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## Coordinated Transmedium Swarm Method for Maritime Search-and-Rescue Support with an Interlock Prohibiting Autonomous Interception or Tow of Occupied Craft and Hand-off to Crewed Authorities

Marginal · 58.5/100

12 claims

### TECHNICAL FIELD

Coordination of multiple transmedium unmanned vehicles for maritime search-and-rescue support, with legal and safety interlocks preserving human authority over occupied craft.

### ABSTRACT

A method coordinates a swarm of transmedium drones to support maritime search and rescue. The swarm cooperatively searches an area across air and water, detects and tracks a vessel or person in distress, illuminates or marks the position, and relays the position and status to a crewed coastguard or border authority over a communications link. An explicit interlock prohibits any autonomous interception, boarding, or tow of an occupied or crewed craft by the swarm; such actions are reserved for, and handed off to, crewed authorities such as a national coastguard, border force, or the competent authority of the relevant jurisdiction. The method is configured to respect maritime safety-of-life and non-refoulement principles: the swarm assists detection, marking, and relay and does not itself intercept, tow, or redirect occupied craft. Roles such as searcher, tracker, illuminator, and relay are assigned and re-assigned among swarm members, with the occupied-craft interlock enforced at the swarm-coordination level so it cannot be overridden by individual-vehicle autonomy.

### BACKGROUND

Maritime search and rescue benefits from many cooperating sensors over a wide and variable air-and-water environment. Drone swarms and multi-robot search are known, as are single-drone SAR aids that drop flotation or relay video. However, applying autonomy to occupied craft at sea raises acute safety and legal issues. Autonomous interception, boarding, redirection, or tow of a craft carrying people can endanger life and conflict with the international duty to render assistance and to preserve safety of life at sea, and with non-refoulement obligations. Known swarm and SAR systems do not encode, at the swarm-coordination level, a hard prohibition on autonomous interception or tow of occupied craft together with a mandatory hand-off of such actions to crewed authorities. There is a real risk that capable transmedium swarms could be configured to act against occupied craft without human authority. There remains a need for a coordination method that lets a transmedium swarm cooperatively detect, track, mark, and relay the position of a vessel or person in distress to crewed coastguard or border authorities, while an interlock enforced at the coordination layer prohibits the swarm from autonomously intercepting or towing occupied craft and instead hands such decisions to a human authority, consistent with safety-of-life and non-refoulement principles.

### SUMMARY OF THE INVENTION

The invention provides a swarm-coordination method for transmedium drones supporting maritime SAR. Member vehicles cooperatively search an area across air and water, with roles of searcher, tracker, illuminator or marker, and relay assigned and re-assigned among them. On detecting a vessel or person in distress, the swarm tracks the target, illuminates or marks the position, and relays the position and status to a crewed coastguard or border authority. A coordination-level interlock prohibits any autonomous interception, boarding, redirection, or tow of an occupied or crewed craft; the swarm hands off such actions to a competent crewed authority. The interlock is enforced at the swarm-coordination layer so that no individual vehicle autonomy can override it. The method is arranged to respect safety-of-life-at-sea and non-refoulement principles, confining the swarm to assistance functions of detection, tracking, marking, and relay. The result is wide-area transmedium SAR support that strengthens, rather than substitutes for, lawful human authority over occupied craft.

## DETAILED DESCRIPTION

FIG. 1 is a schematic of a transmedium swarm of vehicles (100a-100n) searching an air-and-water area with a coordination link (102) and a link (104) to a crewed authority station (106). FIG. 2 is a role-assignment diagram showing searcher, tracker, illuminator or marker, and relay roles. FIG. 3 is a flowchart of the detect, track, mark, and relay method. FIG. 4 is a state diagram of the occupied-craft interlock. FIG. 5 is a message-flow diagram of the hand-off to the crewed authority. FIG. 6 is a coverage map of cooperative search across air and water. FIG. 7 is a block diagram of a swarm-coordination controller enforcing the interlock above individual-vehicle autonomy. Referring to FIG. 1 and FIG. 2, the swarm members (100a-100n) cooperatively cover the search area, each member transmedium and able to search from the air and to enter the water. The coordination function assigns roles and re-assigns them as the situation develops: searcher members expand coverage, a tracker member maintains contact with a detected target, an illuminator or marker member lights or marks the position, and a relay member maintains the link (104) to the crewed authority station (106). Referring to FIG. 3, on detecting a candidate vessel or person in distress the swarm confirms and tracks the target, marks or illuminates the position to aid responders, and relays the position and status to the crewed authority. Referring to FIG. 4 and FIG. 5, if the target is or may be an occupied or crewed craft, the occupied-craft interlock prohibits the swarm from autonomously intercepting, boarding, redirecting, or towing it; the coordination controller instead packages the track and status and hands the decision to the crewed authority station (106), for example a national coastguard, border force, or the competent authority of the relevant jurisdiction. The interlock is enforced by the swarm-coordination controller of FIG. 7 above any individual-vehicle autonomy, so a single vehicle cannot be commanded or self-directed to override it. The method is arranged so that swarm behaviour toward occupied craft respects safety-of-life-at-sea and non-refoulement principles: the swarm assists by detecting, tracking, marking, and relaying, and any action upon an occupied craft is performed only by, or under the explicit authority of, crewed responders. In an embodiment the swarm continues to mark and relay until a crewed asset assumes control, then transitions to a support role under that authority.

## DRAWINGS

FIG. 1 is a schematic of a transmedium swarm searching an air-and-water area with a coordination link and a link to a crewed authority station; FIG. 2 is a role-assignment diagram of searcher, tracker, illuminator or marker, and relay roles; FIG. 3 is a flowchart of the detect, track, mark, and relay method; FIG. 4 is a state diagram of the occupied-craft interlock; FIG. 5 is a message-flow diagram of the hand-off to the crewed authority; FIG. 6 is a coverage map of cooperative search across air and water; FIG. 7 is a block diagram of the swarm-coordination controller enforcing the interlock above individual-vehicle autonomy.

## CLAIMS

1. A method of coordinating a swarm of transmedium unmanned vehicles for maritime search-and-rescue support, the method comprising: cooperatively searching an area across air and water with the vehicles; detecting and tracking a target comprising a vessel or person in distress; illuminating or marking a position of the target; relaying the position and a status of the target to a crewed authority over a communications link; and enforcing a coordination-level interlock that prohibits the swarm from autonomously intercepting, boarding, redirecting, or towing an occupied or crewed craft and that hands off any such action to the crewed authority.
2. A system for coordinating a swarm of transmedium unmanned vehicles for maritime search-and-rescue support, the system comprising: a plurality of transmedium vehicles each operable in air and water; a coordination link among the vehicles; a communications link to a crewed authority station; and a swarm-coordination controller configured to assign search, track, illuminate or mark, and relay roles among the vehicles and to enforce an interlock, above individual-vehicle autonomy, that prohibits autonomous interception, boarding, redirection, or tow of an occupied or crewed craft and hands off any such action to the crewed authority station.
3. The method of claim 1, wherein cooperatively searching comprises assigning and re-assigning roles of searcher, tracker, illuminator or marker, and relay among the vehicles as the search develops.
4. The method of claim 1, wherein the crewed authority comprises one of a national coastguard, a border force, and a competent authority of a relevant jurisdiction.
5. The method of claim 1, wherein enforcing the coordination-level interlock comprises confining the swarm to detection, tracking, marking, and relay with respect to an occupied or crewed craft so that swarm behaviour respects safety-of-life-at-sea and non-refoulement principles.
6. The method of claim 1, further comprising continuing to mark and relay the position of the target until a crewed asset assumes control, and thereafter operating the swarm in a support role under an authority of the crewed asset.

7. The method of claim 1, wherein the interlock is enforced at a swarm-coordination layer such that no individual-vehicle autonomy can override the prohibition on autonomous interception or tow of an occupied or crewed craft.
8. The method of claim 1, further comprising classifying whether the target is or may be occupied and, when the target is or may be occupied, withholding any interception or tow and handing off to the crewed authority.
9. The system of claim 2, wherein the swarm-coordination controller is configured to re-assign roles among the vehicles as a detected target is tracked across air and water.
10. The system of claim 2, wherein the swarm-coordination controller is configured to package a track and status of the target and hand a decision regarding an occupied craft to the crewed authority station.
11. The system of claim 2, wherein the swarm-coordination controller is configured to maintain marking and relay of the target until a crewed asset assumes control and then to operate the swarm in a support role under the crewed asset.
12. The system of claim 2, wherein the interlock prohibiting autonomous interception or tow of an occupied or crewed craft is enforced above individual-vehicle autonomy and cannot be overridden by a single vehicle of the swarm.

### PATENTABILITY SELF-ASSESSMENT (30-FACTOR)

Patentability	62.0%
Prior-art position	52.0%
Technical merit	52.0%
Commercial	64.0%
Composite genius score	58.5/100 (Marginal)

### FILING ROUTES

#### United Kingdom (UK IPO)

GB national application at UK IPO with combined search and examination; tie claims to the technical coordination-layer interlock and hand-off mechanism to navigate computer-program and presentation-of-information exclusions.

#### Ireland (IPOI / Irish PATO)

IE filing at IPOI; an IE 10-year short-term patent is a realistic keystone, with EPO or PCT considered only if the technical coordination effect distinguishes over swarm and SAR prior art.

### PRIOR-ART VERIFICATION (LIVE SEARCHES)

#### UK IPO patent search (Ipsu

UK national register and file inspection  
<https://www.search-for-intellectual-property.service.gov.uk/SearchByNumber>

#### Espacenet (EPO)

European/worldwide prior-art search  
<https://worldwide.espacenet.com/patent/search?q=transmedium%20sar%20support%20swarm%20dron>

#### Google Patents

Full-text + family view  
[https://patents.google.com/?q=\(transmedium%20sar%20support%20swarm%20drone%20UAV%20transmedium\)&type=PATENT](https://patents.google.com/?q=(transmedium%20sar%20support%20swarm%20drone%20UAV%20transmedium)&type=PATENT)

#### IPOI (Irish Patents Office)

Irish national filing route (short-term + full-term)  
<https://www.ipoi.gov.ie/en/types-of-ip/patents/>

#### EPO CPC B64U (UAS)

Unmanned-aircraft classification  
<https://worldwide.espacenet.com/patent/search?q=cpc%3DB64U>

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