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A STUDY FOR THE USAGE OF UNMANNED AERIAL VEHICLES (UAVS) IN SALVAGE OPERATIONS

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ABSTRACT:

Maritime transportation has undergone many advancements including the upsurge of ship values, increase of cargo volumes on board and the current mega-sized ships introduced to cater for the increased global shipping trade and align with the rising market competition. To prevent damages to the vessels in distress and to the overall environment, there is a vital need for immediate and effective salvage responses, to minimize the impact of maritime casualties and provide specialist solutions. This research aims to reduce salvage time and provide accurate, reliable and safe to obtain bathymetric information. Researcher relied on obtaining the information from scientific material in books, international publications, articles and previous studies, available on the websites and approved for reference use. Data used as the footstone of analysis in this research is mainly from public statistics in studies and authorities for the year 2020.

Keywords: Drone, Efficient, Salvage Operations.

1. INTRODUCTION

Salvage operation challenges addressed in this research include: first, in spite of having detailed bathymetric seabed charts, these charts are either outdated or considered a limited property owners who have the ability and equipment to accurately measure the seabed status. Particularly for coastal areas, bathymetry is constantly changing due to diverse natural and manmade factors. Hence, repeated bathymetric data must be obtained to reflect such changes. Traditional bathymetric surveying methods are highly labor-intensive and dangerous; such as boat-based sonar surveys that are limited by shallow water or its inability to access certain areas, which may lead to missing information between the soundings and mislead salvors about the bottom features and depth information. second, salvors are exposed to various risks during their challenging salvage operations and while obtaining of bathymetric data, including unpredictable harsh weather and sea conditions, navigating difficulties in hazardous areas that expose salvors to risk of falls, hypothermic conditions, drowning, fires, collision, injuries or fatalities etc. resulting from heavy equipment or cargo, grounding. Third, the high costs associated with salvage operations due to the use of high-tech equipment, delivery boats and a human power (Shahmoradi, et al., 2020).

Referenced studies focused on current challenges facing the salvage industry due to this increase in ship size and volume, including the gap that has developed between the increasing size of vessels (mainly container ships, passenger vessels, bulk carriers and LNG vessels) and the capabilities to effectively deal with it in case of causalities. Other challenges include the unpredictable weather and sea conditions, expensive equipment and salvage vessels required and knowledge of the seabed data. Mega container vessels, cargo vessel, crude carriers, and cruise ships, if not well managed and planned during accidents, will eventually bring in more complex operations and costs to the maritime industry.

Salvors must have clear understanding of the vessel geometry, location, cargo on-board and human life's, in addition to, reliable and updated nautical charts that illustrate the soundings, seafloor features, waves, tides and depth curves. Salvage of ultra-sized ships also require the availability of large sized salvage equipment and tug boats able to handle such ship sizes and risks the life of salvors during hazardous weathers. All of which lead to longer time for salvors to deal with the causality, plan the salvage process and deal with the diverse unpredictable on-the-spot challenges and hence resulting in more costs (Zilakos et al., 2020).

Salvage industry capabilities and equipment have developed over the past years to adapt to the greater depths, increased challenges in the salvage of huge ships, cargo volumes, nature of casualties and pollution threats. Such developments included enhanced lifting equipment, hydraulic pulling systems and rams, higher bollard pull tugboats, improved communication networks, in addition to, the incorporation of robotics and remotely operated vehicles (Potterton, 2017).

Circumstances of salvage operations during ship accidents are usually challenging, due to the complications faced by salvors in obtaining accurate and reliable information on the features of water bodies and their shorelines, the risks associated with conducting ship status investigation in order to formulate and implement the salvage plan and the high costs of salvage specialized equipment and manpower. Such challenges magnified with the presence of ultra-large container ship casualties – both in the acute stage of the emergency and in the later operational phases (Martyn, 2017).

The salvage industry's focus has evolved from servicing the private sector, which stresses vessel and cargo safety above all else, to an aggressive technique of defending the global economy and environment from any harmful accidents. This new focus is the outcome of changes in the industry's interplay with other variables one of them is overall income from salvage operations has decreased, affecting the industry's investment in salvage equipment and vessels needed to handle mega-sized vessels carrying higher volumes of cargo and/or potentially polluting chemicals, and has limited traditional salvage companies' ability to manage timely responses, moreover The lack of well-structured and safe harbour capable of receiving mega-ships in trouble has also caused ship towing efforts to be delayed, Furthermore Delays in ship hull status examinations, vessel towing operations, and overall salvage operations, which raises the danger of environmental damage.

Such delays may arise as a consequence of unexpected weather, bad vessel state, machine-driven breakdowns of the ship itself, poor towing abilities, and dangerous dangers experienced by salvers as a result of weariness, inexperience, human mistakes, and inadequate communication lines. Adding to variables, delays in ship hull status examinations, vessel towing operations, and overall salvage operations, which raises the danger of environmental damage. Such delays may arise as a consequence of unexpected weather, bad vessel state, machine-driven breakdowns of the ship itself, poor towing abilities, and dangerous dangers experienced by salvers as a result of weariness, inexperience, human mistakes, and inadequate communication lines (AGCS, 2019).

This is in addition to the complex salvage efforts required in investigating large containerships and carrying out salvage actions such as ship lifting or refloating, as well as the increase in the volume of transported cargo and toxic chemicals that must be safely emptied to avoid pollution and environmental disasters. Along with, in coastal environments that experience continuous change in the patterns of energy dispersal and related sediment transport pathways, inadequate or outdated bathymetric data and nautical charts are required to formulate the salvage operation plan, identify accurate water current predictions, and underwater status (Anwer, 2020).

Detailed charts for coastal zones are currently regarded a limited property of regional or worldwide hydrographic agencies and are not shared with the public, or they have low resolution and obsolete information, which raises navigational dangers. This reduces the breadth, quality, and efficiency of salvage operations (Wölfl et al., 2019).

Besides, Salvage businesses have limited time and resources to undertake quick water depth surveys. Reduced water depth, increased risk for divers maneuvering in very shallow rocky and rough water areas, difficulty of navigation in narrow areas, lack of specialized salvage vessels due to their

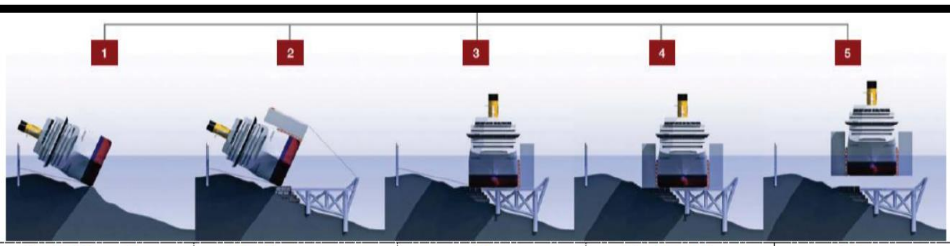
high costs and maintenance requirements, and a variety of challenges in seabed mapping using boats with remote apparatus are all factors that increase mapping time (AGCS, 2019).
It is critical for salvors to analyze seabed state, represent soundings, seafloor characteristics, and depth curves. For example, when a crane is used to raise a vessel out of the sea, it is critical to understand the boat's position, balance, and any places that might potentially break or cause injury to anybody onboard or the surrounding environment based on ship movement on the other hand, the task is expensive, difficult, and frequently takes place in treacherous seas, necessitating precision and surveying experience (NOAA, 2019).

Table (1) Classification of Salvage Operations with Risk Level and Techniques.

Type	*Risk Level*	*Technique & Equipment*
Offshore Salvage - The refloating of ships that are stranded or sunk in exposed coastal waters	Highest Risk Level - due to its exposure to opened & unprotected waters with hostile nature of waves, currents, weather etc., and vessel is prone to fast deterioration. High risks salvaging operations & exposes crew to fatal dangers.	Technique: Timely access to reliable information, accurate identification of the seabed, causality nature and evaluation of the operation constraints.
Equipment: Special salvage vessels, tugs, workboats with cranes and equipment, mobilized quickly for offshore salvage.		
Harbor Salvage - The refloating of ships that are stranded or sunk in sheltered waters	Medium Risk Level - they are not as time dependent as offshore salvages, because the weather and water conditions do not normally damage the boat, as fast as open waters do.	Technique: Clearing out the passage if required for clear navigation of the causality and seabed, if required.
Equipment: Floating cranes, barges and any required heavy equipment's and manpower		
Cargo & Equipment Salvage - Saving cargo & equipment is of higher priority than saving the vessel itself.	Highest Risk Level – Saving cargo and equipment on-board is a priority as it may pose an environmental hazard or include expensive materials	Technique: Rapid removal of goods includes deliberate dissection, disassembly or destruction of the hull.
Equipment: expensive materials such as machinery, motors etc.		
Wreck Removal - Clearing the seabed from hazards or wrecks that have little or no salvage value.	Low Risk Level –focuses on the removal of hazardous or unsightly wrecks that have little or no salvage value and hence has the least or no risk level.	Technique: wrecks are refloated or removed by the cheapest and most practical method, while hazardous materials are removed prior to disposing of the wreck.
Equipment: barges, tugs, cranes, accommodation barges and ancillary equipment		
Afloat Salvage - Salvage of a vessel that is damaged but is still afloat.	This type of salvage is mostly unobtrusive; it does not involve challenging exertions.	Involves damage-controlling, primary repairing tasks like the hull welding & stabilizing by rebalancing ballast tanks, shifting cargo & structural bracing.
Clearance - Salvage of casualties in a harbor or waterway, after catastrophic events like Hurricane, Tsunami, and War etc.	Variable Degrees of Risk / damage due to events like fire, collision, or explosions etc. most commonly takes place after severe weather conditions.	Shipwrecks are scavenged or removed coordinately to clear out the passage in a harbor or waterway that can be blocked for navigation by multiple obstructions.

Source: (Bartholomew, 2013; Duffy, 2018)

Last but not the least Capsizing – extreme motion of the ship and waves and sinking of salvage vessels occur for a variety of reasons, including a mismatch between the calculated Bollard pull (BP) – the tug's pulling capability – and the tug's actual operational BP, erroneous positioning of the tug relative to the assisted unit, overspeed of the assisted larger vessel or barge, and insufficient communication between the vessel (Freyermuth et.al., 2012).



Stabilization Phase	Underwater Support	Par Buckling	Refloating Phase	Post-Refloating
Understanding the event and keeping ship from being driven deeper aground.	Drilling 6 steel platforms into the granite ground floor.	Hydraulic jacks used to raise it upright, installed on the damaged starboard side.	Taking ship out of its position with minimum hull damage.	Controlling the refloated ship.

Figure (1) Phases of Costa Concordia Salvage Operation.
(Source: Smith et al., 2014).

Preparing for and responding to disasters and maritime causalities is a major logistical challenge, for which many organizations are now adopting the use of UAV (Drone) to enhance the efficiency of such responses. This research has explored the latest literature in the use of various types of drones in such operations, the different views supporting drones' integration in maritime salvage and wreck removal based on real case studies of the latest drone usage. It had provided salvors with immediate, accurate and updated data and has opened up a world of possibilities in collecting data, to complete a picture that was previously difficult and time-consuming to obtain and error-prone.

The cases illustrated in earlier, whether for the various maritime industry fields that have benefited from the integration of LIDAR sensors with UAVs or from analyzing the challenges faced in salvage operations that could have been resolved with the use of drones, revealed that drones provide close to real-time information within reduced time-frames and risks to salvors, which ultimately mean improvements in operations and results management, a better understanding of the dynamics of the environment and the overcoming of severe weather restrictions, such as clouds, that limit other remote-sensing platforms.

2. PROBLEM DEFINITION:

Dangerous missions performed by salvors demand continuous research and employment of new technologies to tackle the salvage mission challenges and ensure efficient information for formulating salvage plans. Situation of ships that are stranded or sunk in exposed coastal waters is the most vulnerable and very difficult to work on, due to their exposure to opened, unprotected waters and the hostile nature of waves, currents, weather etc. that hinders the salvage operations & exposes crew to fatal dangers. It also encounters rapid deterioration of the vessel and is time consuming, with limited ability to deploy bulk equipment's for the salvage usage.

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Due to the limitations of using UAVs (Drones) in Egypt, no real time experiments or interviews have been done to support the study, rather, international experiments, publicly available material and real cases have been mentioned:

a. ***The lack of updated or accurate nautical charts, especially in coastal areas, which limits the quality and efficiency of the salvage operations and leads to costly decisions***

In spite of having detailed bathymetric seabed charts, these charts are either outdated or considered a limited property for certain owners, who had the ability and equipment to accurately measure the seabed status. In addition, especially for coastal areas, the bathymetry is constantly changing due to diverse natural and manmade factors. Hence, repeated bathymetric data must be obtained to reflect such changes.

Traditional bathymetric surveying methods are highly labor-intensive and dangerous, requiring surveyors sometimes to swim and dive in the water, while boat-based sonar surveys are limited by shallow water or the inability to access a certain area, all of which may lead to missing information between the soundings and misleads salvors about the bottom features and depth information.

The latest mapping techniques of Airborne LiDAR or Satellites is much more efficient than ship-borne sounding methods and underwater photogrammetric methods, especially in shallower clear water areas, due to its ability to obtain features in coastal regions such as tidal levels, coastal dunes, rock platforms etc. but still involve high costs that are not affordable by all users.

b. ***The risks salvors face in performing real-time bathymetric mapping, investigating the ship in distress, performing towing activities etc.in addition to, the time and resources allocation.***

Salvors are exposed to various risks during the allocation and obtaining of bathymetric data, including unpredictable harsh weather and sea conditions, navigating difficulties in hazardous areas that expose salvors to risk of falls, hypothermic conditions, drowning, fires, collision, injuries or fatalities etc. resulting from heavy equipment or cargo, grounding.

c. ***The high costs associated with salvage operations due to the use of high-tech equipment, salvage and delivery boats and a number of human powers***

The Safety and Shipping review considered an imaginary worst-case scenario for a maritime casualty, involving collision and grounding of two vessels, followed by an environmental pollution. An approximate salvage cost has been estimated for several tasks such as wreck removal, cargo liabilities, bunker removal, litigation and crew liabilities (Figure 1-1). Both vessels have been considered as a constructive total loss with an estimated accumulated loss of 4 billion dollars (AGCS, 2019).

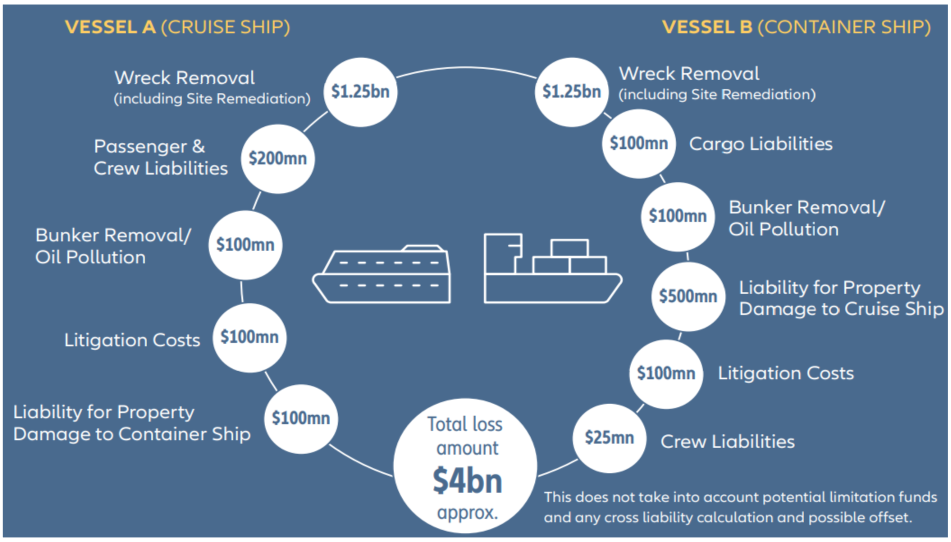

Figure (2) How a $4bn Loss Scenario Could Occur.
(Source: AGCS, 2019)

3. RESEARCH OBJECTIVES:

This research has focused on answering the following questions:

1. What are the major challenges facing salvors?
2. How will the use of Unmanned Aerial Vehicles (UAVs) aid salvors?
3. What are the current UAVs used in the maritime industry? Moreover, what are the major limitations of UAVs in various salvage missions?

This research aims to enhance the efficiency of salvage operations. Research objectives are follows:

1. To discuss factors required to accomplish the salvage mission, including equipment and expertise required.
2. To find out the challenges faced by the salvage industry that led to delayed responses and life-threatening risks on various shipping actors.
3. To present the possibility of solving these problems using Drone.

4. STUDY ANALYSIS:

Researcher depends on a descriptive analytical method; by obtaining information needed from scientific material in books, international publications, articles and previous studies available. Data used as the footstone of analysis in this thesis is mainly from public statistics in studies and authorities for the year 2020.

The majority of papers on drone integration have gone into detail about the technology's possible usage and future applications. According to studies, all stakeholders involved should consider the use of drones in salvage operations, including shipowners, the ship design industry, salvage business, liabilities and insurance companies (Olaf, 2019).

Drone projections, according to reviews, cannot rely on past data because their operation and reliability are based on immediate obstacles encountered during the salvage mission, which varies from mission to mission and cannot deliver consistent results. Experts have been able to identify the issues that have surfaced through the employment of drones in a variety of tasks, but these will continue to vary depending on environmental changes.

Replacing Traditional Salvage Methods with UAVs that can be remotely operated or fly autonomously based on pre-programmed flight plans to perform dangerous salvage jobs on ships and offshore structures, replacing large, expensive dedicated salvage equipment. Salvage activities are completed in a fraction of the time that traditional methods would take, and photographs are processed swiftly in the cloud, allowing for speedy judgments.

1- The challenges faced by salvagers in refloating the MV Höegh Osaka, where salvage tug boats were unable to reach the vessel in distress due to mooring ropes floating in the water surrounding the vessel stern and inclement weather, could have been resolved by using drone technology to connect the vessel tow lines, thus improving overall salvage mission efficiency, avoiding the need to maneuver in hazardous zones, and reducing the time required.

2- Workers suspended on ropes inspected the tank structure, focusing on areas of high stress such as stiffeners, brackets, bracing, webs, and stringers, and assessed the coating condition to check for corrosion and damage within the tank during the delayed inspection of the "Modern Express" vessel and visual inspection of cargo tanks. All of this could have been done in a fraction of the time by using collision avoidance and obstacle detection drones to remotely investigate the ship's interior condition and reduce the risk of life-threatening situations for salvors during their initial assessment and final implementation of the salvage plan.

3- Drones may have also been a useful tool during the examination of "Lady Emma," with all of the essential payloads attached and allowing the crew to see everything.

4.1 LIDAR Drones for Bathymetric Data

LIDAR sensors integrated in drones provide 360-degree visibility rotating around a dedicated axis with a powerful data collection engine that allows survey operators to collect both sensor types in real time, see the full picture above and underwater in 3D through the Real Time Cloud viewer, and thus maximize their LIDAR sensor investment by increasing the sensors' modularity. This is in addition to their obstacle detection, collision avoidance technology, and ability to carry various equipment such as cameras, Global Positioning Systems (GPS), navigation systems, and so on, allowing for the accurate detection of water depths at lower altitudes and slower flight speeds for large and difficult-to-reach water areas.

As a result, UAVs offer a cost-effective option for remote, small, and localized ALB studies. Combining aerial LIDAR with an IMU (inertial motion unit) and a GNSS receiver, which provide information about the position, rotation, and motion of the scanning platform with high relative accuracy, is required to achieve a high level of accuracy.

4.2 Drones for Surveying Tanks and Confined Spaces

Using a UAV (drone) to replace traditional methods for conducting high-risk and difficult tasks such as surveying tanks and confined spaces on ships eliminates the risk of damage to the coating, expedites survey tasks, reduces downtime, eliminates costly and time-consuming workarounds for surveyors, and allows for the investigation of huge tanks on ships that are more than 25 meters tall. Scaffolding, hanging staging equipment, and other specialized solutions, such as portable gas detectors, would have been necessary for such operations, all of which would have to be examined and approved for safety at a considerable expense (Iliaifar, 2018).

4.3 Reduced Costs during Salvage Operations

Using a single drone for a single salvage mission, along with the appropriate sensors and payloads, allows salvors to easily approach projects in areas that are difficult, dirty, or dangerous to access, while also overcoming the limitations of both ground-based and space-borne hydraulic observations and assisting salvors in various other mission tasks such as investigations, immediate image providing, and so on.

Drones have replaced a variety of equipment and are readily available to perform immediate missions, as well as risk reduction in the harsh maritime environment by eliminating the need for direct human presence in the area of inspection, reducing the likelihood of injury in high-risk situations, allowing work to continue uninterrupted in active work zones, and enabling data collection that previously required extensive groundwork or very expensive manned aircraft, in a cost-effective manner.

Future Steps for Incorporating UAVs in Salvage Operations:

Nowadays, UAV technology is expanding, and individuals have begun to see the technology's promise in a variety of businesses. Drones are adaptable and can perform a wide range of tasks. The usage of drones in salvage operations has become increasingly popular due to the high capital costs of specialist salvage equipment and the increased risks that salvors face. They have become commercially available because to significant cost reductions and better performance of practically all of their important sub-systems. In order to safely and efficiently introduce UAVs (Drones) into ship salvage operations, the salvage industry must be able to address and overcome the following obstacles:

1- The UAVs to be approved and legalized in home country as Before operating a drone for any reason in Egypt, permission must first be sought from the Civil Aviation Authority, according to Law No. 28 of 1981, which was updated to include drone laws by Law No. 92 in 2003. Drone use in Egypt is strictly regulated, and there are a number of Egypt drone rules and procedures that must be followed before and during flights in the country.
2- the incorporation of UAVs benefits the salvage industry financially (in terms of salaries, expenditure of time and equipment), while the available ship salvage budget greatly differs, locally between different salvage companies and internationally depending on the different country economies. However, as confirmed by all articles and studies, the drones' market will

highly increase over the next five years, fueled by increasing price competition and new technologies that make flying drones easier and cost effective. This will especially be applicable in the US and Europe markets due to their open markets and easier approaches to new technologies. In terms of reduced salvage operation costs that will be reflected by incorporation of drones, the following points summarize and confirm it through:

a. Drones are typically operated by one person without any extensive safety equipment, meaning the costs associated with the salvors salaries and equipment can be significantly reduced. Each salvage company may in that case calculate the cost of incorporating high-tech equipment versus incorporating UAVs to efficiently accomplish the mission.
b. Replacing salvage vessels with drones for emergency deliveries during salvage operations could help to reduce costs by up to 90% for vessel operations and ship managers. Wilhelmsen Ships Service (WSS) agency researches have revealed that launching a boat for ship deliveries would cost an average of $1500 - $4000 per hire, depending on port locations, while the use of drones for such missions may decrease the cost to $150 per hire or save the maritime industry an average of around $675 million (Martyn, 2017).
c. Using UAV technology to gather data for inspection purposes prior the implementation of salvage operations may also provide a potential saving of $1 million-plus daily savings, especially for certain oil and gas clients (Martyn, 2017)

3- Choosing UAV (Drone) technology and the corresponding LIDAR sensor would be beneficial for the salvage industry missions depends on the salvage operation case, environmental conditions, delivery terms, and budget among other factors. LIDAR manufacturers are developing lighter, more compact sensors suitable for this market (traditional sensors weigh 60-300kg), enabling UAV flight and leading to increased flight endurance. Turbidity is still a factor for depth performance and bottom detection, but with lower mobilization costs, end-users are more willing to test the performance in these environments.

4- The UAV (Drone) technology can be obtained in "Fugro", "RIEGL" and "ASTRALiTe" are all examples of companies which have recently developed sensors targeted UAVs. Drone technology already exists from big manufacturers such as "DNV-GL", "Lloyds Register" & "Maersk", who have already proved their ability to overcome several challenges and perform salvage operations efficiently, access difficult-to-reach areas safely, deliver real time data, ensure high accuracy and spatial resolution in monitoring surface water bodies, allow easier access and capturing volumes of highly accurate data at a limited cost and with high flexibility, and aid in the close-up inspection of hard-to-reach structures, rugged terrain, and remote sites, hence obtaining a clear picture of the casualty status and eventually being able to develop effective salvage plans. Martek Marine supplies drones for a range of applications, including tank and external vessel inspections, with high definition and infrared cameras and high collision-tolerance that can be used to safely access confined spaces. Overall, the choice of the drone and its corresponding payload will again depend on the type of mission, the tasks required and the available budget

5- Training will be required and should be implemented however The Salvage industry must develop a complete guide to drone purchasing/drone services based on the researchers' specific needs and on the legal requirements and limitations. The guide must then be distributed to all related salvage units and be coupled with offers to test flying drones in a safe environment. Interested researchers would be put in contact with an independent drone purchase advisor who would recommend the service or product most suited for the customer's need. While drone training is sometimes included with the purchase of more expensive drones, there are very limited training opportunities for those who wish to purchase a more specialized drone

4.4 UAV Benefits in Salvage Operations

Unmanned Aerial Vehicles (UAV) are currently used to provide real-time data in salvage operations including the inspection of physical structures, identification of buoys, pipes, docks, breakwater cranes, roof-ships and other structures maintenance requirements, calculation of (bulk) volumetric mass inventory, detection of irregular situations, leaks or abnormalities through (thermal and gas) sensors, provide accurate and quick detection of ship location and/or contamination, search and rescue operations and seabed mapping and surveying, especially when adding a GPS/INS sensors. These missions are accomplished without the need to risk salvors lives in hazardous situations (Frederiksen & Knudsen, 2018).

UAV contributed significantly to risk reduction by performing high risk tasks in a safe manner (such as inspections in dangerous areas), offering effective operation in harsh maritime environment with its ability to withstand storm force wind and heavy rain, snow and salt spray, without requiring direct human presence in the area of inspection, reducing the likelihood of injury in high-risk situations and enabling work to continue undisturbed in active work zones.

A LIDAR sensor mounted on a UAV, along with the LIDAR software can process images very quickly in the cloud, allowing for effective decisions to be made by stakeholders and relevant parties. The output from these LIDAR drones and sensors is outstanding. The pace of development and improvement in the LIDAR sensors over the past few years has been tremendous and will continue with more entrants into this sector (V. Klemas 2015).

Overall, UAV aids salvors and hydrographers in several ways; being an inexpensive and accessible method of obtaining point-cloud data and increased capability of maneuvering difficult environment, with no limitations as with bulky aircraft outfitted with LIDAR.

4.5 Challenges Facing the Use of UAVs (Drones) in Salvage Industry

The main challenges facing the UAV industry include (Duffy, et.al., 2018 & B. Custers et.al., 2016):

- Safety of its operations in crowded areas or at very low altitude and invading of privacy and security are factors limiting its official legalization in many countries.
- The need for users to have a full understanding of its operations, the sensors suitable for accomplishing each mission and the expertise in interpreting the resulting data efficiently by surveyors.
- In case of large oil tankers and huge cargo volumes, the pilots are surrounded by lots of steel, which negatively affects the GPS and magnetic compass accuracy (main equipment used to identify and aid the UAVs positioning), causing unpredictable UAV movement and vulnerability to any sudden shock or weather change.
- The harsh weather conditions (such as Tsunamis, Hurricanes, or terrorist attack) may also cause deviations and erroneous results, but is currently resolved by the introduction of shock resistant drones, able to face such difficult weather conditions.
- Energy consumption and battery operation used for hovering, wireless communications, data processing and image analysis, are limited by the drone type and the mission requirements but their limited operating time may still be a major drawback for extended periods of time over disaster-stricken regions.

4.6 Experiments Supporting Use of Drones in Salvage Operations

Replacing the need for human inspections, routine maintenance can be monitored remotely in real-time by surveyors, providing instant feedback to salvors and in turn, reducing costs, increasing efficiency and significantly reducing the risk to human life during initial response phase. UAV applications in salvage operations have been indicated in the following cases:

4.7 UAS Topo-Bathymetric LIDAR Surveys

Traditional survey methods for collecting bathymetric data in shallow water areas, such as Riverine environments, have proven to be highly labor-intensive and dangerous, as salvors had to swim and dive in the water to collect cross-sections of depth measurements, in deep or fast-moving areas. Boat-based sonar surveys used earlier, was limited by shallow water, rapids, or inability to access certain areas, such as "Whychus Creek", which is a remote stream that would be time-consuming to ground survey but was effectively and safely mapped with the BathyCopter.

The purpose of this project within this case was to evaluate the use of UAV platforms combined with interchangeable bathymetric and terrestrial laser scanning sensors, to support Riverine Mapping applications. This has been done by testing the Riegl's Bathymetric Depth Finder (BDF-1) and Riegl VUX-SYS laser scanning system, in three distinct riverine environments, on October 2015, at the Pre-Alpine River (Pielach in Lower Austria), by combining data about water depths and surrounding land elevation, out of which Bathymetric results have been presented.

Experiment was designed and executed to illustrate the accuracy range of UAV platform, reliable detection of water surface and resolution of the river mapping. A 200 m longitudinal section and 12 river cross sections were 51 measured with the BathyCopter sensor system at a flight altitude of 15-20 m above ground level and a measurement rate of 4 kHz. The 3D laser profiler points were compared with data acquisitions using the Riegl VUX1-UAV lightweight topographic laser scanning system (bare earth, water surface) and terrestrial survey (river bed). Logistical considerations of the project included evaluation of water clarity, movement obstructions (trees, powerlines etc.), sensor swap, ground trothing and drone battery life (Mandlburger et.al., 2016).

4.7 RIEGL's Remotely Piloted Ricopter Platform

The RiCopter's main features included offering a flight endurance of 30 minutes per battery, with batteries that can be quickly swapped to enable sequential missions at each location, offering a maximum flight altitude of 400 feet and continuous line-of-sight with the aircraft. Sensor system (Riegl BathyCopter) included a laser range finder, an Inertial Measurement Unit (IMU), a Global Navigation Satellite System (GNSS) receiver, a control unit, and digital cameras mounted on an Octocopter UAV (Ricopter).

The range finder operates on the time-of-flight measurement principle and utilizes very short laser pulses (<1 ns) in the green domain of the spectrum (λ=532 nm) for measuring distances to both the water surface and the river bottom. VUX-SYS is a topographic LIDAR sensor (=1064 nm) designed for UAV applications and has a field-of-view of 230 degrees and a PRF of 350 KHz. BDF-1 pulses a green laser (= 532 nm) at an 8 degree off NADIR look angle and a depth rating of 1.5 Secchi depths. The sensor has a pulse repetition frequency (PRF) of 4 KHz, but averages every 10 pulses, resulting in an effective PRF of 400 Hz. The UAV-based sensors were evaluated for their potential to efficiently collect channel geometry in areas where the water was not easily accessed or it was too dangerous to use ground- or water-based methods.

If planning to use drones in the future, it is important to focus on the changes to the regulations, improvements in technology (hardware, software and firmware) and advances in data collection methodologies and analysis, along with ensuring compliance with all regulations. It is also very important to have trained and specialized salvage teams to efficiently benefit from all drone features and specifications and allocate the suitable drone payload for each mission. On-going training and updated market knowledge are necessary to keep track of all drone advancements.

5. CONCLUSION AND RECOMMENDATIONS:

Drones are holding more roles in the maritime industry day after day and their growth in the commercial markets is expected to continue. Improving safety, providing instant data and accurate readings, reducing costs, speeding up processes and allowing safe operations are a few on much more benefits from incorporating drones in the maritime industry.

Authors found that; there are main challenges facing the UAV industry include:

A. Safety of its operations in crowded areas or at very low altitude and invading of privacy and security are factors limiting its official legalization in many countries.
B. The need for users to have a full understanding of its operations, the sensors suitable for accomplishing each mission and the expertise in interpreting the resulting data efficiently by surveyors.

C. In case of large oil tankers and huge cargo volumes, the pilots are surrounded by lots of steel, which negatively affects the GPS and magnetic compass accuracy (main equipment used to identify and aid the UAV's positioning), causing unpredictable UAV movement and vulnerability to any sudden shock or weather change.
D. The harsh weather conditions (such as Tsunamis, Hurricanes, or terrorist attack) may also cause deviations and erroneous results, but is currently resolved by the introduction of shock resistant drones, able to face such difficult weather conditions.
E. The drone type limits energy consumption and battery operation used for hovering, wireless communications, data processing and image analysis, and the mission requirements but their limited operating time may still be a major drawback for extended periods over disaster-stricken regions.

Authors recommended that:

- Governments and businesses should build necessary infrastructure to improve businesses.
- Efforts have to be made to make spectrum available for the usage of drone in order to accommodate the international usage od drone.

This research is limited, Due to the limitations of using UAVs (Drones) in Egypt, no real time experiments or interviews have been done to support the study, rather, international experiments, publicly available material and real cases have been mentioned.

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