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AIR DRONE AS AN ALTERNATIVE TO SUPPLY BOATS IN SEA PORTS



R.Prasanna Kumar
Dr. V Ajantha Devi

The maritime mode of cargo transfer is an age-old practice of trade between different countries. The efficient turnaround of ships' arrivals to departure depends upon various parameters, including the availability of berths and weather conditions. The vessels stay in the port area at anchorage locations because of non-supportive weather or lack of berths. Due to the nature of cargo loaded on the vessel, the designated anchorage areas are located away from each other for different types of ships. On the seaport requirements, almost in all locations, large vessels' supply needs are fulfilled by conventional supply boats. These supply boats transit between the shore and ships. As we know, the boats use conventional IC engines for their propulsion, and it is not a variable that depends upon the cargo capacity. The efficiency of this mode of transport is poor. Added to the above, the emissions due to diesel fuel used for this purpose affect the environment in the sea ports.

On the other hand, with today's technological advancements and widespread acceptance in the industry, cargo transfer for short distances is done with drones on land. Applying this new invention in the maritime industry, in few ports, air drone transfer is used for small consignment sizes. The main advantage of using drones for supply is that it eliminates the need for humans to travel on water. When we do the close-up view of this technology, the benefit of the energy saving has not been a huge difference from conventional supply boat methods. The path and the distance travelled by drone in the air and supply boat in the water are different, and this is the main contributor to the efficient operation of these vehicles. The objective of this paper is to demonstrate a hybrid

method of drone and supply boat use in small distances and for small-sized consignment transfers between shore and ship.

Keywords: Air Drone, Remote operation, cargo transfer, supply boat, Energy efficiency

1. INTRODUCTION

Several logistics companies, e-commerce retailers, tech companies, and startups have all conducted extensive research into the ability of drones [1] to make autonomous vehicles deliveries. There has been numerous drone - based delivery prototypes and operational modes investigated, some of which have not yet been used. Drones are likely to be less expensive and consume fewer energy per unit of distance travelled than boats since they are much smaller than launch boats and because drone - based delivery technology have evolved dramatically. Furthermore, given that the bulk of delivery drones run on electricity, which may be generated using more environmentally friendly energy sources., they might emit less greenhouse gas per unit of energy than traditional diesel boats. Drones may not be cost-effective or environmentally friendly due to their limited cargo capacity, the need for additional depots or charging stations to increase their short flight ranges, the labour required to operate them. Additionally, a number of studies have found that there are substantial questions regarding their effects on the environment [2-5].

Deliveries from the shore to the ship have been a significant component of the shipping industry ever since it began. Every day around the world, spare parts, medical supplies, and money are just a few examples that are transported to ships [6]. Deliveries have historically been made by launch boats for ships that do not frequent ports and involve a number of expenses, including manpower and fuel costs as well as preparation and travel time,

customs clearance, transfer from launch boat to vessel [7, 8].

Unmanned aerial vehicles (UAVs), also known as drones, have begun to enter the shipping industry as a more effective and environmentally friendly alternative due to the high demand for shore-to-ship deliveries around the world and strict environmental regulations [9]. Many industries are turning to UAVs because of their accessibility, speed, and low operating costs compared to more conventional methods of transportation that require labour, according to the consulting firm [10].

Using a UAV certified for explosive environments, the shipping company Maersk claimed to have made the first delivery by UAV to a ship at sea in 2016. [11]. A project called Skyways, a partnership between the aerospace company Airbus and the ship agency Wilhelmsen, is one of the most recent and pertinent ones that the company has been working on since then to further investigate shore-to-ship solutions [12]. Singapore hosted the first commercial UAV delivery trial in the world, where supplies were delivered to a ship in port over the course of ten minutes [13].

While some studies indicate that, if used carefully, drone-based delivery could lower greenhouse gas (GHG) emissions and energy consumption [14, 15], others indicate that, in many situations, drones used for parcel delivery actually use as much energy as launch boats do [16 – 18].

2. REVIEW OF LITERATURE

Since its discovery, society has always depended on shipping for transportation by water, and it is now a key component of the global economy [19]. 90 percent of global trade is now carried out by shipping, which is also the most economical mode of transportation. Today, launch boats are one of the traditional ways to move cargo from the land to the ship [7]. These deliveries can be challenging and pricey, frequently costing \$1,000 USD or more on average [11].



Figure 1. Traditional Delivery by launch boat

Deliveries have historically been made by launch boats for ships that do not frequent ports and involve a number of expenses, including manpower and fuel costs as well as preparation and travel time, customs clearance, transfer from launch boat to vessel

2.1. Cost, Greenhouse Gases Emissions and Energy Consumption

Drone use for last-mile delivery costs and environmental impacts are also investigated. The most widely utilised functional units of analysis are a single delivery and a unit distance travelled. However, there are few available data on the lifespan emissions of drones [14, 18]. Studies carried out in various countries employ different databases. [20] uses data from Thailand and several nations, including the US, China, and Canada, to assess the environmental effects of drone delivery. [16] suggests a comprehensive energy consumption model for the drone delivery process. It also considers the environment in which it is functioning (wind). The energy usage of diesel boats operating out of the same depot and providing services to the same clients is then compared to that of drones. Because drone delivery consumes more energy than launch boat delivery, the results demonstrate that transitioning to a drone delivery system is not energy-efficiently advantageous.

2.2. Ship Categories

Different commercially used vessels come in a variety of sizes and shapes that are tailored to fit the intended cargo (International Chamber of Shipping). According to [21], the mission of a ship establishes the specific specifications and elements, such as the kind of cargo to be transported, the required speed, the operational range, or the distance to be covered. Additionally, it lists various ship types, including tankers, container ships, roll-on/roll-offs, passenger ships, and dry bulk. There are designated helicopter operations areas on each of these ship types, which can vary in size and location [22]. Given that the procedures will be similar to those for helicopters, these locations will probably be used for UAV shore-to-ship deliveries [23].

2.3. Areas of Marine Application

Inspections and surveys are one of the marine industry's many current uses for UAV technology, according to



Figure 2. Provides an example of a drones

the classification society DNV GL. These are primarily carried out in cargo holds, ballast and cargo tanks on ships, as well as in the structural elements of offshore installations. UAVs have been used in this area, according to some justifications, which include shorter preparation times and increased safety thanks to unmanned inspections. Compared to traditional surveys, this approach allows for high-resolution documentation and can be finished faster and with less expense. Monitoring of ships' sulphur emissions inside Emission Control Areas (ECA) is another use [24]. These ECA areas were created to reduce emissions of SOx and particulate matter, which is typically done by limiting the amount of sulphur in the fuel oils used onboard (International Maritime Organization).

The Danish Maritime Authority (2019) claims that specially made UAVs can help enforce these sulphur limits more effectively. The operator will receive information on the sulphur content of the air by means of special sensors that examine the air's composition as they pass over a ship in motion [25].

Shore-to-ship deliveries are a third application for UAV technology [23]. In addition to having the largest ship agency network in the world, Wilhelmsen has extensive experience arranging daily deliveries of cash, essential spare parts, and medical supplies to shipmasters around the globe [23]. Deliveries made by UAV rather than traditional launch boats would cost 90 percent less to make, pose fewer risks of injury, and have a smaller environmental impact.

3. DELIVERY METHODOLOGY

3.1. Conventional Delivery Strategy

The European Ship Suppliers' Organization claims that shipping is changing due to the need for faster cargo handling, imports, and exports, which has resulted in more



frequent port calls but less time spent in port. Higher demands on suppliers and deliveries are the result of this. Nowadays, some ships only conduct ship-to-ship transactions, leaving the ship with no choice but to have supplies delivered while at anchor.

According to [7], the operation of launch boats was most frequently utilised for shore-to-ship deliveries as shown in the **Figure 1**, and this process is as follows: The beginning of the delivery process involves receiving a customer inquiry, which is followed by an order confirmation. The customer is informed as the order is later prepared for delivery. The price for direct delivery to the vessel is given to the customer who requested it. The client must concur on the price before the process can move forward. Transportation plans are made, and the ship agent's contact information is obtained. When the agent is contacted, the delivery can be scheduled in accordance with anticipated arrival time and loading window availability.

Before any staff are allowed onboard the ship to finish the delivery, operations like anchoring may take some time, and immigration clearance must be completed. When the coordination process is complete, the agent plans the collection of the goods, and the transporter plans the movement of the goods from their warehouse to the loading port. After customs clearance, these items are loaded onto a launch boat. Upon arrival, the launch boat coordinates the delivery with the responsible Officer onboard after informing the vessel of the incoming cargo. The responsible officer signs and stamps the delivery order before returning with the launch boat and transporter after the goods have been transferred to the vessel. Sending the invoice to the client is the process's last step. Every day around the world, smaller launch boats are typically used to deliver supplies or cargo to ships at sea. The source cites Marius Johansen, Vice President,

Drone design	Delivery Operations	Environment
Drone weight	Payload weight	Air density
Number of rotors	Size of payload	Gravity
Size of rotors	Empty return	Wind conditions
Size of drone body	Fleet size and mix	Weather (rain, snow, etc.)
Battery weight	Single-/multi-stop drone trip	Ambient temperature
Battery energy capacity	Delivery mode (landing, tether, parachute)	Regulations
Size of battery	Area of service region	
Power transfer efficiency		
Maximum speed and payload		
Lift-to-drag ratio		
Delivery mechanism		
Avionics		

Figure 3. Impacting factors of Drone

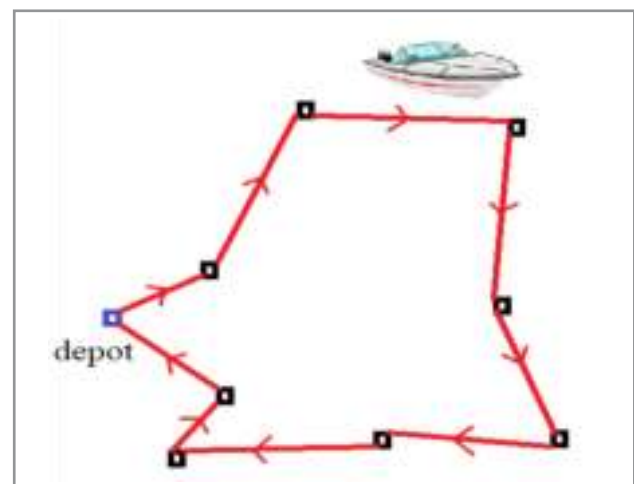


Figure 4. Shows conventional Launch boat delivery where it travels on a multi stop route delivering packages to various ships

Commercial at Wilhelmsen Ships Service (2017) [13] as saying that regardless of the size or number of packages, the average cost for these types of deliveries is around \$1500 USD. The cost will always be the same because this type of transportation always needs a crew for the boat, including labour and fuel. Supply delivery to a ship can frequently be very expensive [30].



and constraints of the field received a lot of attention. The degree to which they were analogous and the date of publication were used to determine whether or not the document was regarded as pertinent to the research questions. Because of the respondents' selection and the background data, which was deemed to be highly pertinent to the research, this study is thought to have a high level of credibility. Previous experiments and activities in the area were conducted on ships at anchor in cities like Singapore [13]. By examining reviews and publications in

3.2. Unmanned Aerial Vehicles (UAV)

A simulation module was developed in a study by [28] to show how a UAV can land onto a ship safely in a predetermined location as in **Figure 2**. The area here was constructed like a helipad platform. There were two distinct phases to the process. The drone had to find the ship in the first phase, which was accomplished by placing four red LED lamps around the helipad in a square configuration. It was possible to manoeuvre in the direction of the red lamps above and hover over the helipad with the aid of a mounted camera. The second stage of the process began when the UAV was hovering above the helipad, and it was finished by using the bottom camera to further centre and position itself over the helipad. An ultrasonic altimeter was used in conjunction with the four lamps as compensation for the movement of a ship in motion. According to Wang & Bai, this allowed for good accuracy and a safe, autonomous landing on the helipad.

scientific journals, it was possible to assess the validity of the information gathered.

Maersk claimed to be the first company to use a drone to deliver supplies from a barge to a vessel in 2016. [11]. Another advancement was made in 2018 by Wilhelmsen Ships Service and Airbus, who set up stations to pilot consumables printed using 3D printers, documents, water test kits, and spare parts to vessels at anchor from Singapore Port's marina south pier [29].

Due to limited lifting capacities and the fact that most respondents are aware that deliveries frequently consist of multiple pallets, it was generally agreed that UAV deliveries could complement but not entirely replace shore-to-ship launches by launch boats. In order to avoid delays, some of the respondents believed that a **UAV might be useful for transporting important documents and spare parts in narrow passages or areas where ships are passing close to the shore**. The authors initially did not think about this kind of implementation, but after studying the literature and conducting interviews, they realised how important it is.

3.3. Validity, Generalisability, and Dependability

In general, data for the background material was compiled from a variety of sources. The technical aspects

This study's main findings, which compare UAV deliveries to launch boats, include potential cost savings, quicker delivery times, risk reduction, and less negative environmental impact as shown in the **Figure 3**. None of these advantages came as a surprise given that UAVs are powered by electricity, unmanned, and transported in air. The lifting capacity presented one of the biggest obstacles to UAV deliveries. In our interviews, the majority of participants said that a UAV's capacity was insufficient for shore-to-ship deliveries. When they made their own reflections based on personal experience, the authors thought this was reasonable. Even though the respondents

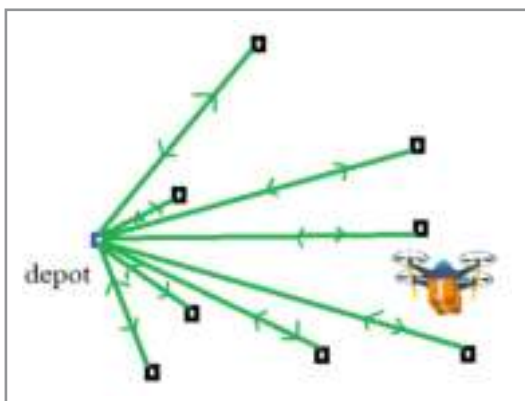


Figure 5. Provides an example of a delivery by drones to a portion of these customers. [Drone stops are indicated by the black square (deliveries).]

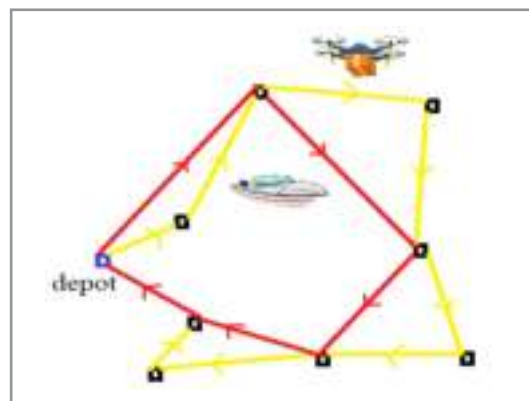


Figure 6. A hybrid Boat-drone delivery system is depicted, in which the launch boat and the drone alternate making deliveries as they pass through the service area.

received adequate information about technology that was already in use, some responses revealed ignorance of it. The predetermined belief that UAVs couldn't lift enough weight, despite the presentation of heavy-duty UAVs capable of lifting 200 kg, is a prime example of this.

Who would be responsible in the event that the UAV or cargo was lost was another issue that worried the respondents. The literature review contained no information on this matter, making it impossible to provide an answer. The respondents' perceptions of the delivery method in general may have been impacted by this.

Since the majority of respondents operate and conduct business with tanker vessels, the majority of the responses were predicated on the assumption that UAVs used for ship deliveries were classified for explosive atmospheres. This has already been classified, and it was assumed that this was necessary in order to discuss more questions with the target group.

The study's findings revealed no particular relationship between the respondents' attitudes toward UAV deliveries and the types of ships they operated. Although when contacting some of the tanker-operating companies for an analysis, the results sometimes included references to laws governing the use of electrical equipment in potentially explosive environments. This demonstrated the significance of classification in potentially explosive environments as well as the general ignorance of UAV development at the time. This led us to wonder if, rather than the precise classifications, modern technology might be the obstacle to implementation. This is further supported by the fact that the shipping sector is frequently described as conservative and traditional.

3.4. Security and Privacy Issues With Drones

The usage of drones provided advantages on both a professional and a private level. But there are several issues with drone systems in terms of security, safety, and privacy [31]. At the highest national level, drone-related privacy and security concerns should be addressed. A very tight policy should also be in place to limit the ability of drones to photograph and video people and property without authorisation. In terms of security and threat analysis, drone assisted networks are different from traditional wireless networks like Mobile Ad-hoc Networks (MANETs) and Wireless Sensor Networks (WSNs) [32]. This is understandable given that it consumes less power and transmits less data compared to a network that makes use of drones to support public safety.

Due to limited lifting capacities and the fact that most respondents are aware that deliveries frequently consist of multiple pallets, it was generally agreed that UAV deliveries could complement but not entirely replace shore-to-ship launches by launch boats

Additionally, compared to WSNs and MANETs, the drone's coverage area is substantially larger. As a result, the main security difficulties stem from the resource and delay limitations of UAVs. Drone use for physical and cyberattacks by bad parties puts society at risk by breaching citizens' privacy and jeopardising public safety. In reality, drones are being abused and misused for possible attacks in a number of technical and practical ways. This requires conducting critical activities based on offensive reconnaissance and surveillance intended to follow specific individuals and certain properties, both of which present dangers to personal privacy [33].

On the other hand, it's critical to prevent the use of drones over restricted areas because doing so results in privacy violations due to careless behaviour and the footage may be used for scamming and/or blackmail. Both material loss and damage and human casualties and deaths would result from this. The majority of studies contrast the speed of drone delivery with that of launch boat delivery. According to results [34, 35], using drones in addition to boat can reduce total delivery time, but the amount of the reduction depends on the speed of the drones compared to the launch boat. [34] make the assumption that the drone is faster than the launch boat by a factor of and demonstrate theoretically that adding a drone to a boat reduces total service time.

3.5. Hybrid Model – Proposed Model

The conventional launch boat model of supply makes the distance travelled by the boat greater and the effect on the environment due to the carbonaceous fuel emissions also higher. Refer to **Figure 4**, when the IC engine is in low power mode when slow-speeding close to the destination, the system's efficiency is lower. When too many stops are added, the overall efficiency of the trip is low.

If a drone-only model is introduced for the same supply as described in **Figure 5**, due to the limitation of the payload in drones, each ship needs to be visited separately. This makes the number of drone flights high. Even though the energy requirement of drone transit is small, because of the higher counts of travel, the overall energy requirement is equal to the launch boat model of the supply.

A hybrid model will be developed using the benefits of both modes of transport. When comparing **Figure 4** and **Figure 6**, the total distance travelled by the boat on the hybrid model is reduced, and the energy requirement as a part of boat travel is reduced. Added to this, the

reduced number of stoppages in this model will lower the time required for part-load operation and increase overall efficiency too.

In the drone part of the shipment, the number of drone movements is reduced and the total distance travelled is also reduced, which lowers the energy consumption on this part too. Overall energy requirement on this hybrid model of the supply system efficiently reduced.

4. CONCLUSION

In conclusion, there is little research on the economic and environmental benefits of drone delivery. While the majority of those research focus on drone-only deliveries, fewer studies look at the launch boat and drone delivery approach, which is another crucial way to employ drones. Few research examines a hybrid delivery model that best integrates drone and sea-drone delivery. Research findings on the energy and emissions efficiency of drone delivery are likewise inconclusive, in part because little is known about drone energy consumption and the wide range of drone energy consumption models and rates. The authors were able to respond to the research questions and derive

conclusions from the findings through literature reviews and interviews. UAV shore-to-ship deliveries to ships at sea could supplement rather than completely replace current launch boat deliveries.

When compared to traditional launch boat deliveries, UAV deliveries have a number of advantages for shipping companies, including lower costs, faster delivery times, a smaller impact on the environment, and lower injury risks. The industry's cautious attitude toward new technology, regulations, classifications of explosive atmospheres, and the limited lifting capacity of UAVs were found to be the main obstacles to the implementation of UAV deliveries in shipping.

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