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Hybrid Buoyant Aircraft: Future STOL Aircraft for Interconnectivity of the Malaysian Islands

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Abstract

Hybrid buoyant aircraft are new to the arena of air travel. They have the potential to boost the industry by leveraging new emerging lighter-than-air (LTA) and heavier-than-air (HTA) technologies. Hybrid buoyant aircraft are possible substitutes for jet and turbo-propeller aircraft currently utilized in aviation, and this manuscript is a country-specific (Malaysia) analysis to determine their potential market, assessing the tourism, business, agricultural, and airport transfer needs of such vehicles. A political, economic, social, and technological factors (PEST) analysis was also conducted to determine the impact of PEST parameters on the development of buoyant aircraft and to assess all existing problems of short takeoff and landing (STOL) aircraft. Hybrid buoyant aircraft will not only result in reduction of transportation costs, but will also improve the economic conditions of the region. New airworthiness regulations can lead to greater levels of competition in the development of hybrid buoyant aircraft.

Keywords: hybrid buoyant aircraft, green energy, PEST analysis

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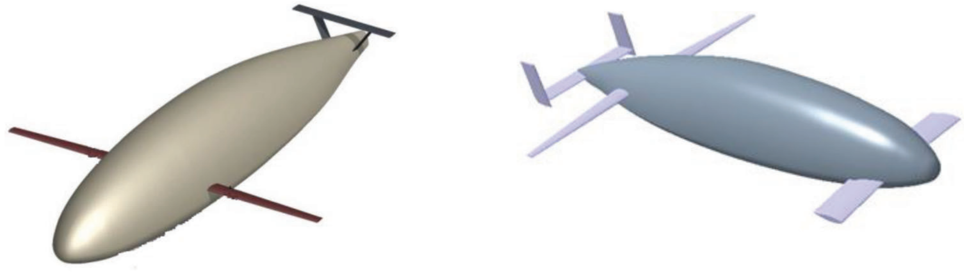
Introduction

It is well-known that a substantial share of the aviation world market is the transport of passengers and goods. Over the years, the number of people traveling by air has also increased. According to a recent survey by International Air Transport Association (IATA, 2013), approximately 3 billion people traveled by air in 2013. Freight/cargo terminals of airports in major cities of the world are also heavily utilized. Due to heavy traffic, the airports are congested, which sometimes may result in delays in departure and takeoff times. Hybrid buoyant aircraft can solve these issues to an extent and can offer an economical traveling option with both less noise and less fuel consumption. Such aircraft can takeoff and land at airports where the freight system and its infrastructure are available to load and unload cargo (Rist, 2012). Most of the international airports are away from city centers; sometimes it takes a long time to reach the destination. Passengers can be transported by deploying hybrid buoyant aircraft such as airport–city center transfer. This idea is not new: Goodyear previously proposed the idea of airship missions in heavily populated areas that have noise and pollution issues (Ardema, 1981). Certified airships are already in operation in many countries such as Germany, Switzerland, and the United States, where their use is limited to the tourism sector only. A hybrid buoyant aircraft is a concept in which the lift to remain airborne is combined with buoyancy. As cited by Carichner and Nicolai (2013), a hybrid buoyant aircraft is an aircraft that combines the lift obtained from buoyancy effects, known as static lift, with that coming from the contour of the big hull, characterized as dynamic lift. With the help of a suitable propulsion system, such aircraft require a short runway to takeoff and land. However, fuel is used for thrust generation at a speed that is lower than that of any other STOL aircraft.

The concept of hybrid buoyant aircraft came from airships; it is not wrong to state that airships have returned in the form of hybrid buoyant aircraft. These aircraft are mostly in the design, testing, and experimental phases and are always in a semibuoyant condition (Blake, 2013; ESTOLAS aircraft, 2012; Rist, 2012). Among them is the Dynalifter (Rist, 2012), a plane disguised as an airship, its fuselage and wing providing half of the total lift; its prototype was flown in late 2012. The ESTOLAS aircraft (2012) is another hybrid buoyant aircraft, funded by the European Union, which is a novel concept of an aircraft with extremely short takeoff and landing on all surfaces.

Hybrid buoyant aircraft have the potential to takeoff and land with short runway requirements. These aircraft will vary from light passenger aircraft to high payload cargo/passenger types. In order to develop demonstration models, a number of research and development (R&D) activities are underway, including the certification requirement for integrating such aircraft in airspace. Its takeoff and landing segments are similar to those of a conventional aircraft and have the capability of short takeoff and landing. Also, there are some fundamental research projects at the academia level to fill in the gap: special methodology for conceptual design and experimental data for estimation of hybrid buoyant aircraft aerodynamic and stability characteristics (Haque et al., 2014a; Haque et al., 2014b; Haque et al., 2015; Haque et al., 2016). Pictorial views of some conceptual models (C-1 and C-2) can be found below in Figure 1.

In the case of conventional aircraft, half of the fuel is used to keep it aloft, whereas the use of aerostatic lift in hybrid buoyant aircraft has the potential to reduce the amount of fuel required to keep the aircraft aloft (Prentice & Knotts, 2014). Hybrid buoyant aircraft combine the aerodynamic (similar to conventional aircraft) and aerostatic lift (similar to airships) and are considered the "best of the both worlds" by Zhang, Han, and Song (2009). Helium is commonly used as the lifting gas to provide buoyant lift. On average, helium gas lifting capacity is about 1.05 kg/m^3 (Carichner & Nicolai, 2013). It is important to note that if the lifting gas bag can freely expand or contract, then the aerostatic lift due to the buoyancy effects remains consistent until pressure height of the buoyant or hybrid buoyant aerial vehicle (Raymer, 2012). In this way, the load balanced by the aerostatic lift remains constant until pressure height. As per the Archimedes principle, buoyancy force is dependent upon the volume immersed in fluid, and its estimation is critical for calculating net weight W_{net}. Equation 1 is the gross takeoff weight minus the weight balanced by the aerostatic lift,



(a) C-1 (b) C-2

Figure 1. Pictorial views of clean configurations of hybrid buoyant aircraft concepts.

and it is the actual weight carried by the wings or other lift-generating components. The gross takeoff mass is expressed in Equation 2, by Raymer (2012):

$$W_{net} = (m_{GTM} \times g - L_{buoy}) \quad (1)$$

$$m_{GTM} = m_{empty} + m_g + m_{crew} + m_{fuel} \quad (2)$$

It is pertinent to highlight that for a buoyant aerial vehicle choosing the correct balance between the payload and accessibility requires a thorough market analysis (Donaldson, et al., 2010). For the present work, research was conducted to carry out such an analysis, focusing on the interconnectivity of the Malaysian islands. The existing market of STOL aircraft in Malaysia is small. Improvement in airport transfer is also noted and addressed under the heading of "Tourism Needs." The present work is related to the PEST analysis to correlate the environmental, economic, social, and technological requirements, which as a whole will impact the potential market of the hybrid buoyant aircraft.

Market Analysis

Less fuel consumption and less speeding capacity are the figures of merit that place the airships in between the two existing modes of transportation: by sea and via airplanes. From a business point of view, there is always a need to first pinpoint the niche market areas that can be fulfilled by introducing a new product. Generally, people have an affinity for products in which they invest more time and energy. This value is not provided unilaterally by the supplier, but stems from other needs. Such requirements are discussed here with special focus on the targeted market.

Environmental Needs

In the early years of aviation, airships were a suitable source of aviation transportation with fewer environmental concerns, and later a source of low- and high-speed aircraft. With the passage of time, larger aircraft were produced, and there was less focus on environmental concerns. Recent research on hybrid buoyant aircraft increases potential for overall reduction in CO_2 emissions in the aviation industry. Compared to conventional airships, hybrid buoyant aircraft may not require any mechanism, traditionally known as a ballast system in airships, to balance the aerodynamic and aerostatic lift. These aircraft takeoff and land either as aircraft (Rist, 2013) or hovercraft (ESTOLAS aircraft, 2012), so there would be no requirement of mooring systems for ground handling (Carichner & Nicolai, 2013). For forward movement, hybrid aircraft would need power from either a reciprocating or diesel engine, which contributes to CO_2 emissions. The ideal requirement of zero emissions for a greener environment cannot be met; however, compared to commercial jet aircraft, emissions from hybrid aircraft are expected to be low. By using an online CO_2 emissions calculator, Hall (2007) conducted a comparison of carbon emissions produced by the Zeppelin NT airship with those of the 120-passenger Bell Jet Ranger aircraft. This analysis was based on CO_2 emissions per passenger. Results revealed that the airship produced only 10 kg, and the aircraft produced about seven times more emissions. As per Watanabe (2009), in the aviation industry one-third of operational costs are fuel costs, and if the airship's fuel cost is one-tenth, then the reduction in operational costs will be around 70%.

City Center Transfer

In Malaysia, Kuala Lumpur (KLIA) is the busiest airport. There are two major terminals in KLIA: the main terminal from where all international flights depart, and the KLIA-II, which accommodates a few international and most of the domestic flights departing and arriving. KLIA-II is the world's largest airport for budget airlines such as Malaysia's Air Asia, the Philippines's Cebu Pacific Air, Singapore's Tiger Airways, and Indonesia's Lion Air. These two terminals are also connected to the Kuala Lumpur Sentral station through automatic train service from the airport; extensive modes of transportation such as buses, trains, taxis, limo services, and shuttle services are available for getting to the city center. However, there still exists a potential market for city center transport, and a number of applications have been proposed, including a military transportation service, an executive transportation service, and a short-to-medium range air taxi. One tested application was a jetpod designed for STOL, developed by Avcen Limited, bit it was involved in tragic accident on August 2009. It had a maximum speed of 550 km/hr, and it only needed 125 m to takeoff or land. Now, the hybrid buoyant aircraft is another potential candidate to fill the niche.

Airspace Needs

As per recent data published online by the International Air Transport Association (2015, p. 2), "worldwide, flights produced 705 million tons of CO_2 in 2013. Globally, humans produced over 36 billion tons of CO_2". It is expected that this value will increase, because the aviation industry will grow drastically in coming decades (Khandelwal et al., 2013). This finding is shown pictorially in Figure 2. By the year 2025, the long-term growth in GDP, passenger travel, and cargo transportation will be 3.1%, 4.9%, and 6.1%, respectively. It is perceived that the airspace at higher altitudes will be more crowded with aircraft in the future. However, lower altitudes will not be as saturated, as most airliners fly at 8–10 km.

Rural Areas

It is well known that airplanes are the fastest means of cargo transportation; however, they are expensive when

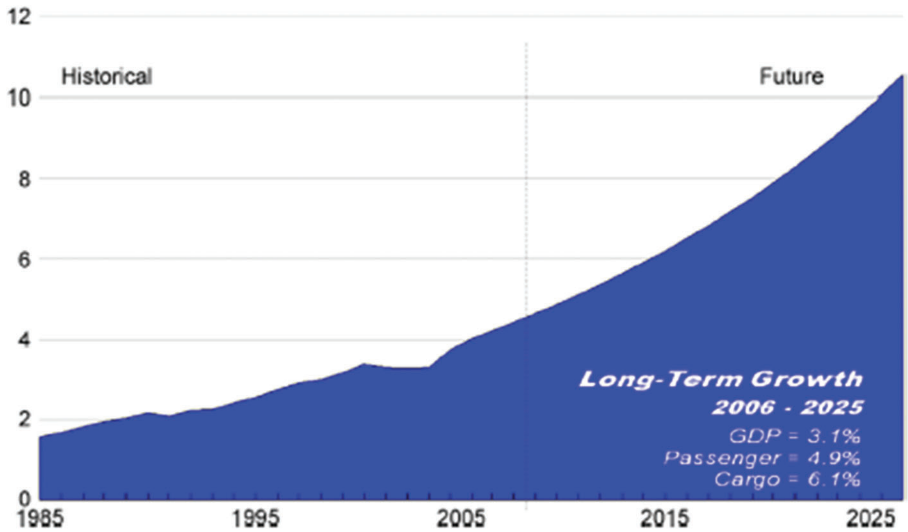


Figure 2. Expected growth in the aviation industry (Khandelwal et al., 2013). Reprinted with permission.

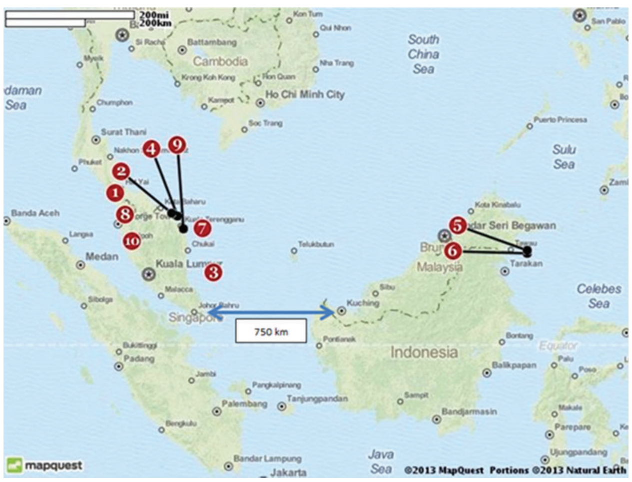


Figure 3. Geographical locations of different islands in Malaysia.

Table 1
Ranges between Kuala Lumpur and nearby islands.

Island	Range (km) from Kuala Lumpur
Pulau Pangkor	172
Pulau Kapas	286
Penang	290
Pulau Teng	285
Pulau Tioman	280
Perhentian Islands	325
Langkawi	407
Redang	145

Note. This data was collected from the following sources: *Sea-Distances.org* (https://sea-distances.org/), *Prokeraia.com* (http://www.prokerala.com/travel/distance/from-kuala-lumpur/), and *SeaRates.com* (https://www.searates.com/reference/portdistance/).

compared to transportation by sea. Moreover, low-value freight is usually transported by ships. From the coast, freight can be transported by rail, trucks, or a combination of transportation modes. Transportation by ship and water-craft is inexpensive compared to commercial and cargo aircraft; however, it is slower and terminates at seaports. As reported by the United Nations Development Programme (UNDP, 2011), there are certain remote rural areas in Malaysia where people are facing transportation difficulties due to the lack of road infrastructure. These are areas in which hybrid airships, as well as interisland transport, could be used.

Tourism Needs

Tourism is a main contributor to the Malaysian economy. Major attractions for tourists are the islands, including Langkawi, Pangkor, Tioman, and Redang. Kuala Lumpur is the central city for tourists, and most of them desire direct transportation to the famous islands of Malaysia (Hamzah & Hampton, 2013). Hybrid buoyant aircraft would be a potential aviation market for such traveling passengers whose basic aim is tourism. The hybrid buoyant aircraft would not only transport the tourists, but also contribute to the GDP of Malaysia. The geographical locations of the islands are shown in Figure 3, and aerial distance from Kuala Lumpur to these islands is shown in Table 1. These distances would be of assistance in defining the design constraints for hybrid buoyant aircraft. This table shows that the longest distance is to Langkawi, one of the attractive islands for tourists. Malaysia is not on the coastline of the Indian or Pacific Ocean; it forms a group of islands. Malaysia consists of West Malaysia and East Malaysia, which are 750 km apart.

Agricultural Needs

It is well known that palm oil, rubber, rice, timber, coconuts, pepper, cocoa, and subsistence crops are Malaysia's main agricultural products. As reported by the Arshad & Ghaffar, 1988, Malaysia is the world's fifth largest

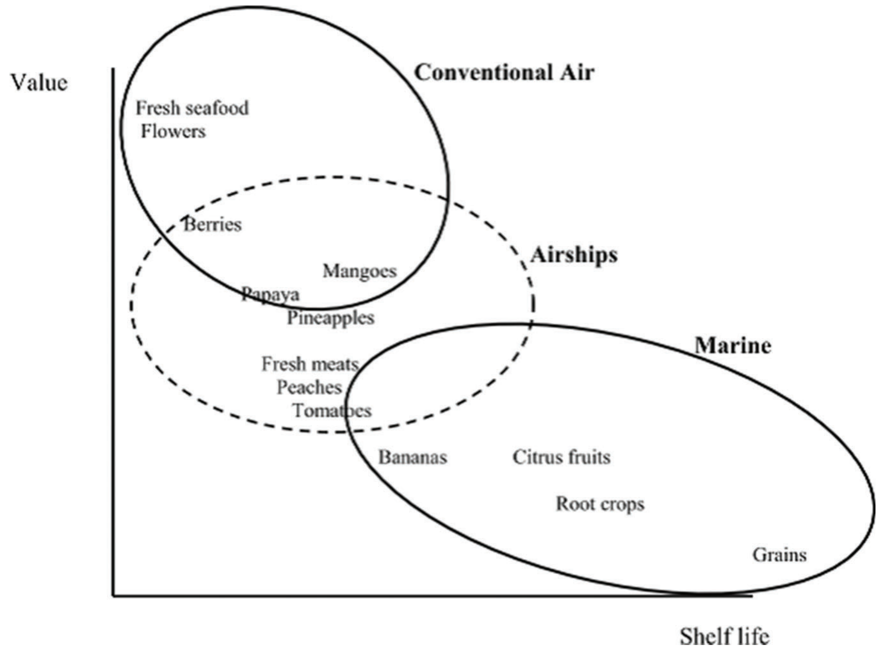


Figure 4. Value, shelf life, and dominant transport modes in intercontinental movements of foodstuffs and ornamentals (Prentice, Richard, Beilock, & Phillips, 2005). Reprinted with permission.

producer of pepper, the world's second largest producer of palm oil, and Asia's fourth largest cocoa grinder. Pepper is one of the key exports of Sarawak (East Malaysia), as the tropical climate of this area is more suitable for its cultivation. Sarawak pepper, both black and white, specifically is renowned internationally for its unique flavor. Malaysia is the fifth largest pepper exporter in the world (Kiong, Rahim, & Shamsudin, 2010), and changes in the export supply of pepper would definitely affect the income levels of farmers. At present, these agricultural products do not have an inexpensive or fast freight mode comparable to aircraft or ships (Haque et al., 2014a). We mentioned earlier that Professor Barry Prentice strongly believes that fresh fruits and vegetables will be the largest single cargo category carried by airships when this technology finally reaches full commercialization (Prentice, Beilock, & Phillips, 2004). For further elaboration, see Figure 4, which shows different modes of transportation. Perishable goods, such as flowers and fresh seafood, can be transported by airships, along with the other products like fresh meats, medium-valued tropical fruits, grains, and coal. Potential usage of the airship is shown in Figure 4 with the dashed circle. It splits the difference with other slower and faster modes of transportation. In line with this proposed model, the concept of using hybrid buoyant aircraft for carrying the agricultural products would be useful. Moreover, by taking advantage of a huge volume of hybrid aircraft/airships, export products can also be transported from remote areas of East Malaysia that have an insufficient ground transportation network. In this way, transportation costs can be shared by using hybrid aircraft. Lau and colleagues (2013) mentioned that at present, for every Malaysian ringgit increase in the import of food, exports of food increase by \$0.803. So the export rate is higher than the import rate. More investments are coming to turn Sarawak into a new "rice bowl" for the nation. Transportation between West Malaysia and other parts of Malaysia for agricultural products like pineapple, rice, pepper, etc., is one of the potential markets for products that require more space; hence, more volume is required as compared with its mass.

Business Travel

Two- to four-seater aircraft are used in the business community for short visits. These aircraft usually fly at 5 km with an average cruise speed of 250 km/hr. The airship is found to be competitive with cruises for short distances (Collozza & Dolce, 2005). Thus, there is another market where hybrid buoyant aircraft can be competitive with the existing fleet of smaller aircraft (Table 1), but with a compromise in terms of less cruise speed. The idea of replacing the commuter type aircraft with airships in Japan was proposed by Hiroyuki (Watanabe, 2009). Advantages of hybrid buoyant aircraft—namely less infrastructure, shorter runways, and less fuel consumed compared to aircraft—can be explored if we have a realistic dataset of their aerodynamic and performance parameters. This can only be achieved if a hybrid aircraft is first designed at a conceptual level and then its performance parameters are compared with those of existing short-range aircraft. A list of main parameters is populated below in Table 2.

Today, cost and time are important resources for everyone. Different modes of transport are available, and due to

Table 2
Specifications of short-range aircraft.

	A-1C Husky	Grumman American AA-5	Cessna 172R	Maule M-7-235
Crew	1	1	1	1
Capacity	1	3	3	4
Wingspan (m)	10.82	9.6	11.00	10.21
Wing area (m^2)	17.0	13	16.2	15.6
Max takeoff weight (kg)	998	1,090	1,111	1,134
Maximum speed (km/hr)	233	265	302	273
Cruise speed (km/hr)	225	224	226	265
Range (km)	1,287	1,270	1,289	1,610
Service ceiling (m)	6,096	4,200	4,100	6,096
POWER plant	Lycoming O-360-A1P (180 hp)	Lycoming O-360-A4K (180 hp)	Lycoming IO-360-L2A (160 hp)	Lycoming IO-540-W (235 hp)

high fuel prices, the transportation cost to reach a destination in minimal time is increasing, with additional penalty on emissions per capita. This initial market analysis indicates that there exists a market gap where hybrid aircraft would have a reasonable advantage over other two-to-four-seater STOL aircraft. In sum, the identified market gap for an alternate mode of transportation should be explored further by considering the option of replacing the existing fleet of STOL aircraft with more environmentally friendly hybrid buoyant aircraft. Another research objective of the present work is the combination of the presented market needs with the political, social, economic, and technological features that can affect the constraints of developing such a buoyant vehicle.

PEST Analysis

If we are thinking from a client's perspective, time and comfort are two key factors. The same is also true from the operator's perspective. Aviation businesses need to avoid making any major decisions to launch hybrid buoyant aircraft before understanding all socioeconomic conditions. Efforts were made in the present study to obtain firsthand knowledge through PEST analysis, and they will perhaps contribute to a greater success rate for aviation businesses. Some of the PEST factors that may impact the development of STOL aircraft include the following:

Political Factors

- Passenger safety is paramount, and, due to certain aircraft accidents in the past, the political establishment may have to ensure strict compliance with regulations for flight operations. Events such as the Malaysian Airlines disappearance, followed by an aircraft destroyed in midair, have adversely affected aviation customers. - In this regard, the biggest challenge is the improvement of logistics operations. This issue is predominant in urban areas, because they have fewer arrivals in comparison to rural areas, where the majority of STOL ports are. For example, the STOL airports east of Malaysia, such as Marudi and Lawas, service only two flights per week. Attractive investments in improving the infrastructure and services at existing STOL airports could create space for hybrid buoyant aircraft.
- Since tourism has a clear relationship with the development of hybrid buoyant aircraft, the government could provide various incentives to the tourism industry to familiarize people with the benefits of traveling on such aircraft to nearby tourist destinations of the region, as well as for city center transfer.
- Competitors for STOL aircraft in the aviation market of Malaysia are quite limited. Because of this, new carriers who will have fleets of hybrid buoyant aircraft may find a place in an already identified market. Hence, in the future STOL airports could be used by new carriers with fleets of hybrid buoyant aircraft.
- Hybrid buoyant aircraft can takeoff and land from the ground. The infrastructure of such a runway network will be required. There are a number of STOL airports already in Sarawak (East Malaysia): namely, Mulu, Lawas, Marudi, Mukah, Kapit, Belaga, Bario, Long Seridan, Long Lellang, Long Semado, Bakelalan, Long Banga, and Long Akah (Malaysia Airports Holdings Berhad, 2014). STOL airports are usually not as congested as other large airports. Hybrid buoyant aircraft can be a useful source of transportation between these STOL airports. The locations of STOL airports are extremely important for hybrid aircraft for tourism operations.

Economic Factors

- Emerging nations in Asia have maintained high economic growth rates. The Malaysian region is unique in that it has high temperatures, high humidity climate, high population density, and large numbers of islands with vast availability of agricultural lands. However, the transportation of agricultural products is mostly limited to seaships.
- The hybrid buoyant type aircraft offers a low-cost solution to meet the needs and requirements of the

tourism industry, with outstanding performance. The multipurpose aircraft require only minimal tools and manpower to undergo a mission.
- Airlines, including low-cost airlines, are facing economic strain due to high fuel prices and maintenance costs. Moreover, the effective material cost for raw materials has increased after implementation of a general sales tax by the government. Also, it is crucial to control transportation costs for agricultural products, which require more volume.
- The potential operators may have to absorb the cost of the first prototype as per their required payload requirements.

Social Factors

- Passenger profiles have changed as people are now more focused on time. Not only business-class passengers are time conscious, but so are middle-class customers. Some people do not want to have a layover stop or change planes and want travel directly to the destination islands. This presents an opportunity to adopt travel on hybrid buoyant aircraft at a lower fare.
- The development of infrastructure for hybrid buoyant aircraft would bring more jobs for people in contact with the aviation industry. Specifically, it would be an opportunity for the local people residing near STOL ports.
- Increased population on the islands has led to a boom in demand for medical supplies, cinchona, tea, coffee, and fresh fruits and vegetables. Seaships are usually slow and are at the mercy of the weather at sea. Hybrid buoyant aircraft is an alternative mode of transportation for such goods, especially for the days when there are floods.
- With more focus on climate change due to carbon footprint, the climate-conscious passenger would prefer to travel on an aircraft in which fuel consumption is almost half, and hence makes less of an impact on the environment.

Technological Factors

- Technological advances always help aviation companies use resources more efficiently. Conventional airships are made of fabrics like vectron, which adds a great deal of weight with a ring-type structure made up of lightweight metal such as aluminum. Lightweight materials, such as composites, can be used for hybrid buoyant aircraft, hence providing strength with no additional weight penalty.
- With intense competition in the airline industry, the latest safety technology needs to be adopted. In the case of hybrid buoyant aircraft, lighter-than-air (LTA) gas can act as a safety jacket in an emergency, as 50 percent of gross takeoff mass is always balanced by the LTA gas. Additionally, technological advancements such as the introduction of the gondola design as a ship can both be safe and protect passengers in the event of catastrophic failure in sea travel.
- A large fuel tank could be housed in the voluminous fuselage of hybrid buoyant aircraft, which in return would provide greater flight time and could act as a reservoir for reserved fuel. Therefore, potential companies should be aware of the latest technologies for pumping fuel from the hull and should not be left out of the technological development process.
- Given the selection of Malaysia's islands as the area in focus, the location of existing STOL airports can be useful for the design of mission profiles of hybrid buoyant aircraft, which promises to reduce fuel consumption and to supply the cargo at specified STOL airports with minimum ground handling.
- Hybrid buoyant aircraft should be designed in such a way that they fulfill the gust load requirement determined by FAA standards. This would help in the ground handling of such aircraft for surface winds, whose maximum value is about 16 knots, as determined by the Malaysian metrological survey (UNDP, 2010).

The PEST analysis results for hybrid buoyant aircraft have highlighted important factors. Additionally, increasing concerns being raised about the environmental impact of aviation can be decreased by utilizing such aircraft. The existing STOL airports on different islands would require aviation security and firefighting crews. These aircraft would be more economical than existing STOL aircraft. Therefore, customers with lower incomes could enjoy the recreational short-distance air travel in such hybrid buoyant vehicles. Specifically, the increased popularity of spending holidays on the Malaysian islands can lead to a boom in demand for hybrid buoyant aircraft. Due to obvious advantages of hybrid buoyant aircraft, it is anticipated that with time the design of a hybrid buoyant aircraft will mature to meet the target market at low operational cost and with ease of operation. Nonetheless, the findings of the PEST analysis of hybrid buoyant aircraft can be utilized in the future to identify its internal strengths and weaknesses, as well as its external opportunities and threats (SWOT) analysis as PEST always identifies SWOT factors, which are perhaps common in both techniques.

This conceptual research paper utilizes the PEST analysis on the commercialization of hybrid buoyant aircraft. Airships, either conventional or hybrid, have voluminous space for carrying bulky agricultural products which have less weight but large volume. However, they have never been used for transportation of such goods due to the ground handling and lack of required infrastructure. However, using hybrid buoyant aircraft for that purpose could be explored in the future. Hybrid buoyant aircraft are mostly in the design and development phase, and little quantitative data is available that can assist in the PEST analysis of such aircraft. So it is nearly impossible to develop a theoretical framework at this stage. Moreover, comparative studies to evaluate the impact of environmental, economic, social, and technological aspects of developing hybrid buoyant aircraft models in other regions and countries are also recommended.

Regulations/Certification Challenges

As per Federal Aviation Administration (FAA) requirements, all general aviation (GA) aircraft have to comply with strict regulatory standards. The term GA is valid for all lighter-than-air (LTA) aircraft, such as airships, and heavier-than-air (HTA) aircraft (Pretience et al., 2005). According to Khandelwal (2012), for airships there is no design standard available and the only references available are the FAA criteria that define the acceptable airworthiness requirements, applicable to non-rigid, near-equilibrium conventional airships and changes to those certificates under Part 21.17(b) of the Federal Aviation Regulations Regulation (2013). GA aircraft are certified under 14 CFR Part 23, and, depending on the weight category and number of passengers, airplane category can be defined (Gudmundsson, 2013). For the purpose of the initial design exercise at a conceptual level, both of these standards can be followed in tandem for hybrid buoyant aircraft.

Stability criteria for HB aircraft are subject to the category of such aircraft under which they can be certified. The hull is the common component in airships and HB aircraft. From a stability point of view, similar to the fuselage of an aircraft, the hull of an airship will always have a destabilizing effect (Haque et al., 2014b). The existing FAA document number FAA-P-8110-2 is not a Federal Aviation Regulation similar to the design criteria of aircraft. Rather, it is a set of requirements that ensure safety for airships (Carichner & Nicolai, 2013). It is assumed that the existing airworthiness standards of aircraft will establish a starting point to define the design requirements for HB aircraft. For instance, when clearance is given by an air traffic controller (ATC) to land, a two-seater HB aircraft would descend to ground level for landing, and it would land within a specified distance as per the certification requirement of a 50 ft obstacle clearance (Gudmundsson, 2013). It is important to note that the Department of Civil Aviation Authority (DCA) Malaysia perhaps follows the FAA; it is, in fact, why we discuss challenges from the perspective of the FAA.

In the future, it is likely that people working in academia and different aviation industries will design and develop many of such aircraft to fill the gaps of transportation needs. Moreover, the fleet of STOL aircraft could be replaced by hybrid aircraft to meet the future challenges of green transport. A robust simulation analysis, comparing the performance of currently operating aircraft and hybrid buoyant aircraft, would strengthen the possible adoption of such aircraft on some routes in Malaysia. Our recommendation is that now is the right time to carry out more research for design and development of such aircraft. A good starting point is to explore the option of replacing the existing fleets of STOL aircraft, with the same payload category, with hybrid buoyant aircraft.

Conclusion

This work examines the technological improvements and the economic feasibility of using hybrid buoyant aircraft for defined niches. Recent increases in fuel costs, congestion in the present airports, and other environmental restrictions, as well as the prospect of high airfares, limit the travel of the average person. A hybrid buoyant aircraft could provide relief to people enjoying recreational trips to the islands. Such aircraft have the potential to takeoff and land with short runway requirements. Moreover, regulatory decisions at the governmental level can impact the demand for such STOL aircraft. Aviation regulations—like those defined by the FAA, and people working in academia and the aviation industry—can define new airworthiness standards and the availability of airspace for hybrid buoyant aircraft in years to come. Research mapping or conceptual frameworks that indicate the impact of market analysis and PEST analysis on the development of buoyant aircraft are recommended for future research.

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