision mode can help achieve the goals of several regional policy programs and agreements, and the prospects of its development should be brought to discussion in those contexts. ECLAC and ESCAP are currently working on a logistics survey focused on the Small Island Developing States of the Great Caribbean and Pacific for the improvement of connectivity and emergency operations via Airships.

Figure 1 The airship and its competitive logistics services



Source: Author original

This technical note has been prepared as part of the activities of the UNDA project “Transport and trade connectivity in the age of pandemics: Contactless, seamless and collaborative UN solutions”.

It was jointly drafted by the ESCAP Transport Division, in cooperation with the ECLAC International Trade and Integration Division.

I. AIRSHIP: NEW COMPLEMENTARY AND COMPETITIVE SERVICE MODE OF TRANSPORT FOCUSED ON ENHANCING CONNECTIVITY, INTEGRATION AND HUMANITARIAN AIDS.

Airships' main general advantages and characteristics.

Airship technology refers to resilient, sustainable and environmentally beneficial air vehicles, which represent the modern stage of vehicles such as the Zeppelin that were used towards the first half of the twentieth century, for the provision of logistics services for cargo and passengers transport, as well as humanitarian and health assistance operations, monitoring and telecommunications service provision, among others. It is characterized by a lift and propulsion method by which the volume of the vehicle, filled with a lighter-than-air gas inside its structure, pushes the air around it thus achieving buoyancy. In certain new airship models of the Hybrid type, the lift is enhanced by the features of an aerodynamic hull, engines, and other elements of the vehicle, which makes them heavier-than-air airships. Among its main advantages is a series of technological innovations in contactless operational solutions, with low environmental impact due to the use of nonflammable gasses such as helium with a lower environmental impact. Below, some of the main advantages and characteristics of this transport technology:

- Its operation involves lower investments of nodal infrastructure (model function), being able to reduce the distance between nodal points and also decrease the distances of the last mile.
- It does not require much terrestrial infrastructure, since it links nodes by air.
- Its speed is estimated between 100 and 350 kilometers per hour and, not having to follow a path defined by roads or maritime lines, the transit time is reduced.
- It improves accessibility, bringing an efficient alternative for reducing transit time compared to other modes, with the exception of conventional aircraft.
- It reduces energy consumption, allowing to modify the energy consumption matrix for transport; and offers advantages for the reduction in greenhouse gas CO2 emissions.
- Its capacity for cargo lifting ranges between 10 and 60 tons, potentially matching or exceeding several truck models and aircraft that serve relatively small communities at the present time. The engineering is being upgraded for volumetrically higher loads, between the 100 and 250 metric ton ranges¹.
- It is resilient and adaptable to requirements of demand; it can carry drones for last-mile delivery.
- It is versatile in functionality and can provide telecommunications, monitoring, healthcare and other services to remote areas.

The technical features in the engineering of airships that represent both their competitiveness and their proficiency in sustainability aims are complex in nature and scope, but may be summarized as it being “slower than an airplane and faster than ships and trucks” at an average of 100 km/h or higher cruise speeds, with varying load capacities going from the 10-20 to the 100 metric tons ranges depending on model and type of operation; its physical dimensions are largely outweighed by its efficiency standards, as will be detailed in the following paragraphs. Table 1 shows the main technical features of this mode of transport exemplified on some of its most prominent models currently in development

¹ Varialift is working on an upgraded version of its ARH50 model: <https://www.varialift.com/page/specification-arh-50>

Table 1 Main Airship technical features and designs.

Vehicle	Varialift ARH50	Flying Whales LCA60T	HAV Airlander 50	Lockheed-Martin LMH1
Loading capacity (in tons)	50	60	50	23.5
Length (meters)	150	154	119	85
Estimated cruise speed (km/h)	350	100	195	111
Range (nautical miles/ kilometers)	6,000/11,112	540/1,000	2,600/4,815	Up to 1,400
Crew	2	3	7	2
Passengers	14	0 (cargo only)	50 (with tourist services)	19
Max. Altitude	30,000 ft.	10,000 ft.	10,000 ft.	10,000 ft.
Type of build	Rigid	Rigid	Hybrid/Rigid	Hybrid

Source: Authors, based on data published by developers. Note: Speed and other figures may be rounded or approximate

This transportation technology offers a major boost for productive sectors, generating employment and innovation. They are distinguished as resilient vehicles, with the potential to increase connectivity, accessibility of isolated and/or remote regions and communities.

Logistic trend towards sustainability.

Logistics involve more than the transport function, "logistics integration is a fundamental part of productive integration, to such an extent that without an adequate and efficient interconnection of infrastructure networks and associated services, it is not possible to generate value chains and productive integration in general"². Bearing in mind the implementation needs of SDGs, ESCAP points out as a challenge to promote smooth and sustainable freight connectivity through a more efficiently integrated infrastructure for all means of transport and a more balanced modal distribution, with better service to users and considerable energy savings.

The fore mentioned set of advantages in employing airships would be crucial for advancing in the new Blue Economy approach, proposed in recent SDG documents, and particularly relevant for Small Islands Developing States in the face of climate change, the Covid-19 pandemic and other issues of global impact. An article released by the United Nations Development Programme, reflecting on the impact of the issues of the last year, formulates the following stance: *"SIDS see themselves as Large Ocean States, their ocean territories are some 20.7 times greater than their land area. As one of their greatest opportunities, they are pioneering the Blue Economy paradigm that promotes sustainable use of ocean resources while generating economic growth, jobs and social and financial inclusion, and preserving and restoring ocean ecosystems. Seychelles has led by example,*

² Políticas de logística y movilidad para el desarrollo sostenible y la integración regional, Jaimurzina A., Perez G., Sánchez R. (2015 y 2016)

launching a first-of-its-kind sovereign blue bond, mobilizing US\$15 million for blue economy projects.”³ Since 2014, initiatives for sustainable development for SIDS have been articulated under the scope of UN’s inter-regional programmes through the ‘Small Islands Developing States Accelerated Modalities of Action (SAMOA) Pathway’ with a 10-year plan focused on international assistance, which would be complemented and enhanced by the improvements on connectivity airships can facilitate.⁴

One main aspect when estimating the performance of airship is the relation between flying times and payload capacity, which is at the center of its capabilities for offsetting its operational costs. A recent case study by the University of Manitoba for the long-distance distribution of agricultural goods to isolated locations illustrates this as follows: *“The cargo airship is assumed to operate 330 days per year, leaving 10% of its time for inspections, maintenance and periods of adverse operating weather. The daily flying time is set at 20 hours, with 2 hours at each end for loading and unloading. This allows the airship to complete one roundtrip every two days. With a payload of 100 MT, traveling at 135 kmph, for 6.600 hours per year, the airship produces 89.1 million tonne-kilometers of output annually. The 100MT airship’s unit cost is approximately 10¢ per kilogram more than trucking (\$0.69/kg versus \$0.59/kg). This cost difference could easily be offset by other indirect benefits of the airship and by the value of carbon reduction”.*⁵

Placing the focus on carbon footprint, landscape care and the cost of construction materials reaching isolated locations depending on modes of transport, French operator Flying Whales developed a case study for the use of Airship in service provision for the population centers of the French Guiana territory, evaluating its advantages *“to transport the 1,312t of resources needed for a worksite in Maripasoula, the biggest town of French Guiana that is not linked to the road and which rely on slow and costly fluvial transportations. The conclusion of this study showed that for the whole transportation of the resources, the airship will reduce by 38% the financial cost and by approximately 63% the CO2 produced (the figure slightly varies depending on the weather). In addition, the airship brings a lot of advantages in term of safety, security, flexibility, worksite design savings, and the possibility to reach Maripasoula in 3 hours compared to the 3 days needed for the combined used of trucks on the road portion and pirogues on the fluvial portion.”*⁶

Incorporating airships as a new means of transport with the feature of contributing to improve mobility and logistics in co-modality / synchro-modality terms, is a goal for the transport and logistic industry, focused on integrated logistics services and infrastructures. It is pursuable with new regulations towards a sustainable network with economic and social global integration achievements through improvements in connectivity. Connectivity is an accessibility feature of a node in a logistics network. Connectivity can be measured through the number of services available from one node to reach another node, as well as efficiency in connection time and cost and node

³ Small island developing states do not have the luxury of time, R. Meddeb (UNDP, 2021)

⁴ Source: UN (<https://www.un.org/en/conferences/small-islands/apia2014>) The Third International Conference on Small Island Developing States (SIDS) was held in Apia, Samoa on 1-4 September 2014.

⁵ Cold chain sustainability: airships versus long-haul trucking, B. Prentice, J. Wilms, M. Gonzalez Alba (Manitoba, 2021)

⁶ Flying Whales case study presentation, July 2021

facilities. ESCAP⁷ which also proposes to consider indicators related to economic well-being, social inclusion, equity, environmental quality and economic resilience.

Logistics advances to co-modality / synchro-modality concepts focus more on sustainability and efficiency transport. In 1980, UNCTAD defines multi-modality as cargo transport using two or more means of transport, inter-modality adds that it is in the same transport unit, door-to-door and with greater integration. Combined transport and co-modality focus mostly on sustainability and efficiency. Synchro-modality (synchronized inter-modality) adds two more attributes, flexibility (adaptive) and transport mode selection based on real-time information. Logistics service providers, in this model, have the flexibility to make real-time decisions based on variations in demand and the availability of resources available in the logistics network.⁸

Technology for logistics and mobility progressively incorporated the appropriate equipment for each type of infrastructure and vehicles for the movement of different product classes. For example, barrel, sack, paddles and finally containers, 60 years ago, express this technological evolution, as did wagons, trains, trucks, boats and barges and others. Valuable developments exist currently in the logistics of the last mile, such as cargo bikes, and electric boats, drones to name three examples of potentially disruptive technologies. However, there are needs not yet completely met for territories of special accessibility conditions because of geographical, climatic, orographic and other difficulties, which complicate their connectivity with other territories that are necessary for them to achieve better living conditions and progress for their inhabitants, conditioned by the objectives of sustainable development. In such territories, traditional infrastructure and vehicle combinations are less performant, which do not meet the requirements of the SDGs. In the case of SIDS, as remote islands, vulnerability to natural disaster, the airship comes to complete this technological chain for logistics and mobility, because it has special operating conditions that prove to be efficient means of transport and with high adaptability, provided that the Sustainable Development Goals are to be observed.

Placing the operational properties in perspective with those of other modes of transport not only highlights the competitive advantages of the Airship, it also raises the need to think of logistics in innovative ways. As IMIEU states: *“A very particular aspect of LTA is that the way LTA crafts operate is entirely different than conventional aviation. The way an LTA platform operates is very specific and conventional aviation engineering insights are not very useful. This makes development for new approaches involving LTA carriers not easy. In the 1920s and 1930s there was more know-how and expertise/equipment and infrastructure than in the current times. However, meanwhile great advances in materials have been made, as well as in remote functioning and sensors, so much more is possible now and probably with new and larger scale investments this backlog can be overhauled. The difference with conventional aviation is large however. This is an essential aspect of upscaling, both perhaps challenging as well as providing opportunities. For example, LTA –platform landing and take-off areas are more broad (e.g. Zeppelin NT needs about 400M diameter) and*

⁷ Review of Sustainable Transport Connectivity in Asia and the Pacific 2019. Addressing the challenges for freight transport, ESCAP (2019) and refers to the study by Mark Robert et al.

⁸ Clearly explain the progress in this trend in Khakdaman M., Rezaei J. y Tavazzy A. (2020) Shippers' willingness to delegate modal control in freight transportation, Transportation Research Part E: Logistics and Transportation Review, Volume 141, 2020, 102027, ISSN 1366-5545, <https://doi.org/10.1016/j.tre.2020.102027>.

square shaped, or round, instead of rectangular, long (up to 1-3 km) and narrower, as airports are for conventional aviation".⁹

Extreme events

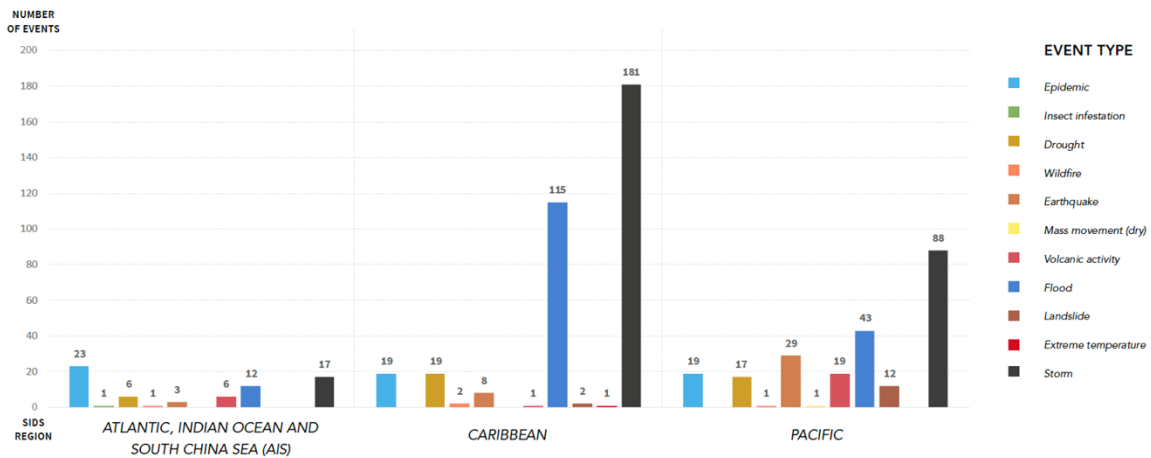
Disasters are the consequence of the combination of two factors: a) the natural phenomena (threats) that trigger processes that affect the assets and flows of an economy, and b) The built vulnerability of human settlements.

SIDS are the countries most prone to disasters in the world due to their geographical location, limited physical size and high-population density in low-elevation coastal areas. In relation to their capital stock, investment and social expenditure, SIDS face the highest potential losses associated with several hazards. SIDS would be expected to lose 20 times more of their capital stock each year compared to Europe and Central Asia.

SIDS combined average annual losses (AAL) is equivalent to 10 per cent of their total annual capital investment, compared to less than 2 per cent in East Asia and the Pacific and around 1.2 per cent in Europe and Central Asia. The AAL in SIDS is equivalent to almost 20 per cent of their total social expenditure, compared to only 1.19 per cent in North America and less than 1 per cent in Europe and Central Asia. From 1970-2020, The Caribbean SIDS had more disasters than the Pacific SIDS, has relatively more population affected and in average, relatively to the size of the economy, more damage.

The following figure 2 shows the number of disasters in SIDS. Disasters are also referenced by economic population and damages.

Figure 2 Catastrophic events associated with different extreme events and hazards (1990-2020) in SIDS macro-regions



Source: Disaster risk and readiness for insurance solutions in Small Island Developing States. UNU-EHS United Nations

⁹ U-LTA- Upscaling Lighter Than-Air Technology - Strategic Cooperation and Stakeholder Investment Programme (IMIEU, 2021)

University, Institute for Environment and Human Security. Based on impact data from EM-DAT. Michael Hagenlocher et al.

II. AIR AND MARITIME CONNECTIVITY FOR SMALL ISLANDS DEVELOPING STATES IN ASIA-PACIFIC AND THE GREATER CARIBBEAN IN THE CONTEXT OF COVID-19

The COVID-19 pandemic was caused by a natural phenomenon of a biological type, a virus, combined with several vulnerabilities that turned it into a disaster: the management and response capacity of the health system, overcrowding, informality, social work practices, and existing public transportation, among others. Unlike threats like earthquakes, hurricanes, and floods, which last for minutes, days, or weeks, an epidemic can last for years.

The large-scale prolonged effects of COVID-19 combined with the potential impact of other hazards and recent events carry the potential to generate concurrent damage and destruction to vital infrastructure and to the life support systems of large parts of societies and economies. A good example of this was the disasters caused by Hurricanes Eta and Iota in Guatemala and Honduras in November 2020 -The Great Caribbean-, and Cyclone Harold in 2020 affected Vanuatu, Fiji, Salomon Islands and Tonga nations in April 2020 -The Pacific-. Those were disasters that overlapped with the one caused by COVID-19.

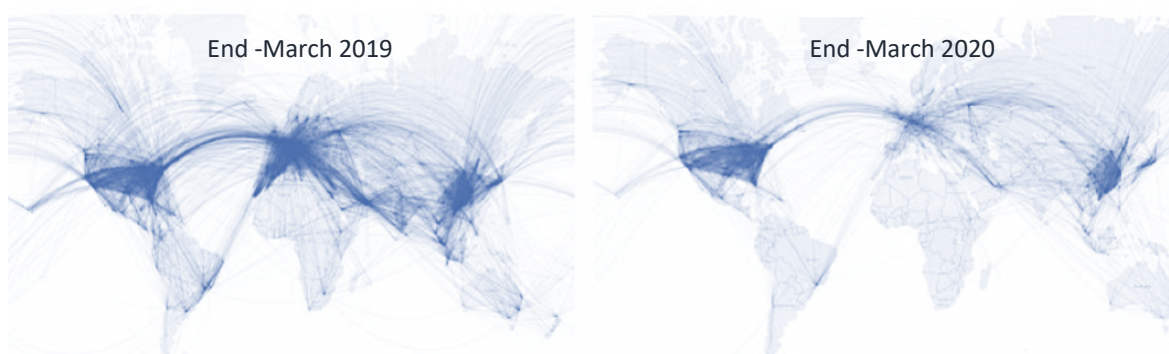
The Great Caribbean and The Pacific was affected by the Pandemic and the lockdown to prevent the spread of the virus. The Table 2 shows the COVID 19 cumulative cases and cases per 100.000 population until 1st July 2021, in countries selected of The Great Caribbean distinguished 9.222.805 cases -5,08% of global cases-, and in The Pacific 153.502 cases -0,08 % of global cases. The Figure 3 represented how the lockdown restrictions affected pair connection by global routes.

Table 2 Great Caribbean and Pacific COVID cumulative cases until 1st July 2021 and cumulative cases per 100.000 population.

GREAT CARIBBEAN ISLANDS			GREAT CARIBBEAN CONTINENT			PACIFIC ISLANDS		
	COVID CASES	COVID CASES per 100.000 population		COVID CASES	COVID CASES per 100.000 population		COVID CASES	COVID CASES per 100.000 population
Dominican Republic	324.364	2.990	Colombia	4.187.194	8.229	Australia	30.562	120
Cuba	188.023	1.660	Mexico	2.507.453	1.945	French Polynesia	19.003	6.765
Puerto Rico	140.021	4.894	Panama	401.332	9.301	Papua New Guinea	17.190	192
Jamaica	50.080	1.691	Costa Rica	364.304	7.151	Guam	8.092	4.795
Trinidad and Tobago	32.343	2.311	Guatemala	292.674	1.634	Fiji	4.144	462
Haiti	18.562	163	Venezuela	270.654	952	New Zealand	2.386	49
Guadeloupe	17.539	4.383	Honduras	260.331	2.628	Northern Mariana Islands	183	318
Bahamas	12.586	3.201	French Guiana	27.415	9.179	New Caledonia	129	45
Curaçao	12.332	7.515	Suriname	21.360	3.641	Solomon Islands	20	3
Martinique	12.286	3.274	Guyana	19.891	2.529	Marshall Islands	4	7
Aruba	11.132	10.427	Belize	13.189	3.317	Vanuatu	3	1
Saint Lucia	5.284	2.878	Nicaragua	6.604	100	Samoa	1	1
Barbados	4.079	1.419				Nauru	0	0
United States Virgin Islands	3.850	3.687				Kiribati	0	0
Sint Maarten	2.613	6.093				Tonga	0	0
Bermuda	2.514	4.037				Tuvalu	0	0
Turks and Caicos Islands	2.424	6.261				Micronesia	0	0
Saint Martin	2.367	6.123				Palau	0	0
Saint Vincent and the Grenadines	2.219	2.000				American Samoa	0	0
Bonaire	1.618	7.736				Cook Islands	0	0
Antigua and Barbuda	1.263	1.290				Niue	0	0
Saint Barthélemy	1.043	10.551						
Cayman Islands	614	934						
Saint Kitts and Nevis	439	825						
British Virgin Islands	298	986						
Dominica	193	268						
Grenada	162	144						
Anguilla	109	727						
Montserrat	20	400						
Sint Eustatius	20	637						
Saba	7	362						

Source: Author's calculation, based on data from WHO.

Figure 3 Global route network before pandemic by March 2019 and by March 2020



Source: IATA Economics using data from flightRadar 24, w/c March 25, 2019 – Air Connectivity. Measuring the connections that drive economic growth (IATA, 2020). (note: recolored in blue)

COVID brought a new paradigm in transport and connectivity, underlining the projects leading to “contactless, seamless and collaborative” solutions. These three priorities stated in the special UNDA project on trade and transport connectivity in times of the pandemics launched in May 2020: cluster A - contactless solutions: It aims at minimizing physical contact among people in cross-border supply chains by facilitating the flow of goods without spreading the virus; cluster B – seamless connectivity: It focuses on eliminating obstacles to cross-border trade and transport operations arising from the COVID-19 crisis; cluster C - Collaborative solutions: It seeks to strengthen regional and sectoral cooperation on transport, trade and logistics operations to facilitate joint actions and solutions in responding to the COVID-19 pandemic.

The occurrence of simultaneous disasters mandates for new logistics processes in order to avoid the spread of the virus. Despite restrictions on air transport, based on interviews, no delays were found in the delivery of humanitarian aids, however it has promoted new challenges.

For countries that are exposed to disasters, the focus is on pre-disaster preparation to face disasters the moment they emerge, the key being connectivity. Regarding how well connected SIDS are: *“Remoteness is one of the main challenges for small island developing States (SIDS). However, this term is commonly used in a narrow sense, referring only to geographical distance from markets resulting in higher transportation costs (...) remoteness is a broader concept, also involving distance to financing sources and political centers. In addition, it can be aggravated or attenuated by connectivity in transportation networks or through political and cultural linkages. Moreover, with the growing weight of the digital economy, issues of access and performance of information and communication technologies gain a higher importance”*¹⁰.

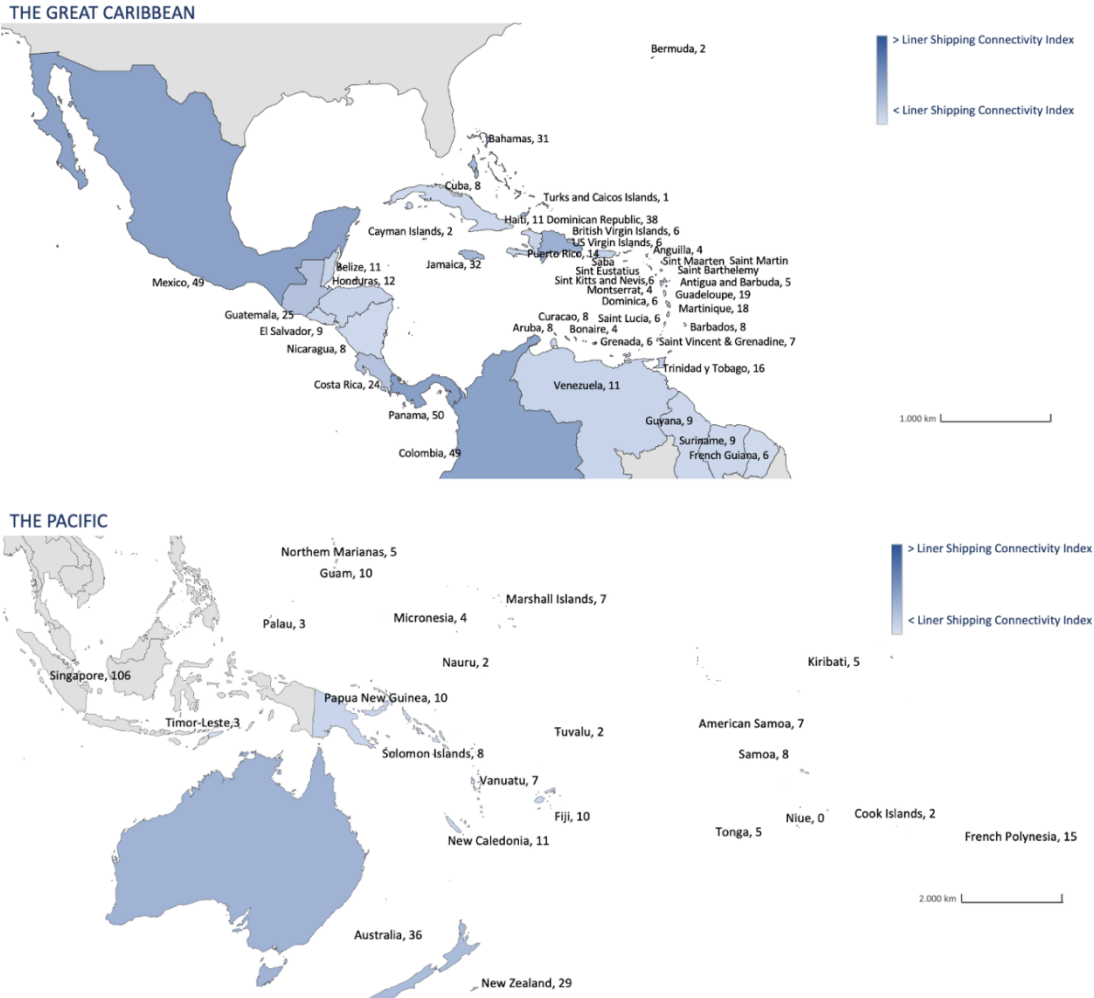
The connectivity, as pair connections, could be improve by different policies, but is characterized by a dependency on the market between other countries. This makes it very important to promote the development of sustainable transport networks, which improve the

¹⁰ Remote but well connected? Neighboring but isolated? Measuring remoteness in the context of SIDS (UNCTAD, 2021)

connectivity of the islands, such as transport systems that integrate airships, and news processes and technologies.

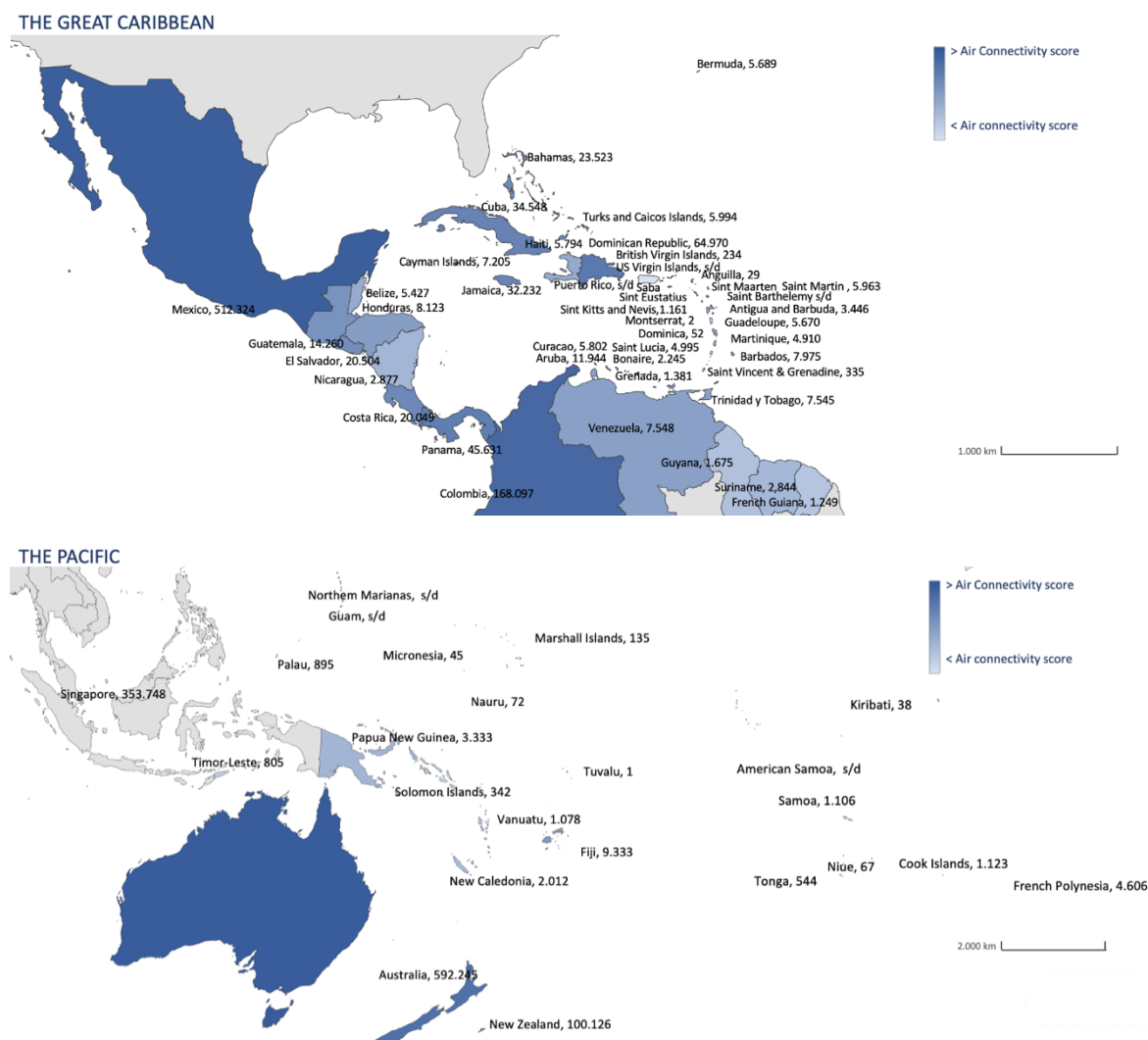
It depends on the specific island, how connected it is. The islands that concentrate of export and import freight cargo, in general attract more services, or the islands that concentrate more tourist also attract more services. The maritime connectivity of different countries usually measures by the index “Liner Shipping Connectivity Index” developed by UNCTAD. This index reflects the maritime direct connection of a countries with other by service lines, so is characteristics of container cargo. There are different benchmarks of the air connectivity, IATA developed an “air connectivity score” the air connectivity characterized the air connection between countries, taking into account the passenger, this is characteristics also by the cargo, due to the fact that the cargo is transported on many occasions in the holds of the airplanes. Figure 4 shows the maritime connectivity and Figure 5 the air connectivity, based on the indicated considerations, the countries colored with the highest intensity correspond to countries with greater connectivity. The air and maritime connectivity there are not comparable, comes from different methodologies.

Figure 4 Maritime connectivity at The Great Caribbean and The Pacific - LSCI Fourth Quarter 2019 UNCTAD-.



Source: Author’s calculation, based on data from UNCTADstat

Figure 5 Air connectivity at The Great Caribbean and The Pacific - Air connectivity score 2019 IATA-



Source: Author’s calculation, based on data from IATA – Air Connectivity. Measuring the connections that drive economic growth (IATA, 2020)

Note Figure 4 and 5, The graphics are schematic and not to scale (Different scales to represent The Greater Caribbean and The Pacific). Some countries on the maps are not colored due to small image size; grey-painted countries indicate lack of data or outside the area covered in the study. The color scale corresponds to the color intensity increasing relative to the value of the indicator. The range of color degradation is not accurate to the ratio of variation of the indicator.

It can be seen that there are countries that according to the maritime connectivity indicator, have high connectivity. However maritime connectivity is related to specialized container ships that calls on the coast and it doesn’t consider the linkage of the nodes on the coast with the nodes in the interior of the territory – Hinterland. For example, the case of French Guyana stands out, where its interior is characterized by a characteristic orography of the Amazon with isolated localities. Likewise, air connectivity considers only the main air infrastructure nodes.

III. OPPORTUNITIES THE AIRSHIP TECHNOLOGY PROVIDES FOR CONNECTIVITY AND EMERGENCY OPERATIONS

In this section, the main advantages of the airship as a logistics response to connectivity issues in remote locations such as SIDS will be addressed. Significant progress has been seen in the last decade in both the technological development of airships and the academic assertion of its cost effectiveness, yet it is important to address the factual feasibility of regional programs that incorporate airships as a new means of transport with the feature of contributing to improve mobility and logistics in co-modality / synchro-modality terms, with improvements in connectivity.

The capability airships provide for achieving last mile delivery is one of its major assets for overcoming limitations in humanitarian aid coverage for isolated communities. Their extended navigational range and flexibility facilitates accessibility more extensively than with the traditional aircraft and land vehicles currently employed in small islands. Their air surveillance functionality of the airship brings a decisive advantage in preventing and containing natural disasters such as widespread fires that might affect those same communities on a frequent basis. Its operating simultaneously with other vehicles that mitigate disasters can guarantee a significant improvement in the chances of the response to be delivered in a timely fashion.

Operational and distribution system feasibility is the decisive factor for the deployment of airships to the regions and community that would most benefit from it to become a reality. Among the extensive variety of technological and operational designs present at different stages of development at the industry in current times, the Hybrid type that relies on built-in landing mechanism may prove more robust and resilient for overtaking the initial investments any airship initiative would require.

In that sense, the current developments in airship technology may allow for a more sustainable infrastructural development in sensitive ecosystems such as rainforest, and major studies across the board maintain both its cost effectiveness in comparison with the total cost of traditional road and airfield infrastructure and its advantages for environmental care.

Trade demand conditions indicate that is not competitive or sustainable to continue damaging natural environments such as those in the Amazon basin by building further roads for a relatively small land vehicle circulation; airships can cover distances in difficult to travel areas by flying in a linear course.

It is important to make the distinction that the technology for buoyancy in airships is not in all cases of the Lighter-Than-Air type, as certain Hybrid models combine the lift that is primarily provided by a buoyant gas with an additional thrust by its aerodynamic hull and engines, making them heavier than air, if only by a small margin. One of the main industry tested advantages of this approach is that it can be combined with built-in landing mechanisms in the form of cushions below the structure of the vehicle to achieve ground handling exercises unhindered by environmental conditions.

As IMIEU states on a recent report regarding the safety aspect of airship engineering and testing: *“Related to the safety aspects, and also in line with the incidents with recent demonstrators so far a very concrete topic for co-operation by some partners was found to be the resistance / or better mitigation by LTA carriers of sudden changes in wind patterns (wind gusts) during ground (or*

landing) operations. The development of a methodology or device to better resist to (sudden) changes in wind patterns seem to have a great interest of all partners."

Researchers consulted on this survey agree the airship would be able to perform operations with approximately minimal contact, due to its low need of crew members on board, and as one expert and developer puts it "no more than just one that would require any physical contact". This offers game-changing benefits for sanitary and epidemiologic response measures.

There is still debate as to whether a fixed landing base system will ultimately be possible to be avoided in favor of autonomous systems. For some developers this question boils down to operational specificity, a stance that might be summarized as: *"Eventually all airships will have transship cargoes this way, if it is a scheduled transportation service. The ability to just land anywhere is only for emergency use."*

Significant advances have been reported for using airships in combination with other recent technological solutions such as air drones, mainly for the completion of goods delivery at difficult to access terrains. Developers consulted in this study attest that this combination is compatible as well with other features of sustainability in lighter-than-air technology such as the development of hydrogen fuel cells, and with the operational characteristics of the airship. Dr. Barry Prentice describes these operations as follows: *"The airship would come in loaded with drones and supplies. Once the drones are released, the airship would become lighter and start to rise. The H₂ would be released and the propellers would keep the airship down until the empty drones returned. Then the H₂ would be released to obtain the right buoyancy. After the airship returns to its base, more hydrogen would need to be added for lift to equal the new loads going out."* Furthermore, a recent research paper from Purdue University proposes a humanitarian flying warehouse (HFW), "... an airship that stays at high altitudes and uses unmanned aerial vehicles (UAVs) to deliver supplies"¹¹

Hybrid airships are also low emission vehicles that supply heavy cargo delivery at a game changing differential of environmental footprint. Most case studies for transport by airship take heavy lift helicopters as a main comparison object in operations to small islands due to it being the prevalent mode in use. The most methodically sound results have been shown through the fuel consumption / speed ratio approach by a significant range of researchers, and the findings across the board allow to place the airship at the point of equilibrium among all significant logistic services modes in existence.

Varied sources estimate the fuel consumption and carbon emissions of a Hybrid airship at nearly one tenth of those of a Heavy-lift helicopter by measure of each nautical ton-mile. Cost effectiveness by reduction of infrastructure needs has been demonstrated by case studies of different approaches, and the airship's suitability for emergency aid and disaster mitigation makes its environmental friendliness a factor of exponential growth in efficiency.

Within the airship industry in present day, there is a variety of operators and producers developing models that have certain engineering aspects in common as well as fundamental and decisive discrepancies. The degree of advance in vehicle building is heterogeneous as well among producers, but in the wider view, the airship technology requires the participation and funding of

¹¹ The humanitarian flying warehouse (2020), Ho Young Jeong, David J. Yu, Byung-Cheol Min, Seokcheon Lee

both public organisms and private parties to reach a desirable and productive stage. Guaranteeing the operational features of a specific model are feasible for the landscape and distances of which an operative schedule is to be set is paramount for developing policies involving airship that will be carried out successfully.

There is an assortment of functionalities that are relevant for humanitarian aid missions in SIDS by airship, many of which may be considered for being performed in tandem with one another. Airships and lighter-than-air vehicles can carry a range of payloads according to model, with variations in the 10/20-ton range in some Hybrid Airships with built-in landing cushion mechanisms that do not require airports or similar land facilities for docking, cargo handling or maintenance stops during missions, which gives them a greater resilience for servicing locations and population centers that are normally difficult to access due to terrain characteristics (among which the distance between small islands in a particular area should be counted) or deficiencies in infrastructure.

These Hybrid airships are flexible for a variety of scheduled or emergency flights. Hybrid airship with no infrastructure needs during missions are rapidly advancing in the increase of their payload capacities. There exist smaller balloon type vehicles near the same cargo capacity range that are remotely operated for regular delivery operations, and Lighter-Than-Air airships around the 60-ton load capacity range with hovering capabilities for load and unload maneuvers which also decreases ground infrastructure needs.

Emergency aid operations respond to delicate and distinctive parameters that should be attended to under the light of inter-modal logistics coordination, and of the specifics of the necessities it aims to serve. A study by the University of Manitoba explains: *“Like any supply chain, climate disaster relief logistics involves delivering the right supplies to the right people, at the right place, at the right time, and in the right quantities. Unlike commercial logistics however, none of the coordination has been established between transport and storage services providers. Response delays can be ameliorated by maintaining full logistics readiness during non-disaster periods. Although readiness is an essential requirement of relief activities, no two events are ever likely to be the same, while the costs of standby preparedness further limits response capabilities.*

Disaster relief supply chains operate within perhaps the most challenging logistics environment. They must be able to respond rapidly, serve multiple destinations simultaneously, coordinate global and local supplies, and more often than not, deal with inefficient means of communication and transportation, or in worst case, an almost total lack of civil means of communication and transportation (Kovács, 2009).”¹²

The proficiency of the Airship for last mile service is certainly one of the cornerstones of the Airship advantages in connectivity, and particularly so for difficult to reach areas in small islands. Moreover, small islands with a greater propensity for extreme natural or climate events have an even higher differential of efficiency to obtain from the use of this technology: *“In cases of natural disasters, the most challenging logistics is the final leg of the delivery in which surface transport infrastructure is disrupted. An airship would be able to fill this role better than any other known device. An airship’s ability to vertically take off and land would allow it to reach remote areas not*

¹² Cold chain sustainability: airships versus long-haul trucking, B. Prentice, J. Wilms, M. Gonzalez Alba (Manitoba, 2021)

*accessible by conventional aircraft. An airship, far cheaper to operate than a conventional aircraft, can transport aid directly from the point of supply to the point of need, with minimal support infrastructure. The strength of cargo airships is to provide sustained logistics response to aid survival and reconstruction.*¹³

The provision of telecommunication and net connection services is possible by many Airship models and a key asset for isolated communities and for the mitigation of disaster events, along with air surveillance capabilities.

Advances have been attested by airship operators such as Flying Whales and Straightline Aviation in different models of mobile healthcare service units for being deployed by airship to remote locations in varying and flexible ranges of frequency according to the specific needs of each demographic group. An industry expert states: *“The airships would be ideal to move mobile clinics into difficult areas, or to the islands. Of course, nothing can be done during the current pandemic, but as we now know, we must be prepared for the next one”*. Together with contactless solutions among others, these advantages make the airship technology not only competitive but also a relevant response to present and future sanitary challenges at a global scale.

IV. OPERATIVE PARAMETERS FOR AIRSHIPS AT SIDS, AND IN EMERGENCY MISSIONS; ADVANTAGES OF ITS INCORPORATION IN REGIONAL POLICIES

Hybrid Airships may be a game changing transport technology that can play a key role in the resolution of logistic services and infrastructure limitations if they are incorporated in regional policies for remote areas such as SIDS. Its industry is at a stage where it requires a level of initial investments to ‘take off’ and build its models at a productive capacity.

For achieving that, it is paramount for this technology to receive greater visibility and consideration and be included in the regional and national policy programs for sustainability, environmental care, humanitarian aid, social and economic reactivation, and logistic resilience it would most greatly benefit due to the breakthrough advantages of its technical features, as summarized in the first chapter and elaborated on in the third chapter of this paper.

A significant array of logistic services providers in the air transport sector state that after the initial improvement in connectivity brought by airships to remote locations, there can be lasting and far reaching benefits in social living standards and in the reactivation of trade and economic activities beyond the impact of emergency aid. The current difficulty of traditional air systems in reaching remote and isolated locations resides in the shift from large to smaller airplanes, having an infrastructural necessity of distribution centers between locations.

It is crucial that policy decision makers and agencies at the national, regional and communitarian levels will engage in evaluations of the operational and technical schemes presented by the diverse vehicles developers and builders, as well as service providers and researchers for feasibility attesting and appraisal. The expertise of operators and development and the eligibility of

¹³ Cold chain sustainability: airships versus long-haul trucking, B. Prentice, J. Wilms, M. Gonzalez Alba (Manitoba, 2021)

the projects they present are key factors that may be assessed through their capacity for making progress with certification issues and with sound technical demonstrations of the integrated systems in the engineering of their model designs. Some of these aspects, such as in ground-handling systems, raise some discrepancies among industry members, yet it is tenable that with a wider participation these debates will reach a productive end, be it in way of standardization or coexistence of diverse engineering designs.

Such debates must take into account that the airship industry is currently incipient as such and it needs an initial investment to put its technical potential into practice, before which a diligent and thorough assessment of each model and its suitability for certain type of terrain and operations, such as emergency response in SIDS, should determine a sound and substantial rationale for its funding programme.

The determination of the feasibility of the different airship models and their engineering parameters is based on the review of technical studies that trace the progress over time and the adaptability of the various technologies available to the different types of uses and operations. While there is not yet a unified airship design in terms of its internal construction, power and propulsion structure and storage compartments, convergent trends in critical mass in recent years allow to identify advances in the discussions about the standardization of technology or the coexistence of a variety of designs suited for different types of operations.

The operational characteristics of airships that explain their cost efficiency should be thoroughly examined to determine the feasibility of a mission in specific territorial conditions and operative objectives. As Dr. Barry Prentice explains, *“There is a clear economic relationship between airship size and “economic” distance. It would be no problem for a 30MT-lift airship to cross the Atlantic, or even the Pacific, but you could never make money doing this at less than cargo airplane rates. Airplanes are expensive, but fast. The key is the number of complete cycles that you can complete in a year. Hence, the need for a larger airship to travel longer distances. Of course, there is no need to stop at 100MT-lift. I used this because it was possible to employ data from the Hindenburg for comparison. The airship in the 150MT-lift or greater would take all the refrigerated trucks off the road. Naturally, bigger is better and this would apply to the islands.”*

There is progress in research that analyses feasibility and complementarity with other means of transport, highlighting cost savings by using airships in remote areas such as the Northern Canadian steppe, for their geographic and demographic configuration, for the transportation of mineral extraction products¹⁴, food and general merchandise¹⁵ and fuel¹⁶. The cited studies were prepared by the University of Manitoba, Canada, and are mainly based on investments and operational cost analyses, based on load distribution by type of consumer’s goods and cost savings disaggregated by location.

Researchers emphasize as well that by calculating investments in road infrastructure of special characteristics, which are commonly used to connect remote areas that are difficult to

¹⁴ Prentice, 2013

¹⁵ Prentice & Adaman, 2017

¹⁶ Prentice & Wilms, 2020

access, on a yearly basis and taking traditional infrastructure costs as a whole, airships are proved to be cost effective, based on the ton/km and distances to be covered and the associated costs.

A survey focused on the Australian desert expanse, is to be noted for its different focus on cost theory and approach to a potential market analysis, applied to an estimate of a 'Potential Airship Fleet Demand' over 2012 and a projection of it by 2030. The calculation consists of the multiplication of the FTK in non-bulk shipments by the result of market share simulations, over the annual FTK of each airship model. The airship's FTK is based on "an individual airship operating 300 days per year, 12 hours a day"¹⁷.

A similar approach, more focused on the operational costs of the airship, was applied on a case study carried out jointly by operator Straightline Aviation and developer Lockheed-Martin for an airfield in Komo, Papua New Guinea completed in 2013 for LNG transportation mainly, comparing infrastructure costs to an airship project (\$924,5M vs \$23,6) among a set of other advantages, its main facts observed on Figure 6.

Figure 6 Hybrid Airship case study in Komo



Source: Straightline Aviation

The feasibility of implementation in distributional circuits and trade routes is developed from the competitive approach with current means of transport¹⁸, and from the standpoint of operational considerations for navigation and ground facilities for mooring, docking and co-modality¹⁹.

¹⁷ Neal & Koo, 2020

¹⁸ Prentice & Knotts, 2016

¹⁹ Lynch, 2018; Prentice & Ahmed, 2017

There is an important progress, shown in this paper, to place the development of airship and its competitive edges in a broader global and historical context²⁰, which is supplemented at the most specific level of market potential assessment in Asian regions²¹, and with case studies for the insertion of these aircraft into other transport systems and operations, such as urban passengers²², the conduct of humanitarian and medical aid²³, assistance in disaster events²⁴, the provision of computer and communication services²⁵, and military operations²⁶, among others.

Climate change is an ongoing global concern and the change the Airship solution can bring is arguably unparalleled in the context of synchro-modality and transport competitiveness. As a recent study by the University of Manitoba states: *“It is possible to estimate the total carbon emissions from transporting fresh produce by truck to Canada. The average travel distance from the various North American production zones to Canadian cities is about 3,000 kilometers. Diesel fuel consumption for a refrigerated tractor trailer is about 39.5L/100km, thereby consuming about 1,185L of fuel to drive a 3,000 km distance. The refrigeration system of the trailer (reefer unit) is estimated to consume 250L of diesel fuel for the journey; increasing total consumption to about 1,435L. The carbon emissions from each liter of diesel fuel are 2.64 kg of CO₂. ii Therefore the 160,000 reefer trucks bringing fresh produce to Canada from the US and Mexico in 2019 released 3.8 MT of CO₂ per truck, for a total of approximately 606,000 MT of CO₂. The current truck transport of fresh produce from Mexico and the USA along selected transportation corridors to Canada could be replaced by zero-carbon emission, electrically-powered, cargo airships. The technology is available and the market appears to be ready. Craig and Koo (2020) found that a proposed cargo airship in Australia could capture up to 34% of the perishable food transport based on a shipper modal choice experiment. The next section presents a theoretical framework for intermodal comparison between these two modes of transport.”*

The principle of sustainability and environmental care of Airships is rooted to a large extent in the consensus around its proficiency for reducing the need for new infrastructure. Although there is debate around many of its engineering aspects from the wide array of technical proposals, that principle is consensual. According to IMIEU: *“In conventional current airports therefore there maybe not much space for LTA platforms, however, in large ports, or on old industrial terrains there are sometimes vast amount of surfaces and land empty and available, unused. These kinds of sites (a lot of times available against relatively low costs) could also provide opportunities for LTA ground operations. Furthermore, LTA ground operations do not need a very large or heavy infrastructure (as the crafts are not very heavy), so that also could provide an asset for the business-case for LTA technologies”.*

The role of the critical mass in consolidating scientific advances and general agreements is evident in the conclusion of collaboration agreements between industry actors, from which innovative initiatives and proposals arise to provide logistics systems with a legal and regulatory

²⁰ Prentice & Knotts, 2014

²¹ Prentice & Lau, 2016

²² Romli & Aminian, 2017

²³ Dorn, Baird & Owen, 2018

²⁴ Lynch, 2018

²⁵ ADB-BASI, 2019; University of the Highlands and Islands, 2019

²⁶ Ghanmi & Sokri, 2010

framework conducive to the insertion of airship (ADB-BASI²⁷, 2019; Aertec Solutions, 2020; Sträter, 2020); the debate is also brought forward to introduce LTA vehicles to the framework of regional and community programmes such as the European Union's Green Deal and the pursuit of the SDGs (Aerodays Forum, 2020; ONU, 2020; UNCTAD, 2020).

V. OPPORTUNITIES FOR INTEGRATION IN INTER-REGIONAL AGREEMENTS AND INVESTMENT PROGRAMS

As was stated before, the airship technology offers a series of logistic solutions and optimizations that significantly match the objectives of regional agreements and programs in social and environmental sustainability and resilience, such as those outlined by the United Nation's Sustainable Development Goals, the communitarian initiatives of the European Union's Green Deal and many more in the same vein.

Moreover, the raising of public awareness in the potential of airship technology is necessary for its being introduced in the context of regional policies that will enable its reaching the funding it requires to develop.

Policy decision makers at all levels, from local to inter-regional, are needed to participate in the evaluation of the feasibility of airship technology and its diverse variants in development together with private actors from all transportation modes industries, encompassing from the practical expertise of traditional aeronautics to maritime transport and others in pursuit of and optimal synchro-modality. If this is observed, the contribution of advantages between the technical capabilities of the airship and the communitarian policy programs it can benefit would be reciprocate.

There are advances in studying the positive impact in employment creation that would result from the development of airship manufacturing at an industrial scale, as well as its long-reaching effects in trade reactivation for developing communities.

Many airship operators have engaged in development and cooperation agreements with international institutions such as the World Food Program and the World Health Organization for achieving a more thorough integration of the technical features of the airship in its response to challenges in issues of global reach. Institutions such as IMIEU in the European community have incorporated airships into their development programs and are actively promoting their suitability in the funding initiatives that are coordinated between their stakeholders, regional policy forums and institutional agencies of the European Union.

Licensing and regulatory issues are sensitive as well and should be treated at inter-regional forums to reach agreements that will be capitalized by logistics networks as a whole. A recent Stakeholder Investment Program bulletin by IMIEU explains it as follows: *“Currently, only a handful of LTA-carriers that have passenger or publicity functions worldwide are certified. The current basis for certification of e.g. semi-rigid or rigid airships are based upon the certification of the Zeppelin NT (LZ NO7-100 and 102), certification basis (CS) 30 N and CS 31 (Hot Air Balloons). New types of*

²⁷ ADB - Airship do Brasil Indústria e Serviços Aéreos Especializados is a Brazilian company focused on airships development (<http://www.adb.ind.br/index.jsp>). BASI - Buoyant Airships Systems International is a Canadian company (<https://www.buoyantaircraft.ca/>). Aertec Solutions is a Spanish company (<https://www.aertecolutions.com>)

*transport platforms as e.g. Flying Whales or Flywin, are based upon this basis but also (for a to be defined part on CS 30H and T. The basis for these specifications came from the earlier stopped development project 'Cargo Lifter', where there was at the end of the project a small demonstrator. As the basis for certification is narrow and many aspects need to be further clarified, information exchange on the aspects to be clarified and safety seems nearly a necessity, also to reduce certification costs."*²⁸

It is important to highlight some of the initiatives carried out by IMIEU in its U-LTA (Upscaling Lighter Than Air)²⁹ Platform and other sustainable transport schedules and forums, so as to raise awareness of a possible path for the funding and development of airship technology: *"At this moment there are not many fully developed projects using Lighter-Than-Air technology, and the ones already in existence are not yet large scale. Due to this, LTA technological applications are not well known at the European level, other than a few unsuccessful projects at the beginning of the millennium. Because of those past issues, and several recent incidents with larger initiatives and demonstrators (Airships do Brazil, and Airlander), the technology does not seem to deliver an impression that it is close to commercialisation, with the exception of the initiatives involving communication and observation (e.g. Sceye and Altran, Cloudline)*

*To counter this, in the first year of the project two meetings are planned at European Level. First, a small-scale meeting was prepared with the most relevant departments within the European Commission on 24 September 2018. Then in November 2019, a meeting was planned in co-operation with the relevant intergroups in the European Commission. In addition, an active input in the information channels of the European information channels is foreseen by a publication in the key information channels, used by cabinets and EC Staff. An informal deliberation group with the European Commission relevant departments is also formed, in order to discuss key document output of the strategic co-operation and take care that the outcomes of the studies land in the relevant DGs and Cabinets (DG Move, DG RTD, DG Grow)."*³⁰

With the purpose of fostering inter-regional debate on the incorporation of new transport technologies, the UN regional Commissions for Asia-Pacific (ESCAP) & Latin America and the Caribbean (ECLAC) are jointly analyzing the technical prospects of carrying humanitarian aid operations via Airship in Small Islands. The game-changing competitive advantages and the multiplicity of applications (from cargo freight to communication and monitoring services) of this new resilient and sustainable logistics mode are weighted under the lens of air connectivity in the face of the challenges posed by the Covid-19 pandemic. The working hypotheses, tested and expanded with the help and collaboration of industry researchers and developers, is that Airship technology can bring long-lasting benefits in connectivity, accessibility and development to isolated locations such as Small Islands beyond the scope of emergency aid operations. Its set of advantages would be crucial for advancing in Sustainability and Blue Economy goals, particularly relevant for Small Islands Developing States in the face of climate change, the Covid-19 pandemic and other issues of global impact, as the progress in the current survey indicates. The present document was

²⁸ U-LTA- Upscaling Lighter Than-Air Technology - Strategic Cooperation and Stakeholder Investment Programme (IMIEU, 2021)

²⁹ <http://imieu.eu/>

³⁰ Ibid.

intended as an introduction to that ongoing work, and an invitation to bring the potential of these innovative solutions to an open debate of inter-regional public transport and development policies.

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