Collaborative Robots and Autonomous Vehicles to Improve Airline Operations and Maintain Sustainability in the Sultanate of Oman's Goal of Reaching Net Zero Emissions by 2050.

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Abstract
This paper will provide insight into the new method in the airline sector, which is net zero emissions. This concept has become of popular in the airline sector as it attracts airline authorities, and they have started to implement some features that can lead to maintaining sustainability in this business. The topic of reaching net zero emissions is a global mandate, as research has shown the impact that operations have on the whole deterioration of the ozone layer, climatic change, and the impact all these have in the long run. There are numerous ways in which corporations have come up with concepts that have been transformational in their operations. This research is narrowed down to airport operations, which are relatively large contributors to emissions. Implementing such a vision will support sustainability and improve innovation in this field. The adaptation of such concepts has already been tested, and the results are evident, which gives a positive outlook on the operations and the main goal of Oman to reduce emissions by 2050. This paper will focus on ground operations and how they can support the airline industry in reaching its goal at the time. This paper is based on a theoretical analysis of previous research on the prediction of future success in implementation. It covers all the ground operations, from baggage handling and staff movement into the airport to maintenance teams from either airline staff or airport staff, as well as passenger movements from and to the airplanes. The focus of this paper is to implement all those movements sustainably and maintain all possibilities for using friendly environmental services at this level.
Keywords:-*Sustainability, last mile, electronic vehicles, operations, and customer behavior.*

1. Introduction

Autonomous Vehicle handling has been in the research area in the past few decades as a move to improve the efficiency in logistics and operations. This has not only been the topic in the last decades but has propelled organizations to probe into this novel invention of easier handling systems that enhance efficiency in airport operations. Globally, the focus is to reduce CO2 and maintain sustainability in different fields, and this paper focuses on the airline sector to reduce the producing emissions and meet the airport's vision of reaching zero emissions by 2050. This paper usesthe document analytical method as the previous studies in the same field. The focus was on daily operations in the airport and finding solutions to reduce the use of traditional methods of movement of staff and equipment in the airport and raising the awareness of the passengers so they can support the vision of international airline authorities. The main areas targeted in this paper in the airport arelast-mile delivery, baggage handling, maintenance team, and cabin crew teams, as they have the highest frequency of movements in the airport to the aircraft and from the aircraft, as well as the passengers to be aligned with the vision.

A race of technological innovation, integration, and transformation pushes industries and businesses from the general to digital and smart handling. The innovation is crucial for ports as well, as we operate in a global village, it is paramount to notice the movement of goods from one place to another. It is inevitable that Oman receives products from other countries, thus making port handling strategies that are cost-effective and advocate for sustainable measures. Demand for smart ports is driven by three key elements: first, outstanding operational performance; second, challenging external

markets, third,new opportunities for business. Autonomous vehicles are being driven by other developments, such as autonomous ships, which are on the rise in countries such as China, and other ports are already shifting to smart technology, such as the Suaz Carnal. Amongst many reasons that can give purpose for the shift, Suaz Carnal which can purport Oman to the adoption of the same are:

1. Higher commercial return – the cost of goods and services would be affected by the effectiveness of maritime transportation and its administration at the SC.
2. Transformation of Industries- The management of ports is delegated to several government agencies in support of operations in the ports.
3. Transformation that is carried out automatically- collect for sample operation, notably during pandemic calamities.
4. Ecologically wise – clean and clear environment

With these proposals, transparency is enhanced in operations and more efficiency, thereby reducing costs and aiding in the achievement of sustainability goals where emissions are one of these. These things can be implemented in the airline sector as well by implementing technology in the field.

2. Problem Statements

In 2021 International Air Transport Association (IATA) announced its commitment to reduce CO2 gradually and reach net zero emissions by 2050 (IATA, 2022). Airlines have put a lot of effort toward environmental protection and meeting the net zero emissions target (Oakleaf et al., 2022; Abdullah et al., 2016). However, more effort is still required to ensure the vision can be moved forward. This study focuses on finding the gaps and supporting this sector to move forward and record progress in this field.

Customer awareness about some of the green initiatives implemented by airlines is very weak(Babakhani et al., 2017; Eslaminassab & Ehmer, 2022),and the staff doesn't believe in it(Sricharoenpramong, 2018). Finding solutions and making sure the awareness has been delivered to the customer will support meeting this goal, which is what we hope to gain at the end of this paper.

3. Methodology

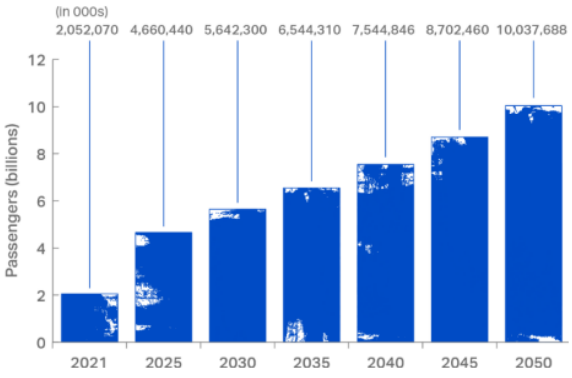
The researcher uses the descriptive methodology in this paper, refers to previous studies conducted in the same fields, and compares what can be implemented in the Sultanate of Oman airports. Analyzing previous study outcomes and findings and benefiting from them in the same area will save the researchers money and time because almost all global airports run the same operations; such research does not requiredistributing questionnaires and conducting interviews with airport management or passengers.Also, the researcher analyzed 388 valid data collected using a self-administrative questionnaire to understand the relationship between green people and purchase behavior – particularly carbon offset behaviors.

4. Literature Review

4.1 SUSTAINABILITY AT THE AIRPORT

The airport is a critical part of the aviation industry as it accommodates domestic and international travelers (Ramakrishnan et al., 2022). Airport operations have increased dramatically to accommodate the massive increase in air travel (Liu& Liao, 2018). Although there was a significant drop in air travelers due to the COVID-19 pandemic, IATA expects air travel to pick up and increase from around 2 billion in 2021 to about 10 billion in 2050 (IATA, 2022). Graph 1 shows the expected increase in air travel from 2021 to 2050.

Figure 1: Current & Forecasted Air Transport Passenger Number, 2021 – 2050



Source: IATA

Airports will be affected directly by the expected increase in global air travel. Airport operations will increase to handle the traffic, and new infrastructure may also be required (Dray, 2020).

The aviation industry negatively affects the environment by producing around 2% of carbon dioxide (CO2) emissions (ICAO, 2022). Currently, there is a high effort to reduce the environmental impact globally. One of the main commitments to moving toward sustainability is to achieve net zero emissions (Rogelj et al., 2021). Airports can effectively reduce the industry's environmental impact and support the net-zero emission target by becoming more sustainable. Santa etal. (2020) defined airport sustainability as a comprehensive approach that considers economic feasibility, operational efficiency, natural resource protection, and social responsibility. Some of the elements that are considered by airports as part of their sustainability program are noise and emissionreduction, water andwastemanagement, and diversity protection (Gómez et al., 2019).

Oman's government is putting a high effort into reducing the environmental impact of climate change.The country is planning to reduce greenhouse gases (GHGs) to 7% by 2030 and produce around 30% of its electricity from renewable energy by 2040 (Oman Government, 2021). Oman airports support the government's objective to move toward sustainability by reducing their impact on air and soil, introducing environmentally friendly technologies, and implementing new procedures that support sustainability (Oman Airports, 2022a & 2022b). As Oman airports are committed to protecting the environment and supporting the government and airlines' environmental targets, more green initiatives should be implemented at the airports. Electrical robots and autonomous vehicles are effective options for Oman airports to be more sustainable (Hájnik et al., 2021).

4.2 LAST MILE SERVICES

Last-mile service in an airline is associated with a variety of activities, including baggage handling from airplane to airplane and cabin crew movements. Below will explain those points in detail:

4.2.1 BAGGAGE HANDLING

Such activity occurs frequently at airports(Lodewijks et al., 2021). Some airports have already implemented systematic and environmental solutions for it, but not fully, as in some stages (Seghezzi et al., 2021), they still use fuel vehicles or physical load to carry out the passengers' bags to the terminal(Rezaei et al., 2018). At this point, the emphasis is on making it a fully sustainable, environmentally friendly solution that will increase its zero emissions(Seghezzi et al., 2021).

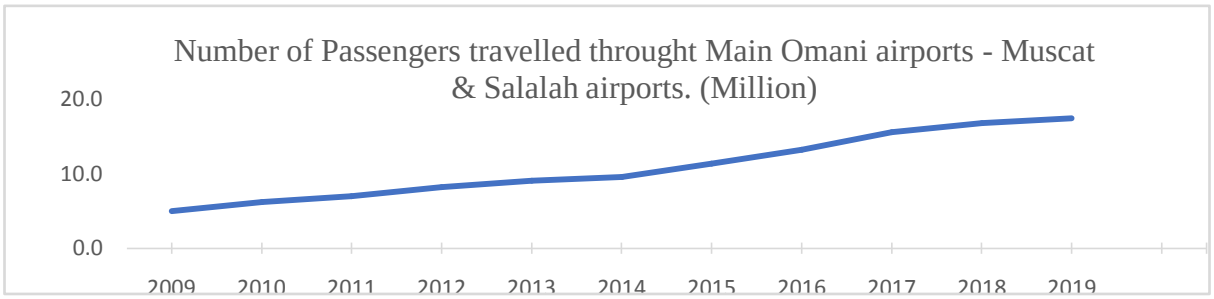
Using a convert built at the airport to collect the bags and link them directly to the airplane will reduce the need for vehicles outside the terminals to move the bags either from the aircraft or to it(Lodewijks et al., 2021). Such a system is available in most Oman airports, and they use it for most of the aircraft(Li et al., 2018), but any passenger can still see some aircraft using the old method at the airport, especially during landing or takeoff. All airlines must use technology to reduce emissions. Using the traditional method cannot support the airline or airport in reaching such a goal.

4.2.2 CABIN CREW MOVEMENTS

According to data from the International Air Transportation Association (IATA), between 2013 and 2017, the number of passengers traveling internationally by air will increase at an average annual growth rate of 5.4 percent. This is in line with the World Tourism Organization's 2014

forecast, which stated that 5 to 6 percent more people would be traveling internationally(Sricharoenpramong, 2018).From that, you can imagine how many air crews will serve each aircraft and all the transportation required for them. If we assume that the staff will move from the house to the airport by using a vehicle, and when they reach the destination, they will use a crew bus, which might use vehicles that produce CO2. For these millions of passengers, they will require a huge number of staff to serve them, and if the airport management provides sustainable solutions for the staff, that will reduce the impact on the environment and, for a long time, will maintain a zero-emission goal.

Figure 2: Passengers Number at Muscat & Salalah Airports in Oman (2009-2019) in Million



Source: Oman National Center for Statistics and Information (NCSI)

5. Daily Operation In The Airport

Most international airports are busy most of the time(Rajapaksha& Jayasuriya, 2020). During flight arrivals and departures, passengers can be seen in all areas of the airport. If they do have a connection flight, they need to catch it before the gates are closed. Inside the terminals you will not see any equipment producing CO2, but outside of the terminals there are a lot of activities that produce CO2(Lodewijks et al., 2021). Activities are around the clock and all year round, which has a negative impact on the environment(Rajapaksha& Jayasuriya, 2020). Implementing solutions that can reduce the production of CO2 will enhance the airport and airline's ability to meet (Doctor et al., 2022).

At the same time, daily operations cannot be stopped, otherwise, it will impact the business and people. But implementing a solution that reduces unnecessary vehicles will lead to good progress toward meeting the goal(Di Mascio& Moretti, 2019). Muscat airport implements pipe fueling for airplanes, which stops the movement of fuel tanks and impacts the airport positively from all perspectives. As there is no fuel truck movement in the runway area and on roads, you cannot see the vehicle, which helps in reducing road junctions, all of which reduce CO2.

5.1 MAINTENANCE TEAM AND STAFF MOVEMENTS

Every single place in the airport needs to be inspected or maintained to make sure everything is in place(Cunha et al., 2021). For sure, such an activity will require many people and a lot of involvement from the maintenance team to meet the airport standards. Such activity will require vehicles to move around and check all facilities, such as runway, terminal buildings, staff offices, catering buildings, waste management, fuel stations, fire stations, duty-free shops, and parking area(de Moura et al., 2021). As you can see, there are many things to be monitored to make sure business will run smoothly(Di Mascio& Moretti, 2019). All of that will need vehicles to move around, and those vehicles produce a lot of CO2. Implementing environmental solutions for staff to move around will reduce that and will support the airline and airport to meet the vision on time(de Moura et al., 2021).

6. Customer Behavior

There is high pressure for the tourism industry (including the airports) to move toward sustainability. The pressure is driven by local government regulations, international environmental requirements, and changes in passengers' behaviors (Han et al., 2020). In addition, airports are becoming sustainable to reduce costs and create a green image (Bąk, 2018). Passengers' positive attitude toward an airport and their willingness to purchase or use its product can enhance the airport's competitive advantages (Han et al., 2019). Thus, understanding factors affecting passengers' green behaviors is essential for airports as it assists them in creating the right marketing strategy (Wijekoon& Sabri, 2021). Increasing passenger's environmental awareness through green promotion and eco-labeling can be used by airports to improve passengers' usage of green products.

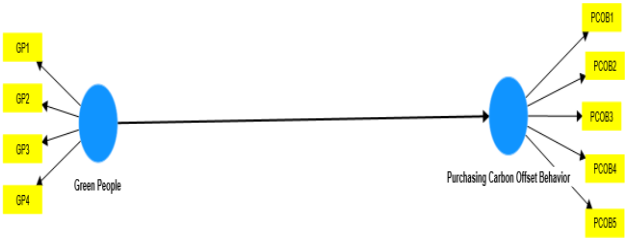
Green promotion is a critical element of the marketing mix that can influence passengers' green behaviors (Rathod & Vaidya, 2019). It is the process of informing consumers about a firm's green products and persuading them to purchase

the products (Mahmoud, 2018). Green promotion is a compulsory strategy for green companies; it introduces new green products or reminds consumers about existing products (Bathmathan & Rajadurai, 2019). Social media, posters, and videos are some tools for an effective promotion campaign (Karunarathna et al., 2020). Eco-labeling is another effective way to create awareness about green products without affecting freedom of choice (Yokessa & Maarette, 2019). It is defined as environmental labels or certifications used to differentiate green products (Tippett et al., 2020). It provides passengers with related ecological information and allows them to compare with other options (Baumeister, 2020).

Omani airports can increase passengers' and employees' awareness of their sustainability plans (including using electric vehicles) through green promotion and eco-labeling. The two techniques positively affect consumers' green behaviors (Karunarathna et al., 2020; Rizqiyana & Wahyono, 2020).

7. Impact of Green People on Customer Behavior:

People are the core asset of an organization as they are the main driver for its success and sustainability. Siripipatthanakul & Chana (2021) argued that people are all the actors who participate in offering a service. Green people are sensitive to the environment and practice green in their daily life (Dzulkarnain el al., 2019; Sundarm, 2020). This research evaluated the impact of green people on airline passengers' behaviors by looking into carbo-offsetting behavior. The data was collected from 480 Omani passengers; however, only 388 data were valid and used for the analysis. Based on the analysis result, green people directly and significantly impact customer green behaviors (Passengers' carbon offset behaviors). Thus, airports and airline shall put high focus on their people by encouraging environmental practices in the workplace and when interacting with customers. The framework and the measurement items are:



❖ **Green People:**

GP51: I will purchase Carbon Offset if the airline employees have high awareness about reducing carbon emissions.

GP2: I will purchase Carbon Offset if the airline employees educate passengers about reducing carbon emissions.

GP3: I will purchase Carbon Offset if the airline employees practice green in the workplace.

GP4: I will purchase Carbon Offset if the airline employees have good knowledge of the environmental issues.

❖ **Purchasing Carbon Offset Behavior:**

PCOB1: I am willing to participate in the airline carbon offset policy

PCOB2: I will pay for carbon offset on my next flight

PCOB3: I will purchase carbon offset for the ecological reason

PCOB4: When booking an airline ticket, I will purchase the one that has a carbon offset

PCOB5: I would be willing to make personal sacrifices to reduce carbon emissions even though the immediate results may not seem significant.

8. Tam Theory

The Technology Acceptance Model (TAM) is a theoretical framework used to understand how users perceive and adopt new technologies. In the context of collaborative robots and autonomous vehicles in the airline industry, the TAM can provide insights into the factors that influence the acceptance and adoption of these technologies to improve operations and maintain sustainability.

Autonomous vehicles can be used to transport passengers and cargo within airport premises. Such technology has the potential to improve efficiency, safety, and sustainability in airline operations.According to the TAM, users' perception of the usefulness and ease of use of technology is a key determinant of its acceptance and adoption. In the case of collaborative robots

and autonomous vehicles in the airline industry, the following factors may influence their adoption:

- **Perceived usefulness**: Users may perceive collaborative robots and autonomous vehicles as useful if they can help reduce manual labor, increase efficiency, and improve safety in airline operations.
- **Perceived ease of use:** Employees and users may be more likely to adopt these technologies if they are easy to use and require minimal training. Autonomous vehicles can be designed with user-friendly interfaces and intuitive controls to make them easier to operate.
- **Perceived compatibility**: Users may be more likely to adopt these technologies if they are compatible with existing systems and workflows.
- **Perceived trust**: Users may be more likely to adopt these technologies if they trust that they are safe and reliable. Autonomous vehicles can be designed with safety features such as collision detection and avoidance systems to improve users' trust in their capabilities.
- **Social influence**: Users may be influenced by the opinions and experiences of their peers and colleagues. Therefore, it is important to involve stakeholders from different levels of the organization in the decision-making process to ensure that their concerns and feedback are taken into account.

By considering these factors, airline operators in the Sultanate of Oman can promote the adoption of collaborative robots and autonomous vehicles to improve their operations and achieve their sustainability goals. Using these technologies can help reduce carbon emissions, improve energy efficiency, and enhance overall sustainability in the airline industry in Oman and globally.

9. Discussion Of Findings

Small things matter. In this study, we focused on the small things that can impact meeting the goal of zero emissions. Using the convert built to move all bags from the aircraft to the terminal and vice versa will stop producing CO2 in this activity, which will support reaching zero emissions. This is due to the fact that there is a high influx of travelers, and this corresponds to the baggage being moved post covid. Instead of using the traditional methods of trucks, which have harmful emissions from points a-b, autonomous vehicles can be incorporated. This includes the movement of staff in the airport, either cabin crew or operation and maintenance team, if they are willing to use a sustainable solution and produce zero carbon emissions that will accelerate meeting the vision of zero emissions.

Airports are always busy and crowded with passengers, which requires monitoring and making sure everything is in place and operations run smoothly daily. Oman airports are doing their best to monitor the sustainability in place and meet the governmental and social goals.

10. Conclusions

Climate change has been recognized as a significant issue that requires immediate action. Net zero emission targets by airlines and airport industries show a clear commitment toward sustainability in those two sectors. Oman airports have introduced several initiatives to reduce CO2 emissions and support the Oman government's target to reduce GHGs by 7% by 2030 and reach net-zero by 2050. However, more initiatives are still required to reach net zero emissions. Oman airports can reduce CO2 by using electric vehicles for all airport transportation and staff movements. Also, there should be a high focus on involving passengers and employees in green initiatives by running environmental promotional campaigns and using eco-labeling. All that was examined in different regions and businesses and reflects the positive improvement in reducing CO2.

11. Future Studies

Passenger involvement in the airport and airline green initiatives is vital. However, many researchers argue that although consumers show a high attitude toward protecting the environment, their current green behavior is still low (Nguyen et al., 2019; Rajadurai et al., 2018; Rausch & Kopplin, 2021). This area can be evaluated for future studies to identify the causes of this gap in the aviation industry, specifically from the airport side. Also, it will assist in understanding the factors affecting passenger green behaviors.

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