CHALMERS

Potential and limitations with UAV deliveries to ships at sea

Bachelor thesis in Marine Engineering

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Department of Mechanics and Maritime Sciences
CHALMERS UNIVERSITY OF TECHNOLOGY
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BACHELOR THESIS 2019:22

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Cover:
Wilhelmsen (2019) *Airbus Skyways Drone lifting off*. Reused with permission.

Printing /Department of Mechanics and Maritime Sciences
Gothenburg, Sweden 2019

ACKNOWLEDGEMENTS

The authors would like to acknowledge all the people that have been helping us to complete the study. The authors want to raise the respondents; Donsötank, Tarbit Shipping, Erik Thun AB, Ektank & Stena bulk for their participation. The authors also want to thank Scanjet, Airbus and Wilhelmsen for providing us with helpful information.

Thanks to the Writing Centre at Chalmers University of Technology that assisted us with correction reading.

A special thanks to Magnus Hellman at Chalmers University of Technology for his guidance and support given during the thesis work.

SAMMANFATTNING

Denna studie undersöker hur den svenska sjöfartens attityd är gentemot leveranser med *obemannade luftfartyg* (UAV) till fartyg samt dess största fördelar och utmaningar i jämförelse med den traditionella leveransmetoden via båt.

Undersökningen visade på att UAVs är mer kostnadseffektiva, har en snabbare leveranstid, en mindre miljöpåverkan och kan eliminera risker för skador som kan uppstå vid traditionella leveranser. Vidare visade studien på att de största utmaningarna med UAV leveranser är dess begränsade lyftkapacitet, regleringar och klassningar för explosiva atmosfärer. Utförda analyser genomfördes från intervjuer med fem olika svenska rederier som visade på att den svenska sjöfarten är optimistisk till leverans metoden men att det kan bli ett möjligt komplement till leveranser med båt i väl trafikerade områden över hela världen. Majoriteten av rederierna som deltog i intervjuerna menar på att sjöfarten är väldigt konservativ och att ny teknologi som UAV leveranser måste ges tid till att mogna tillräckligt mycket utanför branschen innan det kan accepteras och användas.

Nyckelord: Drönare; UAV; Leverans; Sjöfart; Teknik; Effektivitet; Transport

ABSTRACT

This study examines Swedish shipping’s attitude towards deliveries with *Unmanned Aerial Vehicle* (UAV) to ships at sea and its main benefits and challenges in comparison to traditional launch boat deliveries.

UAVs were found to be more cost efficient, have a shorter total delivery time, less environmental impact and the possibility to eliminate risks for injuries that might occur during traditional deliveries. The main challenges found with UAV deliveries was the limited lifting capacity, regulations and classification for explosive atmospheres. Analyses made from conducted interviews with five different Swedish shipping companies shows that the attitude towards UAVs in the industry are optimistic and that the method could be a possible substitute to launch boat deliveries in trafficked areas globally. The majority of the respondents in the interviews consider shipping to be very conservative and therefore new technology like UAV deliveries needs to mature outside the industry before being accepted and implemented.

Keywords: Drone; UAV; Delivery; Shipping; Technology; Efficiency; Transport

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NOMENCLATURE

ATEX	European directives regulating explosive atmospheres
Ballast tank	Space within a ship that holds water as ballast to provide stability
Boarding	Going on board a ship
Cargo Hold	Space within a ship for storing cargo
ECA	Emission Control Area
EX-classification	Classification of equipment for explosive atmospheres
Freeboard	The distance from the waterline to the upper deck level on a ship
GHG	Greenhouse Gas
Launch boat	An open motorboat on which the forward part may be covered
LNG	Liquified Natural Gas
NOx	Nitrogen Oxides and Dioxides
SOLAS	Safety Of Life At Sea
SOx	Sulphur Oxides and Dioxides
UAV	Unmanned Aerial Vehicle
Weather deck	A ship's deck which is open to the weather, the upper deck

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1. INTRODUCTION

Ever since shipping was introduced, shore-to-ship deliveries have been an important part of the industry. Spare parts, medical supplies and cash are a few examples that are being transported to ships daily throughout the world (Wilhelmsen, 2017). For ships not entering ports very often, deliveries have traditionally been carried out by launch boats and requires multiple things: preparation- and travel time, custom clearance, transfer from launch boat to vessel and the costs for manpower and fuel (Brännlund, 2019). The fossil fuel burned during these types of deliveries is a contributing factor to greenhouse gases and global warming (Kopp, 2019).

With a high demand of shore-to-ship deliveries worldwide and strict environmental regulations, more efficient and environmentally friendly alternative have started to infiltrate the shipping business: *Unmanned Aerial Vehicles* (UAVs), also called drones (Technidrone, 2019). According to the consulting company PWC (2016), many industries are turning to UAVs for their accessibility, speed and low operating costs compared to traditional methods of transport requiring manpower.

In 2016, the shipping company Maersk claimed to have made the first delivery by UAV to a vessel at sea using a UAV certified for explosive environments (Cage, 2016). From there on, the business has been investigating shore-to-ship solutions further and one of the most recent and relevant projects is called Skyways, which is a collaboration between the aerospace corporation Airbus and the ship agency Wilhelmsen (Airbus, 2018). The world's first trial of commercial UAV deliveries to a vessel at anchorage successively took place in Singapore where consumables were delivered in a total of ten minutes (Wilhelmsen, 2019).

1.1 Purpose

The purpose of this study is to investigate the attitude towards shore-to-ship deliveries by UAVs from the shipping industry. This thesis will also study the benefits and limitations of UAV deliveries compared to the traditional method.

1.2 Research questions

1. Is shore-to-ship delivery by UAV a potential replacement for traditional delivery by boat?

Sub question

2. What are the main benefits with UAV deliveries for shipping?
3. What are the main challenges with implementing UAV deliveries in shipping?

1.3 Delimitations

This thesis will focus on UAV deliveries as a replacement for traditional deliveries by launch boat. Swedish shipping companies and owners will be the primary groups of interest when looking at the attitude towards the method of delivery.

2. BACKGROUND AND THEORY

Transportation by water with shipping is something society has always been depending on since discovery and is today a vital part of the world economy (Britannica, 2019). The shipping industry today is responsible for 90 percent of the worlds trade and is the most cost-efficient transportation method (UN Business Action Hub, n.d).

One of the traditional methods to transport goods from shore to ship today is by launch boat (Brännlund, 2019). These types of deliveries can be complicated and expensive, often resulting in an average cost on 1000 USD or more (Cage, 2016). Marius Johansen, Vice President, Commercial at Wilhelmsen Ships Service (2019) when introducing their UAV delivery project *Skyways* says;

> Delivery of essential spares, medical supplies and cash to Master via launch boat, is an established part of our portfolio of husbandry services, which we provide day in and day out, in ports all over the world. Modern technology such as Unmanned Aircraft Systems (UAS), is just a new tool.

Johansen also adds that the technology can push our industry forward and improve how we serve our customers.

2.1 Traditional delivery method

According to the European ship suppliers' organization (n.d), shipping is changing with a rapidly growing need for export, import and faster cargo handling, which has led to increased frequency of port calls, but less time spent in port. This has resulted in higher demands on suppliers and deliveries. Today, some vessels never trade in ports, but instead through ship-to-ship transfers, which leaves the ship with no other option but to have supplies delivered during anchorage (European ship suppliers' organization, n.d).

According to Gabriel Brännlund, General Manager at Scanjet Asia Pacific Pte Ltd, the most common method used for shore-to-ship deliveries is by launch boat. Brännlund (2019) describes this process as following: the delivery process starts with a receival of an inquiry from a customer, which is followed up by an order confirmation. Further on, the order is prepared for delivery and the customer is informed. The customer requests direct delivery to the vessel and receives the price for this. For the process to continue, the customer needs to confirm the cost. Arrangements for transportation are made and details for the ship agent is acquired. The agent is contacted, and the delivery can be coordinated in terms of estimated time of arrival and available timing for loading. Operations like anchoring can be time consuming and the immigration clearance needs to be all done before any personnel are allowed onboard the ship to complete the delivery. When coordinating is finished, the agent arranges collecting of goods and the transporter is arranging transfer of the goods from their warehouse to the loading port. These goods are loaded onto a launch boat after custom clearance is complete. The vessel is informed about incoming goods and at arrival, the launch boat is coordinating the delivery with the responsible Officer onboard. The goods are transferred to the vessel and the responsible officer are to sign and stamp the delivery order which then returns with the launch boat and transporter. The last step in the process is to send the invoice to the customer.

2.2 Ship types

Vessels of different commercial use varies in size and shape with a design to fit intended cargo (International Chamber of Shipping, n.d.). According to Stilwell & Woodward (2018) the mission of a ship is what determines the detail requirements and factors like what type of cargo is to be carried, required speed, operational area or distance to travel. It also lists different ship types: Tanker, Container ship, Roll-on/ Roll-off, Passenger ship and Dry bulk being some of them. On all of these ship types there are specific areas dedicated for helicopter operations, which can vary in location and size (Bhattathiri, 2017). These areas will likely be used for UAVs in shore-to-ship deliveries since the procedures will be similar to those of helicopters (Wilhelmsen, 2018).

2.3 History of UAVs

In the early days, a UAV was often referred to as an autonomous aircraft used in the air force with no pilot driving it (Nationalencyklopedin, 2019b). The first ever UAV was used in the first world war and the main purpose was to train air defence personnel. The first ever modern UAV was developed by Israel as a result of the October war in 1973 and was used for reconnaissance missions where it was often equipped with tv camera, infrared scanners or cameras (Nationalencyklopedin, 2019a). These UAVs were very efficient at searching through large areas in a short time and were able to circulate in the air for a long time with small risk of being discovered. The navigation was controlled through satellite, inertial or control operators which could be located anywhere in the world (Nationalencyklopedin, 2019b).

Recently there have been numerous companies developing UAV deliveries as an option to be used for commercial purposes (Gce logistics, n.d). These companies have been using UAVs as a delivery method for spare parts (Gce logistics, n.d).

2.4 Marine Application Areas

According to the classification society DNV GL (n.d), there are currently many areas in the marine industry exploiting UAV technology where one of these areas is inspections and surveys. These are mainly performed in ship’s cargo- and ballast tanks, cargo holds and structural components of offshore installations (DNV GL n.d). Some of the claims to why UAVs have been implemented in this area is the reduction of preparation times and the improvement of safety as a result of unmanned inspections. In comparison to regular surveys, this method allows high resolution documentation and can be completed in less time for lower costs (DNV GL n.d).

Another area is sulphur emission monitoring of ships inside Emission Control Areas (ECA) (Danish Maritime Authority, 2019). These ECA areas are established to limit SOx and particulate matter emissions which most commonly is achieved by limiting the content of sulphur in the fuel oils used onboard (International Maritime Organization, n.d). According to the Danish Maritime Authority (2019), specially designed UAVs can contribute to a more efficient enforcement of these sulphur limits. With special sensors analysing the content of the air when passing over a ship in operation, the operator will be provided with sulphur content data (Martek, 2017).

A third area where UAV technology is being integrated is shore-to-ship deliveries (Wilhelmsen, 2018). A recent experimental project called Skyways was started in a collaboration between Airbus and Wilhelmsen to develop what they call “a safe and commercially viable aerial unmanned delivery system for use in dense urban cities” (Airbus, 2018). Wilhelmsen has the largest ship agency network in the world and great experience of organizing deliveries of medical supplies, essential spare parts or cash to masters onboard ships every single day, all around the world (Wilhelmsen, 2018). With delivery by UAV instead of conventional launch boats, delivery costs would be reduced by 90 percent, many risks for injuries would be eliminated, and the environmental impact would be less (Wilhelmsen, 2018).

2.5 Lithium-ion batteries

Lithium-ion batteries are increasingly being used in aerospace applications like UAVs due to their high energy density (Metalstech, n.d). They are commonly used due to its favourable characteristics like high output power, slow loss of charge when not in use, lack of memory effect, high energy density, fast charging and that they are maintenance free (Wu, 2015). Generally, they weigh less than other types of rechargeable batteries in the same size and the electrodes are made of lightweight lithium and carbon (Metalstech, n.d). There are some shortcomings with the battery type according to Yuping Wu (2015). In his book "Lithium-ion batteries" he mentions high costs for the positive electrode materials as one of them, and also the need of a special protection circuitry in order to avoid overcharging. Lithium-ion batteries are rechargeable batteries in which lithium ions move from the positive anode to the negative cathode during discharge and reversed during charging (Metalstech, n.d).

Leo Jeoh, Head of Aviation Safety Hub in Asia Pacific Region at Airbus, answers when asked about cost estimations regarding their project "Skyways" in collaboration with Wilhelmsen ship service, that generally one of the primary cost elements in UAV deliveries are the batteries. Jeoh says that typically used lithium ion batteries need attention since there are a limited number of charges. Jeoh also adds that these cycles are normally around 750 to 1000 depending on quality.

2.6 UAV types

The type of UAV is of great importance to the technical characteristic (Ravich, 2016). The most common types are multi rotor, single rotor, fixed-wing and fixed wing hybrids (Chapman 2016; Ravich, 2016). Following chapter serves the purpose to provide an overview of these different UAV types, their general applications, advantages and eventual limitations. Shapes and design are often determined from the technical characteristics (Ravich, 2016).

2.6.1 Fixed-Wing

Andrew Chapman, NSW Director of Operations for Australian UAV (2016), says that a fixed-wing type, seen in figure 2.1, are using normal wings as lift force rather than vertical lift rotors As a result of this, the only energy use needed is to move forward, making it a very efficient design with high-speed capacity. Chapman adds that gas engines is an alternative for this type and because of the high energy density in the fuels that can be used, the aerial time can be around 16 hours, making this suitable for covering long distances and larger areas. Downsides with this type are the inability to hover in one spot, problem with launch and landing and that they are expensive to build (Chapman, 2016).

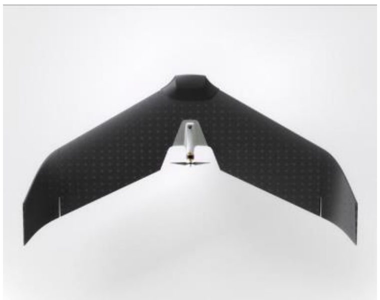

Figure 2.1 Fixed Wing UAV flying (Aviation, 2016). CC-BY

2.6.2 Single-Rotor

According to Chapman (2016), a single-rotor type, seen in figure 2.2, is constructed with a blade that spins relatively slow and it is typically much larger than other UAV types. Chapman also says that single-rotors are very efficient and can be powered by a gas engine for longer endurance. Downsides with this type are its complexity, vibrations and more expensive design (Chapman, 2016).

Figure 2.2 Single rotor UAV standing still on the ground (Mckarri, 2009). CC-BY

2.6.3 Fixed-Wing Hybrid

This is a type with aim to merge the ability to hover in place and to fly forward with higher efficiency, a merge of fixed-wing and rotor design as can be seen in figure 2.3. This design is still very much in developing stage and has been used for the purpose of deliveries as experiment. This type has long flight time but compared to previously mentioned types, not the same hovering or flight forward capacity (Chapman, 2016).

Figure 2.3 Fixed-Wing Hybrid flying in the air (Licht, 2015) CC-BY

2.6.4 Multi Rotor

Multi rotor types of UAVs as shown in figure 2.4 are of a simple construction design and are relatively inexpensive according to Chapman (2016). Chapman also says that the multi rotor is performing well regarding position control and framing and therefore is fit for tasks like aerial photography work and visual inspections. Some drawbacks with the type are the limitation of endurance and speed, which makes them unfit for tasks like large-scale aerial mapping or long endurance monitoring (Chapman, 2016). The type requires a lot of energy just to hover with its own weight and it is restricted to electrical powering due to practical reasons according to Chapman (2016).

Figure 2.4 Multirotor UAV with camera flying (Pidvalnyi, 2018). CC-BY

The capacity of commercial multi rotor UAVs has a big variety depending on the purpose (Brown, 2019). In table 2.1, examples are shown to illustrate this variety in form of specifications (Griff Aviation, n.d; Brown, 2019).

Table 2.1 Different models of multirotor with its maximum payload and battery time (Author's own copyright)

UAV Model	**Battery Time**	**Payload**
DJI MATRICE 600	16 min	6,0 kg
DJI S900	18 min	8,2 kg
ONYXSTAR HYDRA-12	30 min	12 kg
FREEFLY ALTA 8	16 min	18,0 kg
Griff Savior	30-45 min	200 kg

2.7 Categories for permit

The use of UAVs has increased significantly through the years and more people are using UAVs for private use (Hobbs, 2010). According to Hofverberg (2016), most of the UAV models carry a camera for visual purposes. The increased use and relative few regulations have pushed the authorities to divide UAVs into five different categories (Hofverberg, 2016). Following chapter will present the requirements and rules for operating UAVs in these different categories.

2.7.1 Category 1

UAVs weighing less than 7 kg requires no permit to fly but there are some rules that needs to be followed (Transportstyrelsen, n.da.).
Transportstyrelsen (n.da) lists requirements for category 1 as:

- Mark the UAV with the operator's name and phone number.
- Liability insurance is not required but essential because home insurance may not cover damages.
- Make sure that the UAV is in good shape and have functional lightning if night flying.
- Designate a pilot as Captain and plan the route before the flight.
- Fly within sight and maximum 120 meter above ground.
- Keep distance from humans, animals and properties.
- Prohibited to fly over restricted airspace (prisons, military and airports).
- Make way for all other air traffic.
- Don’t fly closer than 1 km from a heliport.
- Always fly within the airports control zones or traffic information zones.
- If flying outside the airports different flight zones, contact the airport.
- Do not take offensive photos and do not spread flight photos without permission.
- Make sure the radio equipment is CE marked and the right frequencies are used.

2.7.2 Category 2

UAVs weighing in between 7 kg to 25 kg and flown within the visual line of sight requires permit to fly. In order to get the permit, requirements written in category 1 and the ones stated below needs to be fulfilled (Transportstyrelsen, n.db.).
Transportstyrelsen (n.db) lists additional requirements for category 2 as:

- UAVs equipped with auto flight along their programmed route shall always have the possibility for a pilot to cancel and take over the control for evasive actions.
- The UAV should have a built-in fail system with the ability to interrupt the flight.

- Flights should be documented in a logbook or equivalent with information such as dates, pilot in-command, aircraft-ID, departure and landing sites, flight time, total flight time, commissions type as well as deviations.

This permit requires an insurance with the exception if the drone is used for private purpose and weight less than 20 kg (Transportstyrelsen, n.db.).

The pilot must also complete training for the relevant unmanned aircraft system and pass the Swedish transport agencies practical and theoretical exam before the permit is issued (Transportstyrelsen, n.dc). The pilot should also possess knowledge of air law and ATC procedures found in AMC1 FCL.210; FCL.215 in Part-FCL.

2.7.3 Category 3

UAVs weighing more than 25 kg and flown within the visual line of sight requires permit to fly and is for organizations that are using UAVs (Transportstyrelsen, n.dd). To achieve permit, the pilot must complete training and exam which is stated in category 2 and send in an application form with two main parts: general information and an operations and maintenance manual (Transportstyrelsen, n.dd). According to Transportstyrelsen (n.dd), it should be stated in the general information:

- Company or applicants e-mail, phone number and postal address.
- Depending on the organization the identity number for the personal or corporate.
- CVs of the person responsible for operations, operations officer, technical officer and pilot as well a description of the organization or management assigned for the operations.
- Information of the planned operations.
- Information of the unmanned aircraft system such as designation/manufacturer, dimensions and other technical specifications. Type of flight control system and a presentation of how the requirements of Chapter 4, section 10-17 of TSFS 2017:110 is compiled (Transportstyrelsen, 2017).
- A copy of the insurance certificate.

The operations and maintenance manual shall contain information stated in Chapter 4, Sections 18-19 of TSFS 2017:110 (Transportstyrelsen, n.dc).

2.7.4 Category 4

If UAVs are intended to be flown beyond the pilot's visual line of sight and without any special operating limitations permit category 4 is required (Transportstyrelsen, 2017). To achieve a full permit to be issued, the drone must have a type certificate. It should also be equipped with a fully approved detection and avoidance of other aircraft system. General rule, the application should contain the information stated in annex 4 in the Swedish Transport Agency's Regulations on Unmanned Aircraft TSFS 2017:11 (Transportstyrelsen, 2017).

2.7.5 Category 5

This permit is a special permit for when certain operations exempted from categories 1 - 3 is being used (Transportstyrelsen, n.de.). This permit can be divided into 3 subcategories, 5A, 5B and 5C. 5A are for UAVs flying higher than 120 meters from the ground. 5B are for UAVs flying beyond the pilot's line of sight, exception applies if the UAV is visual for observers then the observers must monitor the air and ground for safety of obstacles. 5B has some exemptions for category 1, 2 and 3. 5A and 5B can be applied as a separate or supplement permit to category 2, 3 and 1 but with the exception that a built-in fail system is installed (Transportstyrelsen, n.de.). If applied to a category the requirements for that must also be fulfilled in order to get the 5A accepted.

UAVs, which do not fall into any of the categories stated above, should be carried out with 5C special permit. For example, operations where flights are beyond visual line of sight and in special areas or flights higher than 120 meter above water or ground (Transportstyrelsen, n.de.).

2.8 Classification for explosive atmospheres

Xamen technologies, a company based in south western France has developed an ATEX classified UAV called "LE-8X Dual ATEX" which is approved to carry out close investigations where there is a risk of explosion or to make deliveries to tanker ships (HazardEx, 2016). They conducted the world's first UAV delivery to a Maersk tanker in the North Sea, using a UAV, which at the time could carry 2kg in payload and travel in 16 m/s.

According to the Health and Safety Executive (HSE) (n.d), ATEX is the name of two European directives that is regulating explosive atmospheres. An explosive atmosphere can be created when mists, vapours, combustible dusts or flammable gases mix with air, according to HSE (n.d). In this atmosphere, in atmospheric conditions, a source of ignition will cause an explosion. Atmospheric conditions are temperatures between -20 degrees and 40 degrees under a pressure of 0,8 to 1,1 bars.

In order to meet the requirements for ATEX classification according to HSE (n.d) is that manufacturers or suppliers must assure that their product meets the essential health and safety requirements. This normally includes testing and certification by a third-party body. When the equipment or product has passed the certification, it is marked with an "EX" symbol, indicating approval for use in explosive atmospheres. This type of certification makes sure that the equipment is fit for the purpose (Health and Safety Executive, n.d).

To categorize environments by different levels of danger, ATEX is using zone numbers as seen in figure 2.5 (IPU, n.d). These zone numbers are selected based on the risk or chance for an explosive atmosphere to occur and its persistence if it does. ATEX also distinguishes explosive atmospheres created by dust or gas. ATEX zone 0 with gas present is the most dangerous workspace type out of all zones (IPU, n.d).

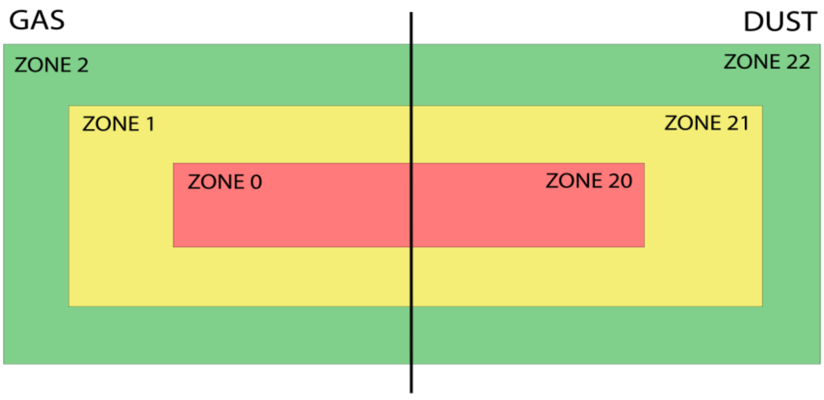

Figure 2.5 Illustration of ATEX zones (Authors own copyright)

2.9 Communication

While the shipping industry is growing, the importance of safety and security is growing as well and when critical decisions must be made, good communication is essential (The maritime industry knowledge centre, n.d.). Onboard ships advanced communications system such as satellite, land-based radio and telephone infrastructure is used. For UAVs the communication systems are vital in order to obtain desired data (BATS Wireless, n.d.). In this chapter, some examples of communications models will be presented and what regulations that applies to them.

2.9.1 SOLAS regulation for VHF radio onboard

Every ship at sea must be provided with a VHF radio with enough capacity to transmit and receive distress alerts, maritime safety information, search and rescue, coordinating communications, on-scene communications, general info and bridge-to-bridge from shore-to-ship (International Maritime organization, 1974).

2.9.2 Transmission for UAVs

According to the learning site getFPV (2018), two of the most critical parts required to operate a UAV is a radio transmitter and radio receiver. The transmitter is an electronic device that is using radio frequencies in order to transmit commands wirelessly. The commands are transmitted via a fixed radio frequency to the receiver, which is located in the drone as described by getFPV (2018). The purpose of this is to "translate" the actions and commands made by the pilot into manoeuvring and movement of the UAV. According to Barry Davis (2016) the transmitter and receivers comes with a number of channels, each one assigned to a particular function. Four of these functions: pitch, throttle, yaw, and roll, are essential to accomplish basic manoeuvring (getFPV, 2018).

Frequencies used today depends on the type of UAV, the payload and the flight characteristics (Ravich,2016). Two very popular bands for commanding and controlling UAVs today is the 2.4000 - 2.4835MHz and 5.470 - 5.725MHz (Ravich,2016).

2.9.3 Hijacking

According to Feng et al (2017), the use of civil UAVs is growing rapidly. Feng et al adds that this raises serious security challenges and since UAVs today rely upon GPS navigation during middle or long distance flights, it is vulnerable to deceptive GPS attacks where the UAV can receive false GPS signals. These spoofed signals can be modified to cause the receiver to read its location someplace where it is not (Feng et al., 2017).

According to Malek Murison (2018), the company Amazon successfully filed a patent titled "Hostile takeover avoidance of unmanned vehicles" which relies upon a "heartbeat" function. Murison explains that the heartbeat is transmitted as a signal every few seconds and if it were to be stopped, which would occur in the event of a hijacking, it would switch from normal to safety mode. This would force the UAV to perform pre-programmed manoeuvres in order to re-establish communication, take control, land in safety and send out an alarm (Murison, 2018). Murison continues to explain that a function like this could prevent individuals or systems to be able to control UAVs by hacking the communication signals sent from the controller.

2.9.4 Delivery information to customer

Marius Johansen, Vice President, Commercial at Wilhelmsen's ship service (2018c) regarding delivery confirmation and customer communication says;

> In terms of delivery confirmation and communication with the vessel as well as the boarding officer, along the delivery process, we have been fortunate to develop an app together with a company called Tockan. In essence, the app is very similar to functionality to known apps like Uber, Grab, or Foodpanda.

He continues by saying "these types of applications, provide a very smooth user interface and allows you to get confirmation once you have ordered, when the parcel is on its way and a final confirmation from the customer once the package is received". Johansen adds that if confirmation in paper form is required, it is possible to have the UAV bringing it back to shore.

2.10 UAV to Ship

In a study conducted by Wang & Bai (2018), a simulation module was created to illustrate how a UAV can land safely onto a ship in a specific designated area. This area was made out of a helipad platform. The process was divided in two different stages. The first stage consisted of the drone locating the ship, which was managed by having four red led lamps organized into a square around the helipad. With the help of a mounted camera, it was possible to navigate towards the red lamps above and hover over the helipad. When hovering above the pad, the process entered the second stage, which was completed by using the bottom camera of the UAV to further centre and place itself over the helipad. Considering the movement of a ship under way, an ultrasonic altimeter was used as compensation combined with the four lamps. Wang &

Bai says that this made it possible to achieve good accuracy and to safely, autonomously land on the helipad.
In 2016 Maersk claimed to be the first company delivering supplies from a barge to a vessel using a drone (Cage, 2016). Another development in 2018 has been made by Wilhelmsen ships service and Airbus where they were setting up stations to pilot spare parts, documents, water test kits and 3D printed consumables to vessels at anchor from Singapore port’s marina south pier (Wilhelmsen, 2018b). The first delivery trial was of 1,5-kilogram 3D printed consumables to an Anchor handling tug supply vessel named *M/V Pacific Centurion* which was located 1,5 kilometres from the launching position (Wilhelmsen, 2019). The delivery was completed and landed on shore again after 10 minutes.

According to the Maritime Executive (2019), Griff Aviation, a Norwegian UAV builder, is working on a large shore-to-ship delivery system for the offshore sector. They also say that Griff have received support from the Research Council of Norway, the Northern Research Institute and Olympic Subsea. Griff Aviation is best known for the Griff 300, which are designed for payloads of up to 500 pounds (MarEx, 2019)

2.11 Delivery costs

Delivery of supplies to a ship can often be very expensive (Gcaptain, 2017). Smaller launch boats are typically used for transport of supplies or goods to vessels at sea every day globally (Wilhelmsen, 2019). A delivery cost estimation was made of a “spare part package” to around 450 USD by Gabriel Brännlund, General Manager at Scanjet Asia Pacific Pte Ltd from warehouse to vessel in Singapore. According to another source, Marius Johansen, Vice President, Commercial at Wilhelmsen Ships Service (2017), an average cost for these types of delivery is around 1500 USD regardless of size or quantity of parcels. Since this type of transport will always require a crew for the boat with manpower and fuel, the price will always remain similar. By using UAV deliveries instead, these factors no longer affect the price and can therefore be reduced with up to 90% in some ports (Wilhelmsen, 2019). Wilhelmsen (2018c) continues to say that they have made an estimate that is indicating possible savings of 675 million USD for the industry as such.

With an average of three UAV deliveries per year for one vessel, the potential cost reduction can result in 3000 – 9000 USD with a UAV capable of carrying smaller payloads (Cage, 2016).

Other primary costs that can be found in UAV deliveries are ground control systems, manpower for operations, UAVs and batteries (Jeoh, 2019).

2.12 Environmental impact

According to data acquired from the United States Environmental Protection Agency (EPA) (2017), the largest source of Global anthropogenic greenhouse gas (GHG) emissions from human activities in the U.S is from burning of fossil fuels. Burning and combustion of fossil fuels are responsible for the rising concentrations of GHG in the atmosphere and has resulted in increased capacity of absorbing infrared radiation (Mann, 2019), meaning better absorption of heat from the sun and increased temperature. This environmental issue is often referred to as the "greenhouse effect" (Department of the Environment and Energy, n.d). Nitrogen oxides (NOx) is another by-product which is formed when fuel is burned (EPA, n.d). NOx is typically known for contributing to the environmental issue "acid rain", which can be harmful to sensitive ecosystems such as forests and lakes (EPA, n.d). Fossil fuel is typically used in traditional launch boats offering shore-to-ship deliveries (Cast Launch Services, n.d). Wilhelmsen (2018a) says that UAVs as a replacement for these launch boats in shore-to-ship deliveries could be a progress towards reducing environmental impact.

3. METHOD

This study aims to investigate Swedish shipping companies' attitudes and opinions regarding the possible implementation of UAV deliveries to ships at sea. Also, the purpose is to study the advantages and challenges that comes with it. In order to answer the research questions, literature was collected, and a systematic review was conducted since it was considered to be the best alternative for this kind of research according to Höst, Regnell & Runesson (2006). To find a more generalized and applicable answer for the research questions, several shipping companies relevant for the studies were contacted and interviewed.

3.1 Data Collection

In this study, suitable literature for the background have been acquired to gain enough knowledge, data and information to answer the research questions. The interviews were conducted with companies in the shipping industry, whom could provide relevant information for the study. Reflections and answers given during these were written down and the interviews were recorded with permission. The interview was introduced with a short summary of the subject to prepare the respondents as described by Höst, Regnell & Runeson (2006).

3.1.1 Background Material

The selection of information for the background material has been gathered from different sources. The systematic review provided solid background for the study and contributed with answers to the research questions. Comprehensive knowledge of literature in the study area is considered essential to complete studies of this form (University of North Carolina at Chapel Hill, 2018).

By using bibliographic finding tools online, it was possible to complete the systematic review, which resulted in a running text that serves the purpose to provide an overview. The focus of the search was on UAV and conventional delivery methods in shipping but also in other businesses. Databases like Science direct from Chalmers library's search engine was mainly used but also databases like ResearchGate, Web of science and Google Scholar were used to expand the search. Within these online tools, the use of English search words made it possible to filter out irrelevant documents. Documents found and selected for systematic review were determined relevant and reliable for the research questions by the authors.

3.2 Interviews

The selection of respondents for the interviews were carried out on a few Swedish shipping companies which were provided background information about UAV deliveries by email beforehand. This was made in order for them to prepare their opinions and thoughts on the subject before giving answers suggested by Denscombe (2017). With their expertise in shipping, they were able to provide answers relevant to the research. Semi-structured interviews were used in order to give the respondents more possibilities for own reflections and elaboration on the questions asked. The interviews were based on a protocol with questions in flexible order as guidance.

The companies interested agreed upon an interview and were scheduled to be in person if possible, otherwise the answers could be provided over the phone or sent by email. The interviews were held over phone with one exceptional answer by email, which according to Martyn Denscombe (2017) is beneficial because it is already in-text and removes any possibilities for transcription errors. During the interviews, notes and voice recordings were taken in order to analyse and evaluate the information more thoroughly (Höst, Regnell & Runeson, 2006).

3.2.1 Background Interview

When researching background and information for the study, there were not sufficient sources with enough literature to be found. Therefore, companies in the industry were contacted with a request of an interview. Two different companies provided reliable and detailed information about processes and general experience in the subject that could not be found by literature. These interviews were of semi-structured form.

3.3 Reliability, validity, generalizability

Generally, information for the background material has been gathered from different sources. Much focus was given to technical aspects and limitations of the area. Whether or not the document was considered relevant to the research questions was determined by how analogous they were and what publication date it had.

The credibility for this study is considered to be high, because of the choice of respondents and background information, which was considered very relevant to the research. Previous activities and trials in the area have been made in places like Singapore on ships at anchor (Wilhelmsen, 2019).

The reliability of material gathered was determined by looking at reviews and publications in scientific journals. Documents that were not published in scientific journals but still used were further investigated in order to be established a trustworthy source of information.

3.4 Ethical considerations

According to Denscombe (2017), a trust between the interviewer and the respondent needs to be built in order to acquire trustworthy information during an interview. Especially when asking about subjects like technical solutions, economics or prospects for the future, since this can be considered sensitive. Denscombe also says that interview questions can easily be misled if subjects presented during an interview are considered sensitive. By keeping the questions passive and neutral, sincere answers are more likely to be given. All information from the interviews were used with permission from the respondents.

4. RESULT

The result of the study is divided in two parts. The first part, 4.1, is the findings and results from the conducted systematic review. The second part, 4.2, consist of the gathered results from several different interviews with shipping companies.

4.1 Literature

Following part will present information relevant for the research questions that was collected from scientific journals, articles and from background interviews with companies in industries relevant to the research. Chapter 4.1.1 will present benefits and chapter 4.1.2 will present challenges with UAV deliveries in comparison to conventional delivery methods by launch boat to vessels at sea.

4.1.1 Benefits with UAV deliveries

One of the benefits found in literature with UAV deliveries compared to traditionally used methods by launch boat was the reduction of delivery costs (Wilhelmsen, 2019). According to Marius Johansen, Vice president, commercial at Wilhelmsen Ships Service (2017), a reduction from 1500 USD to 150 USD can be achieved when switching from boat to UAV. According to Wilhelmsen (2019), UAV deliveries are less labour dependent than deliveries with launch boats and therefore has the potential to achieve cost reductions of 90% in some ports.

Another factor considered beneficial with UAV deliveries is the small carbon footprint it leaves in comparison to launch boats (Wilhelmsen, 2019). UAVs most often are electrically powered by batteries, due to its high energy density (Wu, 2015) and therefore has no environmental impact like air pollution that fossil fuels typically have when combusted (Britannica, 2018).

A third advantage with the delivery method is the potential to shorten the delivery time with up to 6 times compared to delivery by launch boat (Wilhelmsen, 2018a). When Wilhelmsen (2019) in their project skyways, made a delivery of 1,5 kilometres with consumables from shore-to-ship in Singapore, it took 10 minutes in total. Time consuming parts of the delivery like loading and transfer between shore, launch boat and vessel as described in interview with Brännlund (2019) are no longer required when the delivery is made by UAVs.

4.1.2 Challenges with UAV deliveries

One challenge regarding economical sustainability was found with the electrical powering by lithium batteries. Yuping Wu (2015) mentions that there is a high cost to produce the positive electrode material which also requires a special protection to avoid overcharging. Leo Jeoh, Head of Aviation Safety Hub in Asia Pacific Region at Airbus also explains that the batteries are one of the primary costs due to its limited amount of charge and discharge cycles, which Jeoh claims to be around 750- 1000 charges.

Regulations and classifications were also found to be considered a challenge for implementation of this type of deliveries. When operating in potential explosive atmospheres, special designs and constructions to eliminate or reduce the risks of ignition must be used (Health and Safety Executive, n.d). Philippe Barthomeuf, Chief Executive Officer at Xamen Technologies talks about modifications needed to achieve this when discussing their developed ATEX classified UAV (Aeronews, n.d). To acquire ATEX classification, the equipment needs to go through a third-party body (Health and Safety Executive, n.d).

There are also requirements that needs to be fulfilled in order to get a permit to use a UAV for flight operations (Hofverberg, 2016). These permits are regulated through different categories depending on the size and purpose, where some requires training and examination.

Marius Johansen, Vice President, Commercial at Wilhelmsen ships service (2018c), when asked about restrictions and regulations regarding their project skyways with the company Airbus in Singapore answered;

> Regulation is an extremely important part of a project like this and our ability to be able to operate with regulators both on the aviation side as well as on the port side, has been a fundamental success factor in this project.

Johansen continues to say that when moving forward from the pilot into a commercial operation they must proceed from the sort of temporary permit regime they have been operating under into a regime that allows flight at a “need-to basis”. Further Johansen adds that a supportive regulatory framework would be essential for these types of commercial operations.

4.2 Interviews with shipping companies

This chapter presents information gathered from several interviews with shipping companies. The majority of the shipping companies that were interviewed mainly operates with tankers and is trading in the North Europe, Baltic Sea or Globally either with spot trade or time charter. The authors have summarized responses of the interview questions attached in appendix 1, strictly based on recordings and documentation taken during the interview.

4.2.1 Implementation in the shipping industry

When Henrik Källsson, deputy managing director at the shipping company Erik Thun AB was asked about his opinion and thoughts on UAV implementation he answered:

> The shipping industry is sometimes a very conservative business. New technology needs its maturing outside the shipping business before being implemented in the industry. Nevertheless there is a try to implement new technologies, such as autonomous ships, but it doesn't usually leave the scientific stage even when successful.

Källsson at Erik Thun AB continues to explain that the reason behind these failed attempts of implementation is fear of change from the regulators and government organisations. He also says that he thinks some kind of confirmation on improved safety level together with reduced delivery cost in comparison with traditional launch boat will be required for full implementation. Källsson at Erik Thun AB adds that he thinks that UAV deliveries has to be proven by the aviation industry due to its recognised track record and approval by the oil & gas industry.

Anders Hermansson, Technical Manager at Tarbit Shipping AB also describes the industry as conservative and traditional, which could impact the implementation time of UAV deliveries by making it slower. Hermansson adds that some kind of government or company approval for future UAV operations in the industry might be required with certificates and quality guarantees.

Regarding UAV deliveries in the maritime industry, Sara Westerberg, Manager for commercial operations at Stena Bulk considers that there is a lot of questions that still need answers in order for it to be implemented. They consider the primary questions to be about the regulations and secondary of insurances & responsibilities.

A common answer given by the respondents regarding requirements to fully accept the implementation in the industry was certification of the UAV for explosive atmospheres, since they all trade partly or exclusively with tankers.

Not all respondents were familiar with the delivery method since before. Technical Manager, Henrik Lorensson at Donsötank when asked about his thoughts on the method answered:

> To me, deliveries by UAV is something new and totally unknown. The thought has never struck my mind before. I'm acquainted with the implementation in photography and videography but in the maritime industry, not so much. I have heard about tank inspections being conducted by drones.

4.2.2 Benefits and Challenges

Jörgen Johnsson, Managing Director at Ektank was asked what he considered to be the biggest challenges with UAV deliveries to ships at sea, on which he answered, "the biggest challenge for implementing UAV deliveries are the weight which it can carry". Johnsson at Ektank adds that other problematic parts could be the visual communication and capacity to travel longer distances, since ships at anchorage often are located far from shore. Lorensson at Donsötank also mentions the distance as a potential barrier for implementation by saying:

> With longer distances, it will be time consuming to fly multiple times to and from shore when larger quantities are to be delivered. However, deliveries by boat will be time consuming as well and will also require manpower.

Lorensson at Donsötank continues by mentioning a potential benefit and solution with deliveries during bad weather by saying:

> One problem we have today is delivering goods during bad weather. Our vessels themselves are not affected by rolling but the small launch boat delivering often is. Usually they have a difficult time with boarding or connecting the goods to our cranes onboard. This can result in injuries or total failure of delivery which could possibly be eliminated by delivering the goods by UAV instead.

Regarding the same issue, Johnsson at Ektank says that bad weather with strong winds might be considered a challenge.

Hermansson at Tarbit Shipping AB finds the biggest challenge to be the lifting capacity and further adds:

> I am aware that ex-classified UAVs already exists so that problem seems to be solved. No sparks can occur during delivery or landing. Maybe the monitoring and communication with UAVs, to be able to make sure who is approaching the vessel by drone and its cargo, that it's not a threat instead.

Hermansson at Tarbit Shipping AB continues to mention reduced risks during deliveries in rough rolling as a benefit with implementation of UAV deliveries. Hermansson at Tarbit Shipping AB also adds potential time and cost savings, flexibility and ability to make critical deliveries where traditional launch boats are not available, to be the primary benefits.

When looking at what benefits deliveries by UAV might bring in comparison with launch boat, the respondents commonly included increased efficiency in terms of faster deliveries and cost reductions in their answers. Westerberg at Stena Bulk says that one part which contributes to better efficiency is "the potential ability to take deliveries underway in passages and not be required to wait for launch boats in port". Westerberg also mentions that through a sustainability perspective, electrically powered UAVs seems promising since the burning of fossil fuel that occurs during launch boat operations can be removed.

4.2.3 Possible replacement of launch boat deliveries

When the respondents were asked if they think that UAV deliveries could replace the traditional boat deliveries, the common opinion was that it probably could not, but instead have the potential to be a complement to traditional launch boats. Källsson at Erik Thun AB says, "it could be an optional method but not always a replacement".

Westerberg at Stena Bulk AB and Hermansson at Tarbit Shipping AB both mentions that it could be a supplement to shore-to-ship deliveries, but not a total replacement.

Johnsson at Ektank says "the delivery method can be a replacement for some ship types but not everyone, it all depends on the vessels sailing route". Johnsson adds that it is a potential replacement when it comes to deliveries of lightweight packages in easily accessible locations. Lorensson at Donsötank also considers UAVs a possible replacement for deliveries of smaller parcels. When discussing the potential replacement of delivery method for larger parcels, Lorensson says that he is not certain, much because of the communication with the UAV during delivery and if it would be possible to rely upon cameras to be sufficient for the job. Lorensson continues by bringing up the duties of todays' ship agents and says:

> Agents takes a lot of time and has a environmental impact with car transport etc. Often it is very inefficient due to delays and waiting time. I think the function of an agent today could be replaced by UAVs, even though i think papers and documents in physical form are outdated and could be removed completely.

When the respondents were asked which places that can be suitable for a UAV station Lorensson at Donsötank says "Singapore is a great place for document deliveries and where agents could be replaced by UAVs ". He also mentions that other places for a UAV station might be passages like Suez or the Kiel-canal. Källsson at Erik Thun AB thinks:

> Gothenburg could be good place for a UAV station. Though there are key for a triple helix approach. Where University, the government and industry must approach it together with a lead from the industry. The industry could be a large company, as for example SAAB.

Johnsson at Ektank says "places like Öresund, Belt or Kiel canal were ships passing close to shore can be a great place to have UAV station for delivery ". Westerberg at Stena Bulk AB answers that Singapore is a good place of implementation, but also Rotterdam, the English Channel and in the US gulf. Westerberg adds "Basically in very busy areas with vessels waiting".

Regarding locations fit for implementation, Hermansson at Tarbit Shipping AB says:

> Places like Gibraltar or Suez, The Gothenburg area and around Skagen, also at Råå in Helsingborg. At these places, launch boats are very busy and also limited in amount. Basically, locations with heavy traffic and that is close to shore will be good area to implement UAV deliveries.

5. DISCUSSION

The discussion is separated into three different parts. The first one, 5.1, discuss the method of choice. The second one, 5.2, discusses the validity, reliability and generalizability of the study. In the last one, 5.3, concerns the result of the research questions.

5.1 Method Discussion

Systematic review was conducted, since it was considered to be the best alternative for our kind of research and to provide solid background in order to answer the research questions. The literature was found by using acknowledged bibliographic finding tools online. Information about actual deliveries to ships at sea were limited and the information that existed was often found on company press releases.

To find a more generalized and applicable answer for our research questions, several shipping companies, relevant for our study were contacted and interviewed. These interviews were of semi-structured form and were conducted via telephone and in one case, via email. The authors chose this approach since it was considered to be a suitable method to investigate opinions, reflections and general attitudes of the respondents towards UAV deliveries. This aspect of semi structured interview could be considered both negative and positive since it resulted in large variety of answers. The structure also made it possible to further introduce the subject to the respondents and to clarify any questions. This was of great importance since the subject of the research was very new to the shipping industry and not known to all the respondents prior to contact.

This study cannot be fully generalized for all Swedish shipping companies since the ones included in our study mainly operates with tankers and dry bulk. Companies operating with e.g. liner shipping and traffic the same routes, several times a week, were not included in this study since the demand for the studied delivery method was estimated not to exist there due to the possibility of deliveries in port. This makes the statistical probability for the same data to reappear on a study conducted on other ship types less likely (Denscombe, 2017). Although, there are special requirements for tankers in the Safety of Life at Sea (SOLAS) regarding e.g. fire safety provision, since the risks are higher compared to dry cargo ships (International

Maritime Organization, n.d), making tankers representative for other ship types regarding minimum safety requirements.

With permission from the respondents, the interviews were recorded and summarized, which turned out to be a very time-consuming process. The respondents themselves decided to proceed with the interview via phone rather than in-person due to time efficiency. This form of execution was not considered to have any effect on the answers given.

For the interviews a more quantity-based approach was considered, in the form of questionnaires, but the authors chose not to proceed with this approach since it was of to strict form and would not allow the respondents to discuss and make further reflections. It became clear when summarizing the results that a stricter method would have been more efficient.

5.2 Reliability, validity, generalizability

Except for Scientific reports, other contributing literature was news articles and websites that were considered to be credible and reliable. Some sources from the literature research can be considered somehow bias since they could be used for commercial benefits in the future by proving UAV deliveries to be promising. However, most of these sources were backed up by real trials and had governmental support and was therefore considered more trustworthy.

For this study, eleven different Swedish shipping companies were contacted which all trades exclusively or partly with tankers. Out of these, five of them were able to take part in an interview. The representatives from each company had great expertise and experience in the shipping industry and their answers from the interviews were considered reliable.

The purpose of these interviews was to study the shipping companies' attitudes towards UAV deliveries to ships at sea. The limited number of interviews conducted makes it difficult to generalize the results for Swedish shipping in general. If more interviews would have been made with companies operating with different ship types, more generalization could have been made. Another contributing factor affecting the generalization of the study is that the fleets of the shipping companies participating, mainly consisted of tankers even though a big part of Swedish shipping is operating with tankers.

5.3 Result Discussion

The majority of the respondents recognizes the commonality that deliveries often consists of several pallets and due to limited lifting capacities, the common conclusion was that UAV deliveries could be a complement to shore-to-ship deliveries by launch boat but not a complete replacement. Some of the respondents thought it may be useful with a UAV when it comes to transporting documents and critical spare parts in passages or in places where ships are passing close to shore, in order to prevent time delays. This type of implementation was something the authors did not consider at first, but together with studied literature and interviews made, the demand for this became clear.

Some of the main benefits concluded from this study with UAV deliveries in comparison with launch boats, is the potential cost savings, faster delivery time, risk reduction and the reduced environmental impact. None of these benefits were surprising when considering the fact that UAVs are electrically driven, unmanned and transports by air.

One of the main challenges that could be found with deliveries by UAV was the lifting capacity. The majority of the respondents in our interviews answered that the capacity of a UAV was insufficient in regard to shore-to-ship deliveries. The authors considered this reasonable when making own reflections based upon personal experience. However, even though the respondents were provided with sufficient information regarding already existing technology, some answers indicated lack of knowledge about this. Since this information served the purpose to prepare and introduce the respondents to the thesis and the questions, the interviews sometimes became more difficult to execute and might have had significant impact on some answers. A clear example of this was the already determined opinion that UAVs had non-sufficient lifting capacity even though heavy duty UAVs capable of lifting 200 kg were presented before the interview by email.

Another challenge the respondents were concerned about was insurance question and who would be responsible if the UAV or cargo was lost. Information regarding this issue could not be found in the literature research and therefore could not be answered. This might have affected the respondents' attitude towards the delivery method in general and possibly the other questions asked.

Most of the answers given were based upon the assumption that UAVs used for ship deliveries were classified for explosive atmospheres, since the majority of the respondents operates and trades with tanker vessels. Classification for this has previously been made and the assumption was a necessity to be able to discuss further questions with the target group. Information about this was retrieved by literature research but in total, not much could be found. Since the market for this is relatively new and several companies most likely are working towards being able to offer the same type of services, it can be assumed that the lack of information regarding this is because of competition on the market.

The results from the interviews did not show any special correlation between what ship types the respondents operated with and their attitude towards UAV deliveries. Although when reaching out to some of the companies operating with tankers for an interview, the answer given in some cases included references to regulations regarding electrical equipment in explosive environments. This showed the importance of classification in explosive atmospheres but also the lack of knowledge about the present UAV development. This made us question whether the modern technology itself might be the barrier for implementation and not the specific classifications. This is also strengthened by how the shipping industry often is referred to as conservative and traditional.

6. CONCLUSION

Through the literature studies and interviews the authors were able to answer the research questions and draw conclusions from the result.

- Shore-to-ship deliveries to vessels at sea by UAV is a potential complement to traditional deliveries by launch boat, but not a total replacement.
- The main benefits for shipping companies with UAV deliveries compared to traditional launch boat deliveries are reduced costs, increased speed, less environmental impact and lowered risks for injuries.
- The main challenges for implementation of UAV deliveries in shipping was found to be the limited lifting capacity of UAVs, regulations, classifications regarding explosive atmospheres and the industry's conservative approach towards new technology.

6.1. Future research

Since this research is limited to Swedish shipping companies where the majority operates with tankers, it would be interesting to see future studies of companies that operates with different ship types, for example RoRo vessels or cruise ships.
It would be interesting to study future implementation of drone deliveries from an economical perspective and to investigate the potential savings of costs for resources and waiting time.
Since this study focused on deliveries to non-moving ships, future research could be of deliveries to ships underway.

Trials included in this research were conducted close to shore and therefore it would be interesting to study the possibility of making deliveries at longer distances.

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APPENDIX

Appendix 1 – Questions used for semi-structured interviews with Swedish shipping companies.

- How would you describe your own view on UAVs being implemented?
- Do you think UAV deliveries are something to be considered in the near future?
- What would it take for you to choose a delivery by UAV instead of launch boat?
- What do you consider to be the biggest challenges or risks with UAV deliveries?
- What do you think the main benefits of UAV deliveries could be?
- What do you think would be required for UAV deliveries to be fully implement in the maritime industry?
- Trials has been made in Singapore, which places do you think would be a good idea to implement stations?
- Do you think UAV delivery is a potential shore-to-ship replacement for traditional delivery by boat?