

Multipurpose Drone Used in Emergencies at Sea

Dr. Meena Ravi Shankar¹, Mr. Ravichandran Thanigaiprabhu²

¹HR & Soft Skills Faculty, The Great Eastern Institute Of Maritime Studies

²Third Engineer, The Great Eastern Institute Of Maritime Studies

ABSTRACT

Drones are the future for almost in every industry, as its application is wide, remotely accessed also acts as “moving eyes”. As described it has entered in all industries lending their hands to maritime industries also. It can play a major role in maritime industry because marine sector has high risk and potential hazards as there are so many hidden places and places which can't be easily accessed by human (under water, enclosed spaces, cargo holds, cargo tanks, ballast tanks, ballast tanks containing water and so on). Unlike maintenance, and troubleshooting it can also be used in handling emergency situations, will be discussed, exploring the options and suggestions.

KEYWORDS: Drones-Future in maritime industry-Applications in emergency

1. Introduction

There is an explosive technological growth in the last decades with the invention of fifth generation of computers, added semiconductors gave rise to rapid growth with automation, software's leading to mobile phones & advanced automatic cameras. The innovation of cameras for the aerial view along with the aeronautical engineering led to new machine called Drones.

Drones are the beautiful invention though it started with massive UAV (unmanned Aerial Vehicle) for carrying the missiles during the world war. Moving next level for surveillance by adding the cameras with manoeuvring skills along with the remote operations, created a compatible eye with controlled brain, in a remote by human, made it appropriate in marine situations.

The curiosity to explore the seas has led to the invention of underwater drones. The availability of underwater drones had made its way into marine applications and situations,

Objectives of the Paper:

1. To analyse the impact of shipping activities on marine accidents and emergency situations and to find the technical and practical solutions using the drone technology
2. To explore the advancement of drone technology and to find the opportunities to use in the maritime industry

2. Drones types and applications

Drones can be classified based on sizes, medium of floating, type operating wings, capacities and based on applications

2a) Based on medium

Drone unmanned can be classified based on the medium it is flying or floating

- UAV (Unmanned Aerial Vehicles) Air Drones
- UUV (Unmanned Under water Vehicles) Under water drones

UAV- Air Drones

Air drones are micro and Nano unmanned helicopters with inbuilt camera can be manoeuvred using a remote or Artificial intelligence or coding (inbuilt instructions).

UUV-Water Drones

Water drones are micro and nano unmanned machines which can be propelled under the water and also in air using a remote or Artificial intelligence or coding

2b) Based on sizes

- Very small drones- micro drones
- Small drones
- Medium drones
- Large drones

Very small drones

Very small drones are also called as Nano drones comes between the sizes between 10mm to 500mm. these kinds of drones can be used for detection of flaws. It looks like a small bee; design is very complex and precise. It is rarely used in maritime industry.

Small drones

Small drones are slightly bigger than the Nano drones vary from 500mm to 2000mm. These are the compact drones can be widely used for several applications in several industries. These drones are handled easily which has wide applications on the maritime industry. It has normally fixed wings with two or four rotors

Medium drones

Medium drones are heavier drones which normally doesn't have much role in maritime industry. It can be used for larger photography and to carry products. It sizes above 2000mm and heavier in weight too.

Large drones

Large drones are almost similar to mini helicopter which is used to carry people and heavy objects in shorter ranges .It is mainly used in emergency situations and natural calamities to rescue people. These kind of drones are carried in small crafts and used for search and rescue operations

2c) Types of drones according to wing types

- Fixed wing drones
- Single rotor drones
- Multi rotor drones
- Hybrid drones(fixed wing and rotor)

Fixed wing drones

Fixed wing drones are like mini airplanes, this drone applications are limited as the manoeuvring is difficult but take-off and landing of the drones is made more comfortable and easy. Fixed wing drones can be used only on air (UAV) not on water (UUV).

Single Rotor drones

Single Rotor drones are like mini helicopter, these drones are the early invention with a remote access. It had only one rotor and it can be manoeuvred better than fixed wing drones.

Multi rotor drones

These are the drones invented to overcome the manoeuvring limitations, with two or four rotors which can even rotate in zero degrees. This excellent manoeuvring capacity had led to several applications in all

sectors. These drone’s rotors acts as propellers in under water drones leading to applications in maritime industry

Hybrid Drones

Hybrid drones are combination of both Multi rotor drones and fixed wing drones to mingle both the advantages of easy taking off and landing also to have excellent manoeuvring like multi rotor drones.

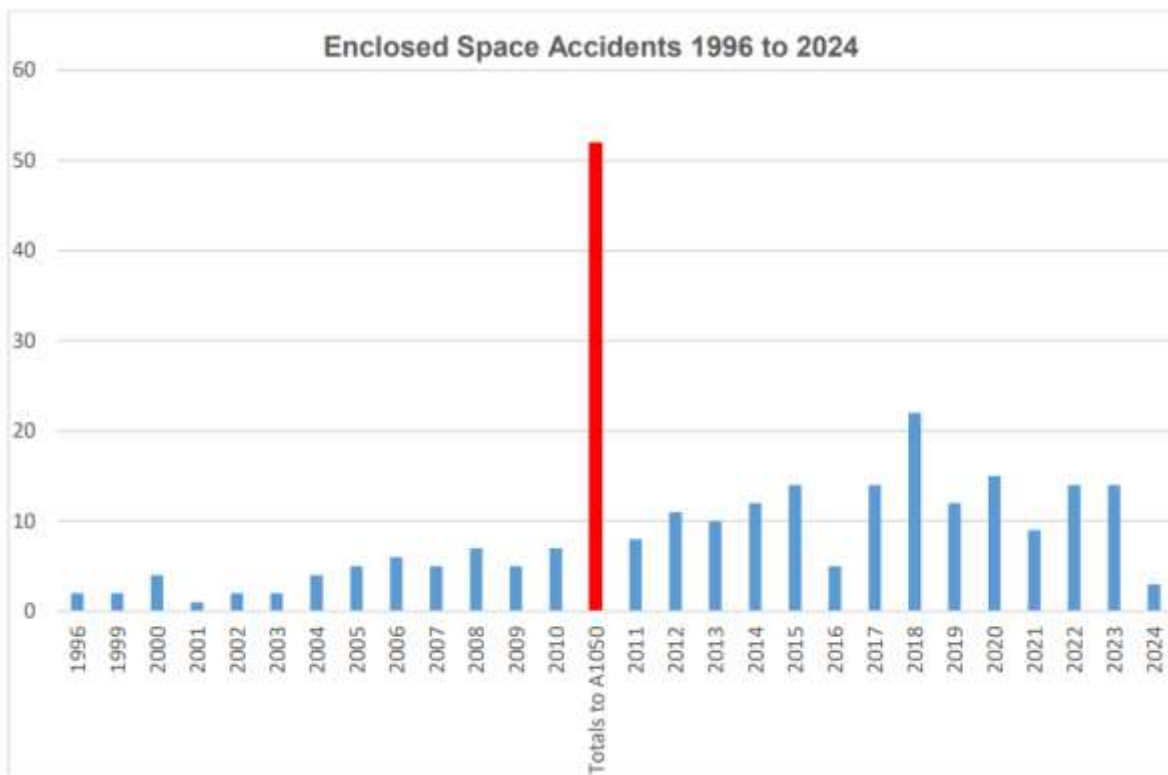
2d). Emergencies and Risks on board and solutions with drone applications

The maritime industry is challenging and high risk involved sector that starts from laying the keel till to the ship until it is sent back to scrap yard.

The risks on shore during the construction of the ship is reduced as the job is carried on the land. The more risk is involved, when the vessel is sailing, and maintaining during sailing or when the ship is at the sea. There are more risk to lives when human themselves involved in those operations like diving & tank inspection. So the technology inventions of drones help to mitigate the human error involved in high risk operations.

2e). Tank inspection

Tank inspection on the ship is routine and high-risk operation is carried out on almost all the vessels (Ballast tanks). Every company and yard has their own checklist to enter the tank with guidelines given by SOLAS, OCIMF, Class and Flag State.

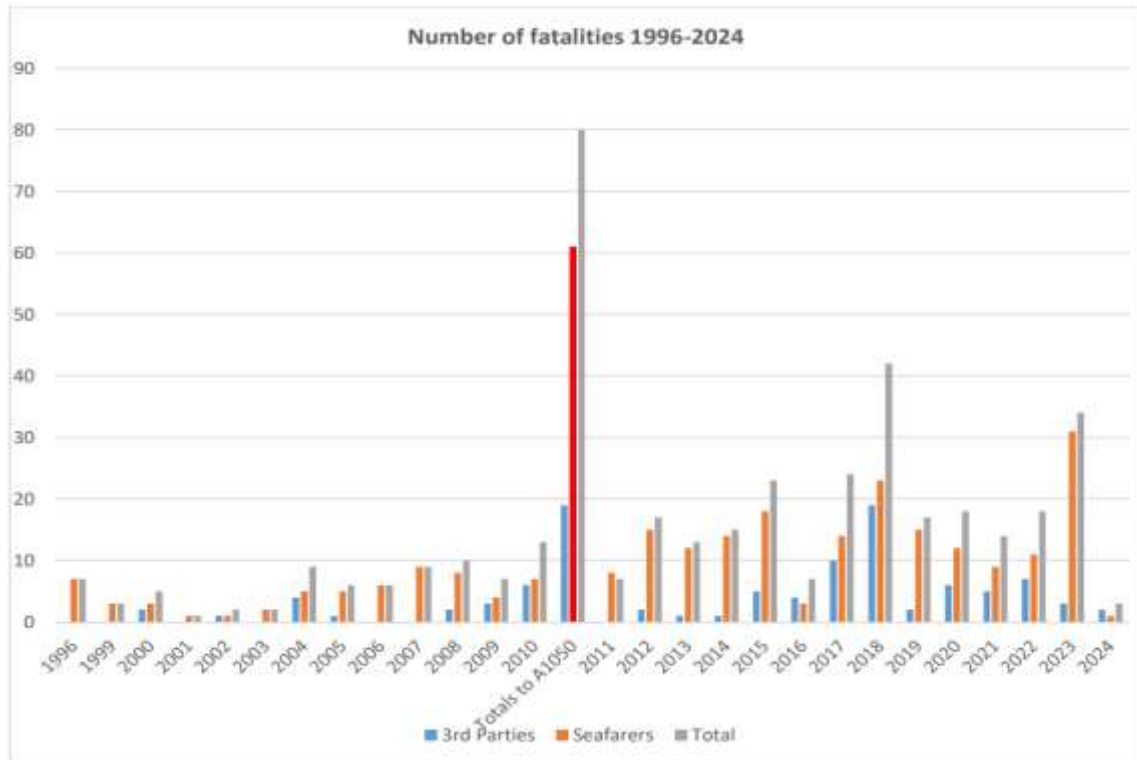


Data table:1 The vertical axis is the count of accidents, and the horizontal axis represents individual years. The red vertical bar indicates cumulative accidents that occurred before the introduction of the Assembly resolution on Revised recommendations for entering enclosed spaces aboard ships (resolution A.1050(27))./Credit: InterManager

The above graph states the number of fatalities over the years till 2024 happened during enclosed space entries. The number of fatalities during 2024 is rapidly dropped due to the several improvements and with

stringent rules practiced by the companies and constantly learning from the incidents. So many organisation like IMO, Flag states are continuously working to achieve zero accidents on board

Figure 2



The following colour key has been used:

- Buff – Seafarers who have died in enclosed spaces on board ships for the year indicated.
- Blue – Third parties who have died in enclosed spaces on board ships for the year indicated.
- Grey – The total number of seafarers and third parties who have died in enclosed spaces on board ships for the year indicated.
- Red – The totals from 1996 to the end of 2011, the time period prior to the introduction of the current Assembly resolution on enclosed spaces.

2e)i) Drones for Tank inspections.

So to avoid all these situations now a days companies are coming with a suggestion to go with remote operated or automated drone tank inspection. These can be operated from the top the tank with the remote monitoring systems. But there is a condition that the tanks designs should be suitable for the movements of the drones. Newly built ships are coming with easy access condition for the movement of the drones.

ii) Drones for assisting tank inspection and surveillance

There is difficulties in using these modern automated drones in the old designed tanks which comes with complex bulkhead designs still it can be operated with very skilled and trained professionals.



source:fiberscope.net

Pic: Drone for tank inspection (sky copter)

There are situations where one fatality was found inside the tanks and the watch keeping person entered without proper PPE and became a victim (This is called as emotional response). In these conditions drones can be used for additional monitoring of the persons under the tanks also the tanks can be inspected in layers (drones can be operated in layers as the old tank designs are quite complex) which can give the visual idea of the tanks as well as the persons inside the tanks.

iii)) Recently company has done the trail in real time

Case study carried out in a vessel named KLAVENESS, combination carrier voyage from New York to Bahamas, with a fully automated tank inspection using the “Scout 137 Drone system” without any human assistance. This fully automated tank inspection can be carried out in any number of intervals (not necessary one continuous process). So we can expect in upcoming days with more advanced technologies to cope up with old designs besides, assisting the humans who undergo tank inspections.

2 f). Drones for hull inspection

In recent days for cost cutting and with advanced systems, ship efficiency has increased by often inspection of hull, carried out by trained divers. This is also being done by Underwater drones to avoid the risk of humans involving in those operations. These drones are also approved by class. These drones can remove potential hazards instead of sending the person.

i). Drones for ballast tank inspection in ballast condition

The underwater drones can also be used for ballast tank inspection during the ballast condition itself. The ideas have been implanted to make use of the drones for emergency inspection of valve and tank conditions

3. Literature Review

S. Drone assisted device to device cooperative communication for critical environments. IET Communications, 2021. Kumar, P.Darshi, S., and Shailendra.[1] This paper proposes drone assisted device-to-device cooperative communication (DA-DDCC) for critical situations during post-disaster management. The proposed network utilizes the autonomous mode of D2D communication for setting up the link in the absence of a central node. This network incorporates cooperative communication using

drone in D2D session for improving reliability of the overall system. A probability-based statistical channel model for such networks is proposed by taking the statistical independence of links into consideration. Unlike the existing air-to-ground (A2G) channel models that use either Rayleigh or Rician distribution for uplink (UL) and downlink (DL) channel modelling, our approach takes the probability of occurrence of line of sight (LoS) into account while predicting the appropriate channel distribution for UL and DL separately. For performance evaluation of the proposed network, average outage probability and average capacity are derived using the proposed channel model. Monte Carlo simulations are conducted to verify our analysis. Moreover, a multi-cluster DA-DDCC scenario is also being analyzed through simulations from an interference perspective to justify the usefulness of the proposed channel model. Results obtained through this investigation can be utilized in selecting various crucial system parameters judiciously for enhanced performance during post-disaster scenario.

IJTSRD (2023). "Drones in Maritime Industry." International Journal of Trend in Scientific Research and Development.[2] Drones are remotely or autonomously controlled aircrafts that operate without a pilot. In the maritime industry, drones have found their place to provide an important function in the areas of deliveries, inspections of ships, and safeguarding national security. Drones are increasingly used in the maritime industry for a variety of tasks, including inspection, security, search and rescue, and environmental monitoring. The maritime industry and Navy deploy maritime drones for patrol, reconnaissance, and surveillance. Drone technologies will significantly enhance safety and security in and around ports. Drones are already solving some of shipping's greatest inspection challenges at sea. This paper examines the various uses of drones in the maritime industry.

4. Methodology

4a). Drones for painting to avoid working aloft condition

The drone technology has emerging with ideas and trails for routine painting for aloft conditions and hull structures. Painting is the major routine on the vessels to be carried out almost every day. The painting on the heights like funnel deck, hull structures on the sides. The arrangements and preparations for painting these heights take huge amount of time and man hours with risks involved (making scaffolding, weather conditions). These could reduce the risk of humans involving in the painting especially on the funnel decks and hull structures which is required for the better running of the vessels.

4b). Drones for Fire fighting

All the ships are constructed as per SOLAS regulations with fixed firefighting systems. Now a days, ships are equipped with automatic operated hyper mist systems.

Also fire alarms are fixed to monitor the ship's (engine room/ accommodation) condition all the times to avoid the fire at any point of time. So, in case fire occurs as per emergency plans fire fighters (in pairs) with all safeties (fire suit, shoes, walkie talkie, helmets, SCBA) enter the zone to fight the fire and access the situation in the space and with captains instructions fixed firefighting system is activated after everybody is evacuated from that space.

Drones can be employed for these firefighting purpose instead of persons, either remotely operated or automated. These firefighting drones are fixed with thermal cameras to detect the aerial view of the surroundings.

There are challenging conditions on board, few times the integrity of fire detection system is questioned with some false alarms due to sensor failures. In those conditions drones can be employed to access the conditions in quick time (live) without risking human lives and along with firefighting mediums.

The interesting and crucial part is accessing the conditions after the fire is extinguished as there are always more chances for the fire to re-ignite after extinguished, and chances of ingress of air while entering the isolated or extinguished zone.

Instead of allowing the humans to access the situations drones can be employed with thermal mapping and live streaming to find the inside condition of the area which is safer and more reliable as we are visualizing the real time conditions.

4c). Drones for security purposes.

Drones, as it unmanned aerial vehicle it can be used for surveillances as well, the question is, in what way these can be better than the fixed cameras on board (in recent days companies are installing the cameras as well). Here comes the answer as the drones are moving eyes. It can do surveillance in the places where ever we require. There will be some unseen places in the fixed camera, such as on the bulkheads of the ship.

We have seen the cases of theft occurring from the ship's sides in few ports. Also, some strange illegal activities using the ship, by fixing on the ship's structures without the knowledge of crew.

Those situations can be avoided by using UAV (unmanned Aerial Vehicles) and UUV (Unmanned Underwater Vehicle) while carrying out the inspections by the ship crew, before entering and leaving the risky ports.

5. Recommendations

a. Motivating the young researches to explore the options in Maritime sector

- Motivate young researchers to find practically solutions from drone technology in the maritime sector

b. Identify the places where drones can be employed in high risk areas

- Try to identify the places or applications where drone can be used instead of human in high risk areas, to mitigate the fatalities.

c. Carry out trials with drones

- Carry out trails with drones, and take feedbacks to identify the practical difficulties also to achieve class approvals to move forward with technology.

d. Training to the crew and making use of AI

- Establishing the training to crew and companies very important to have the maximum output from the instrument, also establish AI technology to have trouble shooting system from shore

e. Companies to encourage through sponsorship program

- Companies to encourage through sponsorship program to identify the advancement trails to find the Gray areas in the technology

f. Increasing the life of batteries used in drones

- There are few crucial things in operating the drones, major part is life of the battery inbuilt in the drones, which determines the quality of operations and time of operations. In case of emergencies the extended operation time could be more helpful.

g. considering tank spaces with simple designs

- Upcoming ship designs should be considering the ease of access of drones, which can lead to comfortable access by the crew

6. Conclusion

The maritime sector, which demanding technologies advancements started adopting with newer technologies. Drones will be unavoidable medium to work in emergencies or to avoid emergencies. It plays a major role is reducing the huge amount of man power and very high-risk factors involving humans. There are few limitations to overcome factors like weather in both UAV and UUV (weather, wind, heat, battery type and life etc in case of UAV and under water currents, marine organisms, temperatures of water, battery type and life oceanographic structures in case of UUV), also to be consider the training of the crew and ease of operations should me made user friendly. This communication can be assisted using IoT(internet of Things) from shore and with more advanced developments.

There are different kind of drones as stated which can be used for the several applications to fire fighting drones, hull inspection drones, painting drones, ballast tank inspection drones, surveillance drones. But in future these drones can be used for minor maintenances as well underwater which will be a great leap for the maritime industry.

7. References

1. IJTSRD (2023). "Drones in Maritime Industry." International Journal of Trend in Scientific Research and Development. Available at: <https://www.ijtsrd.com/papers/ijtsrd97093.pdf>
2. World Maritime University (2023). "Remotely Piloted Aircraft Systems in the Maritime Sector." WMU Dissertations Collection. Available at: https://commons.wmu.se/cgi/viewcontent.cgi?article=3127&context=all_dissertations
3. Demol Bartosz (2016). "The use of drones in the maritime sector – areas and benefits." (in Polish, with English summary). Available at: <https://bibliotekanauki.pl/articles/2033624.pdf>
4. M. J. Irwin & T. A. Parks (2024). "Development Of A Drone-Based Surveillance System For Monitoring Maritime Traffic." IJCRT. Available at: <https://www.ijcrt.org/papers/IJCRT2405689.pdf>
5. Flyability (2024). "Exploring Maritime Drones: Uses & Benefits." Flyability Industry Blog. Available at: <https://www.flyability.com/blog/maritime-drone>
6. Transport Development (2023). "Modern Ships and the Integration of Drones – A New Era for Marine Communication." Available at: <https://journals.onmu.in.ua/index.php/journal/article/view/277>
7. MDPI/Engineering (2023). "Applications, Evolutions, and Challenges of Drones in Maritime Transport." Available at: <https://researchonline.ljmu.ac.uk/id/eprint/23827/>
8. IEEE Xplore (2022). "Maritime Drone Services Ecosystem—Potentials and Challenges." Available at: <https://ieeexplore.ieee.org/document/9858251>
9. ASME (2024). "Blog: Drones Deliver in the Maritime Environment." ASME Topics & Resources. Available at: <https://www.asme.org/topics-resources/content/blog-drones-deliver-in-the-maritime-environment>
10. Depalo, S. (2023). "Applications of Unmanned Aerial Vehicles In Maritime Transportation Industry: A Scoping Review." SSRN. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4334518
11. Ioannidis, J.P.A., Boyack, K.W., and Baas, J. Updated science-wide author databases of standardized citation indicators. PLoS Biol, 2020. 18 (10): p. e3000918
12. Organization, I.M., Integration of Drones in Marine Communication Systems: Opportunities and Challenges. 2023.

13. Zhang, R., et al., Survey on Deep Learning-Based Marine Object Detection. *Journal of Advanced Transportation*, 2021. 2021: p. 5808206.
14. Zhao, J., et al., Integrating Communications and Control for UAV Systems: Opportunities and Challenges. *IEEE Access*, 2018. 6: p. 67519–67527.
15. Ferreira, F., and Mišković, N. Operating drones at sea – maritime law implications. in *OCEANS 2022, Hampton Roads*. 2022
16. Bloom, D., et al., Drones detect illegal and derelict crab traps in a shallow water estuary. *Fisheries Management and Ecology*, 2019. 26 (4): p. 311–318.
17. Wang, Y., et al. Maritime Object Detection based on YOLOx for Aviation Image. in *2022 International Conference on Artificial Intelligence and Computer Information Technology (AICIT)*. 2022.
18. Alsamhi, S.H., et al., UAV Computing-Assisted Search and Rescue Mission Framework for Disaster and Harsh Environment Mitigation. *Drones*, 2022. 6 (7): p. 154.
19. Li, Y., et al., GGT-YOLO: A Novel Object Detection Algorithm for Drone-Based Maritime Cruising. *Drones*, 2022. 6 (11): p. 335.
20. Yu, G., Ding, X., and Liu, S. Joint Resource Management and Trajectory Optimization for UAV-Enabled Maritime Network. *Sensors*, 2022. 22 (24): p. 9763.
21. Liao, Y.-H. and Juang, J.-G. Real-Time UAV Trash Monitoring System. *Applied Sciences*, 2022. 12 (4): p. 1838
22. Seo, J., Duque, L. and Wacker, J.P. Field Application of UAS-Based Bridge Inspection. *Transportation Research Record*, 2018. 2672 (12): p. 72–81.
23. Kumar, P., Darshi, S., and Shailendra, S. Drone assisted device to device cooperative communication for critical environments. *IET Communications*, 2021. 15 (7): p. 957–972.
24. Pinto, L.R., et al., Radiological Scouting, Monitoring and Inspection Using Drones. *Sensors*, 2021. 21(9): p. 3143.
25. Colefax, A.P., et al., Reliability of marine faunal detections in drone-based monitoring. *Ocean & Coastal Management*, 2019. 174: p. 108–115.
26. (EENA), T.E.E.N.A., *The Role of Drones in Emergency Response*. 2021.
27. Xie, W., Tao, H., Gong, J., Luo, W., Yin, F., & Liang, X., Research advances in the development status and key technology of unmanned marine vehicle swarm operation. *Chinese Journal of Ship Research*, 2021. 16: p. 7–17.
28. Butcher, P.A., et al., Beach safety: can drones provide a platform for sighting sharks? *Wildlife Research*, 2019. 46 (8): p. 701–712.
29. Akram, T., et al., Multicriteria UAV Base Stations Placement for Disaster Management. *IEEE Systems Journal*, 2020. 14 (3): p. 3475–3482.
30. Ahn, H., et al. Real-Time Drone Formation Control for Group Display. in *Proceedings of the 13th International Conference on Ubiquitous Information Management and Communication (IMCOM) 2019*. 2019. Cham: Springer International Publishing.
31. Boviatsis, M., and Vlachos, G. Sustainable Operation of Unmanned Ships under Current International Maritime Law. *Sustainability*, 2022. 14 (12): p. 7369.
32. <https://safety4sea.com/intermanager-raises-alarm-on-enclosed-space-deaths/>
33. <https://www.scoutdi.com/automated-drone-inspections-at-sea-a-glimpse-into-the-future/>
34. <https://www.flyability.com/maritime-drones>