Loitering Munitions – The Threat to Merchant Ships

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Contents

Glossary

Anti-radiation seeker A sensor designed to detect and home in on a specific electronic emission source.

Best practice OCIMF views this as a method of working or procedure to aspire to as part of continuous improvement.

Countermeasure An action taken to counteract a threat.

Drone The common name for any unmanned aerial vehicle.

Fixed wing An aircraft, such as an aeroplane, which is capable of flight using wings that generate lift caused by the vehicle's forward airspeed and the shape of the wings.

Guidance Provision of advice or information by OCIMF.

Intelligence, surveillance and reconnaissance operations The use of an Unmanned Aerial Vehicle (UAV), commonly known as a drone, to observe, track, understand, and/or document the positions and/or movement of friendly assets, particularly to collect targeting and other information to support an attack.

Jamming A form of electronic countermeasure that intentionally sends out radio frequency signals to interfere with the operation of radar by saturating its receiver with noise or false information.

Loitering munition A weapon system in which the munition (drone) loiters around a target area for some time, searches for targets, and attacks once a target is located. Also known as a suicide or kamikaze drone.

Operator Remote pilot or person manipulating the mission parameters to control the flight path or other behaviour of a UAV.

Payload Additional components which the drone is designed to transport under specified conditions of operation, in addition to its unladen weight.

Recommendations OCIMF supports and endorses a particular method of working or procedure.

Rotary wing An aircraft that is lifted or propelled by rotating aerofoils.

Spoofing The act of disguising a communication from an unknown source as being from a known, trusted source.

Unmanned Aerial Vehicle Commonly known as a drone. An aircraft with no human pilot, crew, or passengers on board.

Warhead The forward section of a device that contains the explosive agent or toxic material that is delivered by a missile, rocket, torpedo or bomb.

Abbreviations

AIS	Automatic Identification System
BMP	Best Management Practice
CENTCOM	Central Command
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IMO	International Maritime Organization
ISR	Intelligence, Surveillance and Reconnaissance
LM	Loitering Munition
SOLAS	International Convention for the Safety of Life at Sea
UAV	Unmanned Aerial Vehicle
VHF	Very High Frequency

1 Introduction

Over the past decade, the use of Unmanned Aerial Vehicles (UAVs), commonly known as drones, has grown. As technology advances, its uses become wide-ranging and this brings both positives and negatives for the maritime industry. Drones have successfully reduced risk in operations such as tank inspection. They have shown flexibility in their use, for example in delivering stores, monitoring operations or in maritime surveillance. The focus of this paper is on the drones increasingly being used to carry munitions designed to cause harm.

Loitering munitions (LM) are a form of UAV with a built-in weapon and the capability to loiter (wait passively) in the target area until the target is located. The number of LM attacks against both civilian and military targets in the Middle East and North Africa has risen, and since 2021 merchant ships have been targeted. The maritime industry has experienced several attacks, thought to be by state actors using LM. These attacks have generally occurred in the Arabian Gulf, the Gulf of Oman and the Arabian Sea. The global proliferation of these rapidly advancing autonomous technologies, to both state and private actors, poses a new and rising security risk to commercial shipping. This is likely to continue for the foreseeable future.

This information paper covers:

- The threat posed by LM such as the Shahed-136, which has been used against commercial vessels.
- Operational characteristics and trends related to the employment of these systems, and the technical characteristics of LM.
- Considerations, including guidance for best practices.

This paper does not include information about drones used for inspection, monitoring, or deliveries. It does not cover the effectiveness of any commercially available onboard defence system or use of private maritime security companies. There are regulatory issues surrounding the use of counter-drone processes that should be considered by any operator employing security personnel or equipment for this purpose. These systems or the use of weapons will require Flag State authorisation, legal, ethical, and competency considerations.

1.1 Methodology

This information paper uses technical details gathered by a study commissioned by OCIMF and produced by global risk analysts Sibylline. The study leveraged a variety of information sources and discussions with experts. The findings and considerations presented in this report originate from news outlets, declassified intelligence reports, international legal texts, social media intelligence and imagery, as well as academic studies. Experts, including airpower and air defence specialists, have corroborated the findings, as well as persons with direct experience and knowledge of the events discussed using opensource information.

1.2 Key findings

- In the event of an LM attack, there is limited action a ship's crew can take.
- LM pose a notable threat to commercial shipping. Recent attacks highlight the overall low-detectability and effectiveness of these platforms in targeting stationary and moving targets, both during the day and night and in most weather conditions.
- The proliferation of military grade drone technology to state and private actors confirms the need to consider countermeasures and best practice to mitigate the security risks. As conflict drives development of these new technologies, use beyond the Middle East in the maritime environment is likely.
- Switching off Automatic Identification Systems (AIS) may make a ship more difficult for a drone to detect, but is unlikely to ultimately prevent an attack. The presence of cameras and other sensors onboard the LM would counter such mitigation efforts, as the LM may still be able to track and target a vessel without its AIS active.
- Commercial systems to counter LM are being developed.

2 Introduction to loitering munitions

Loitering munitions (LM), are often referred to as 'suicide' or 'kamikaze' drones. These are unmanned aerial weapons that loiter over a predesignated area before hitting a target. The size of an LM, its payload, warhead, and operational range can differ, allowing for a variety of options and capabilities to conduct attacks. They are designed for single-use missions and were originally deployed by military forces for the suppression of enemy air defences. The first LM emerged in the 1980s, becoming more popular in the 1990s and 2000s. Recently LM have been used in Nagorno-Karabakh, Yemen, Saudi Arabia, Iraq, Syria, and Ukraine by both state and non-state actors against military and non-military targets. Since 2021, they have been used against merchant ships. Given the low cost and availability, this technology is expected to be more widely used and will remain a safety and security threat for the foreseeable future.

3 The threat

The Shahed-136 has been identified as the LM most commonly used against merchant ships operating in the Middle East. According to US Central Command (USCENTCOM) and media reports, the Shahed-136 was used for the first time between September and December 2020 in Yemen. Since then, the Shahed-136 and its smaller variant, the Shahed-131, which has similar characteristics, have occasionally featured in media and propaganda videos. US CENTCOM and the Defense Intelligence Agency confirmed the Shahed-136 was used against the tanker MT Mercer Street in July 2021. The Shahed-136 has been used by military forces in various locations, including Ukraine, Iraq and Syria, showing the extent of its availability.

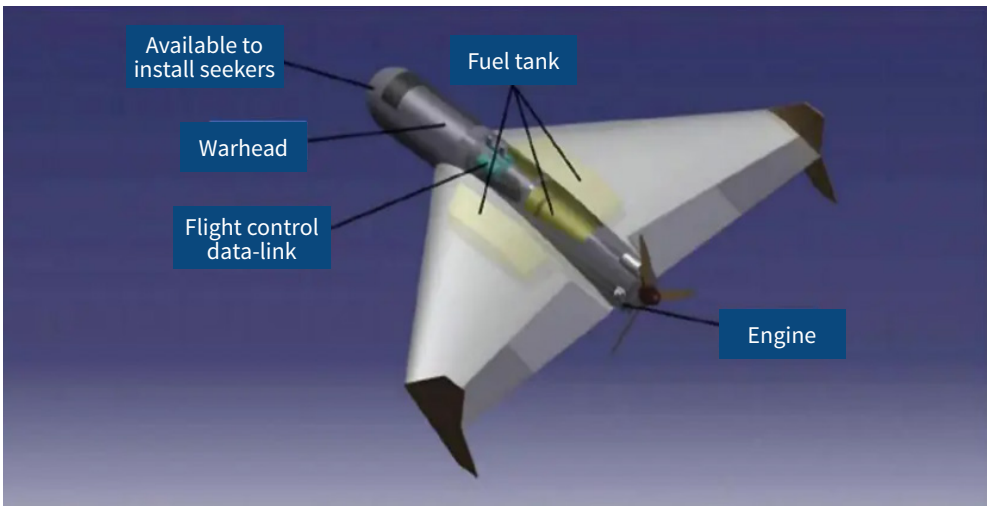


Figure 3.1: *Characteristics of the Shahed-136*

The Shahed-136 is a rudimentary but highly effective LM that uses commercial off-the-shelf technology. The Shahed-136, and its smaller predecessor, Shahed-131, are distinguishable from other similar-sized LM by their delta-shaped design and circular, protruding nose. The Shahed-136 can be distinguished from the Shahed-131 by its larger size and the wing stabiliser.

Shahed-136's main characteristics include:

- Delta-wing design gives it a low radar signature, which when combined with a low altitude flight profile (max 1,000m) makes detection by a commercial radar difficult.
- Main body is composed of composite material (including plastics and carbon fibre) and the engine's propeller is made of wood.
- Light mass gives an extensive flying range (estimated to be as much as 1,800 nautical miles or around 3,330 kilometres), posing a notable threat well beyond its launch point.
- Can be launched from containers on a truck or a ship. Launch from a ship vastly increases the deployment area.

- Despite low radar profile, the acoustic signature of the MD550 engine sounds like a motorcycle, making it possible to detect. Some nickname it 'the flying lawnmower'. The engine also gives off a thermal signature which might be detected by thermal devices.

3.1 How do loitering munitions find and fix on merchant ships?

The forward section of an LM is modular and can be equipped with a variety of sensors. These include electro-optical/infrared (EO/IR) sensors or laser-spot trackers (LST). Each sensor would require a different secondary guidance source, such as another drone in the air to help track and lock onto a designated target. For example, if equipped with an LST then a 'buddy laser' from another aircraft is necessary. A ground or vessel-based station could also use laser markers. According to open-source information, the Shahed-136 used against merchant ships did not feature any additional sensors or a laser seeker. LM usually have an inertial navigation system (INS) and potentially onboard sensors connected to a Global Navigation Satellite System (GNSS), such as GPS or GLONASS. According to images released in November 2022, the Shahed-136 used to attack MV Pacific Zircon featured a GNSS receiver. Real-time navigation via GNSS improves the LM accuracy and may allow human operators to manually alter target coordinates and flight path in real time. The Shahed-136 is thought to benefit from connections to the commercial satellite communication networks. The flight control unit found in a Shahed-131 during the Russia-Ukraine conflict featured this capability. It may be that operators controlling the Shahed-131/136 LM connect via satellite communications to alter the path mid-flight, improving target tracking and accuracy functions. Communications are likely to be lost once the LM begins its final steep dive to the target.

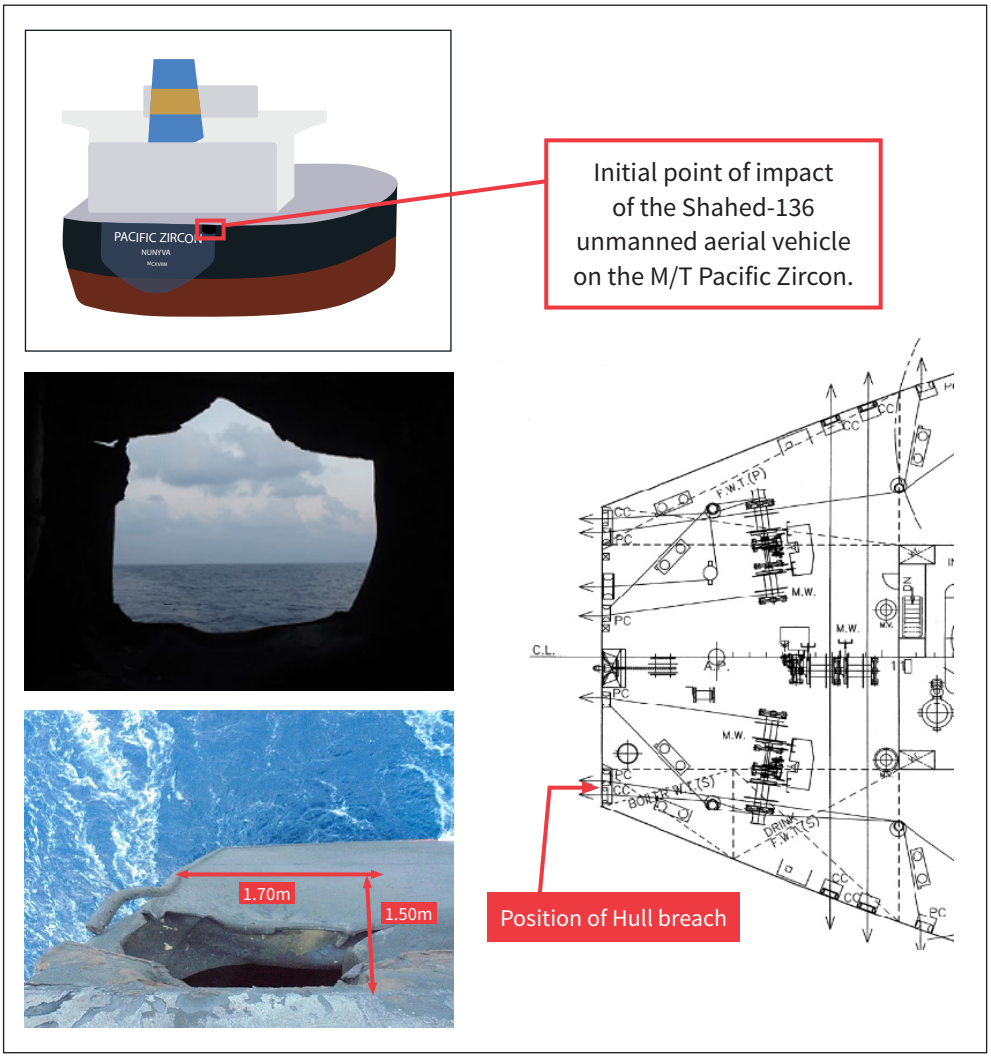


Figure 3.2: *The attack on Pacific Zircon*

LM may also have an anti-radiation seeker. The anti-radiation seeker, which is usually pre-set, allows it to track and target moving objects day and night and in all weathers. Technical capabilities of anti-radiation seekers are not known, but operational successes indicate they can detect any commercial radio frequencies. Despite lacking advanced optics and sensors, the anti-radiation seeker provides an alternative homing mechanism. During its loitering phase, it searches for a corresponding radio signal, either a specific radio frequency or a manually-input frequency range. This allows it to fix onto and home-in on its target.

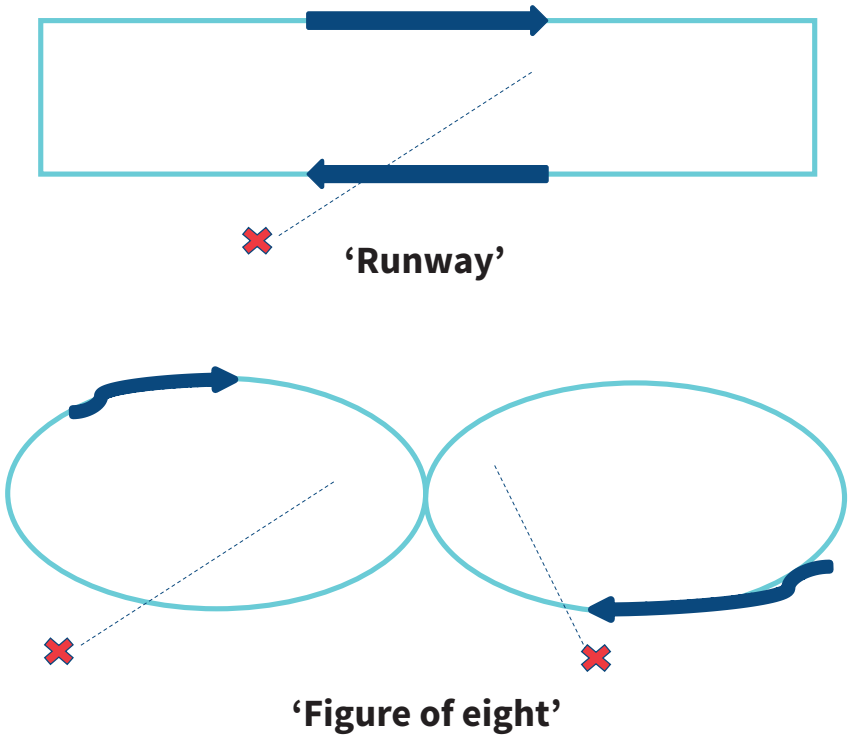


Figure 3.3: *The most common flight patterns followed by loitering munitions. After detecting its target(s), the LM would home-in on it following a top-attack method.*

4 Operations against merchant ships

It is likely that LM use a variety of intelligence sources to locate, identify, and track civilian target ships, making it difficult for ships to avoid detection. These efforts may be aided by open-source information available on multiple online platforms that offer maritime tracking services, including complete histories of ship's journeys. Some platforms also offer 'route forecast' functions, indicating a ship's expected coordinates throughout its journey. An element of this may be cyber-related, such as the exploitation of communications vulnerabilities. It might be possible for a foe to exploit these sources to estimate a ship's position.

It is likely that additional drones and/or ships are deployed to relay valuable data back to the drone operators. Reconnaissance drones fitted with visual aids could precede the Shahed-136 and be present in the airspace near the target ship before and/or during the attack. Witness accounts have corroborated this claim. Such drones would likely observe the operation by providing visual confirmation of the target to the operators.

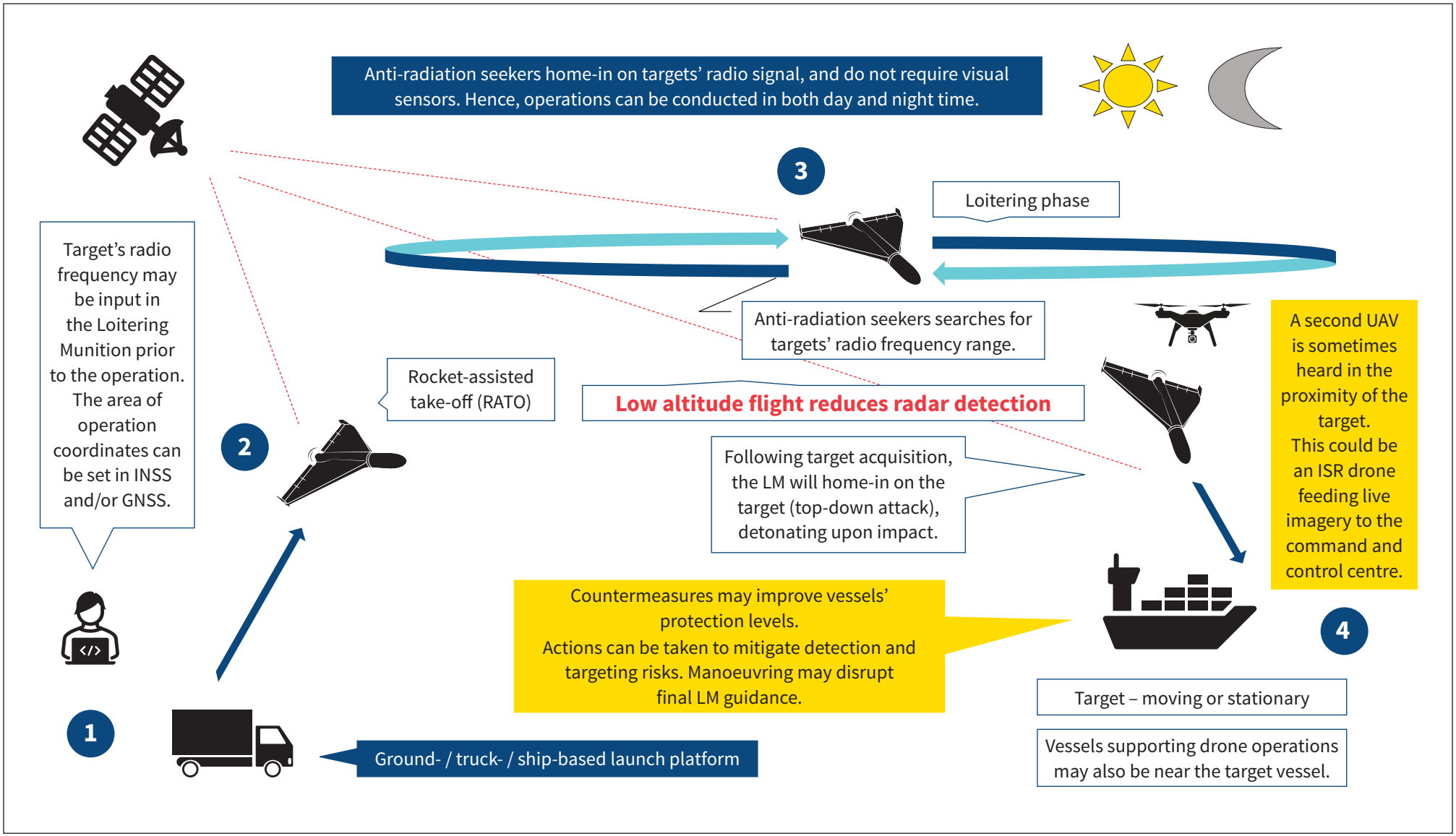


Figure 4.1: *The flight stages of an LM, its guidance and targeting process*

5 Considerations for Automatic Identification Systems and radio regulations

International Maritime Organization (IMO) Circular A1106 (29) para 22 outlines the use of AIS. It states that, 'if the Master believes that the continual operation of AIS might compromise the safety or security of his/her ship or where security incidents are imminent, the AIS may be switched off'.

Open-source information on vessels and their movements combined with state level collection capabilities enables threat actors to exploit ships' AIS, radar and communications data to track, target, and potentially attack them.

The International Convention for the Safety of Life at Sea (SOLAS) requires ships to be fitted with a very high frequency radiotelephone station capable of working on frequencies between 405-535 kHz, with the transmitter being capable of having a range of 75-150 miles. Ship specific international maritime radio channels, frequencies and radars are available and exploited by threat actors.

6 Observations

1. The MT Mercer Street incident indicates LM targeting used AIS transponder data. However, the MV Pacific Zircon was still attacked despite AIS being switched off. It is possible that historic AIS voyage data was used to estimate a likely position; this enables the LM to use other sensors for accurate location.

   Limiting the information in AIS data fields or switching off AIS could make a ship harder to locate but is unlikely to ultimately prevent an attack.

2. Simultaneously switching off AIS and altering the ship safely away from its original course may provide limited mitigation capabilities to avoid being attacked.

   Changes in voyage routing should be considered to make it harder to estimate a position. Not including next port of call (NPOC) in the AIS data fields could be considered.

3. Attacks have been conducted in the Gulf of Oman/Indian Ocean (up to 600 nautical miles or 1,100 kilometres offshore) however, ship-launched LM can extend this range.

   Voyage threat and risk assessment should consider the threat from LM.

4. Eyewitness accounts indicate LM can be detected, albeit at limited range, acoustically before being seen.

   An all-round good look out is important but response times will be limited.

5. It is recommended all drone sightings are reported to the appropriate reporting centre. As observed in Ukraine, where an effective drone reporting system mitigates issues associated with its low detection signatures, all reports increase maritime awareness and help mitigate this threat. For this mitigation to be effective, reporting centres will have to be dynamic in response.

   All drone sightings are reported and regional reporting centres develop timely mechanisms to inform mariners.

6. A safe muster point/citadel inside the ship and above the waterline should be identified and could provide safety to the crew. In the event of a ship detecting a drone, the Master should consider alerting the crew by the ship's alarm and ordering them to the designated safety space. This mitigation requires quick reaction times after detecting the threat and should be practiced. As a minimum, the crew should be inside the structure with doors and windows closed. Firefighting equipment should be rigged and quickly operational.

   BMP offers guidance on safe muster point and the brace position.

7 Countermeasures

Commercially available solutions for countering LM are being developed and rely on either destroying the LM in flight or disrupting the controlling radio frequencies by jamming or spoofing. The solutions' aim is to disrupt the GPS receivers by broadcasting a strong signal on the relevant bandwidth, flood it and thwart the device from receiving satellite signals. While this is the scope of state/military grade systems, there are some regulated-civil applications, such as those used in airports and on critical infrastructures such as oil platforms and maritime terminals. Some countries have already deployed counter-drone systems on oil and gas sea platforms.

Practical countermeasures for merchant ships are generally actions to either prevent the LM detecting a ship or to limit the damage on impact. In the Middle East region, it will not be known if a detected UAV/LM is friend or foe. Unless otherwise informed, all detections or warnings of detections should be treated as a threat.

To prevent detection in areas of increased threat:

- Threat assessment should identify areas of increased LM threat.
- Monitor and understand regional advisories and notifications.
- Consider changes to voyage routing to become less predictable.
- Review AIS policy.
  - To reduce detection, consider minimising information in the data fields. For voyage related data, SOLAS requires Ship's draught – Hazardous cargo (type – as required by the competent authority) – Destination and ETA (at Master's discretion) – Optional – Route plan (waypoints).
- Close radar watch. Commercial radars can detect a fast-moving contact, however:
  - Research suggests LM detection by radar can vary from 2-5km.
  - The radar cross section of LM can be small, comparable to some birds. Most commercial radar are configured to ignore the response to avoid clutter. Some radar manufacturers offer software upgrades designed to detect small airborne targets.
  - LM construction and design can have a significant impact on a radar's detection ability, as can the LM orientation to the radar.
  - The operating frequency of commercial radar for small target detection is limited, but may detect small, fast, airborne targets.
- All round audible and visual lookout.

Limiting damage on impact:

- Crew briefed and emergency drills practiced.
- On detecting an LM, consider safe manoeuvring such as displacing the ship as quickly as possible from its original track.
- If time and safety conditions permit, consider manoeuvring the ship to reduce any impact on the accommodation block or area where crew may be mustered.

8 Summary

The threat to merchant ships from loitering munitions is likely to increase and, given the limited mitigations available, will continue to hamper freedom of navigation, sea lines of communication and the economics of the global supply chain.

Appendix A: Example of Bridge Card when operating in the Middle East

This bridge card is for ships operating in the Middle East and the threat outlined in this paper. This may need to be updated as the threat changes.

Attack by Unmanned Aerial Vehicle (UAV/Loitering Munition)

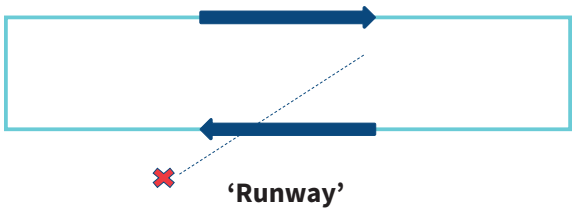
Attacks can take place at any time – day or night. Unless warning is received, the only warning of detection will be audio or visual.

A GOOD ALL-ROUND LOOKOUT IS ESSENTIAL

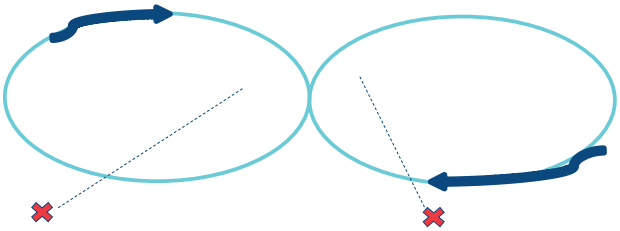
It will not be known if a detected UAV/LM is friend or foe. Unless otherwise informed, all detections or warnings of detections should be treated as **a threat.**

If Threat Assessment indicates UAV/LM attack likely, ensure response plan is briefed. All round visual and listening lookout for UAV/LM.

UAV/LM detected:
- Sound the ship's alarm, crew to designated muster point.
- Alter course by evasive manoeuvre.
- Consider switching off AIS.
- Alert nearby vessels on VHF.
- Alert Maritime Security Authorities.



'Runway'



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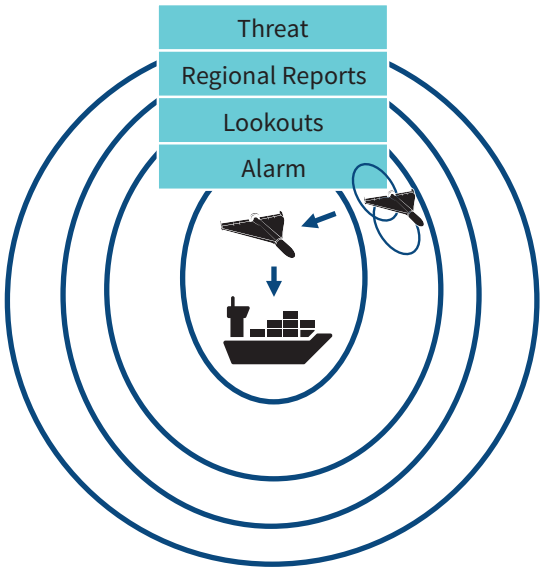

The flight patterns above are the most common followed by loitering munitions and highlighted to lookouts. After detecting its target/s, the LM would home in on it following a top-attack method.

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