CLAIMS

1. A system comprising one or more processing circuitries configured to:

perform in-advance target detection of at least one target, the in-advance target detection comprising performing, in a period of time comprising a relative motion between a marine vehicle and the at least one target, in which the marine vehicle has not passed over the at least one target:

obtaining first position comprising position of one or more first areas determined by at least one underwater detection system associated with the marine vehicle, the one or more first areas potentially including the at least one target,

obtaining magnetic detection data of at least one underwater magnetic detection system associated with the marine vehicle, and

using a detection algorithm configured to search for one or more targets in space based on the magnetic detection data, wherein the first position data is used to limit at least part of said space, to estimate a position of the at least one target.

2. The system of claim 1, wherein the at least one detection system comprises:

(i) an acoustic detection system, or

(ii) a laser detection system.

3. The system of claim 1 or of claim 2, wherein said target detection outputs at least one target position estimate which is outside of said one or more first areas.

4. The system of any one of claims 1 to 3, wherein detection algorithm corresponds to a magnetic detection algorithm.

5. The system of any one of claims 1 to 4, configured to:

(i) use the first position data to determine a set of one or more three-dimensional search areas, and

use at least part of the magnetic detection data to perform a target detection within the set of one or more three-dimensional search areas;

(ii) use the first position data to determine a set of one or more three-dimensional search areas, and use at least part of the magnetic detection data to perform a target detection within the set

of one or more three-dimensional search areas, wherein said target detection is limited within the space, said space corresponding to said set of one or more three-dimensional search area;

(iii) use the first position data to determine a set of one or more three-dimensional search areas, and use at least part of the magnetic detection data to perform a target detection within the set of one or more three-dimensional search areas, wherein said target detection includes using the magnetic detection data to search for one or more targets within a plurality of sub-areas of each three-dimensional search area of the set;

(iv) use the first position data to determine a set of one or more three-dimensional search areas, and use at least part of the magnetic detection data to perform a target detection within the set of one or more three-dimensional search areas, wherein the system is configured to select one or more dimensions of the one or more three-dimensional search areas based on an estimated range between the marine vehicle and the target.

6. The system of any one of claims 1 to 5, configured to:

use the first position data to determine, for at least one given first area of the one or more first areas, a given three-dimensional search area comprising the given first area, with a larger volume than the given first area, thereby obtaining a set of one or more three-dimensional search areas, and

feed the magnetic detection data to the detection algorithm to perform a target detection within the space, wherein said space is defined based on the set of one or more three-dimensional search areas.

7. The system of any one of claims 1 to 6, wherein the first position data comprise range and azimuth of each of the one or more first areas, but do not comprise elevation of each of the one or more first areas.

8. The system of any one of claims 1 to 7, configured to:

use the first position data to determine a set of one or more three-dimensional search areas, and

use at least part of the magnetic detection data to perform a target detection within the space constrained by said set of one or more three-dimensional search areas, said target detection

comprising, for each given sub-area of a plurality of sub-areas of each given three-dimensional search area:

comparing the magnetic detection data, or data derived thereof, with one or more expected magnetic signatures of one or more targets.

9. The system of any one of claims 1 to 8, configured to perform (1), (ii) or (iii)

(i) obtain magnetic detection data for different positions of the marine vehicle relative to the target, thereby obtaining a set of a plurality of magnetic detection data,

responsive to detection that a range between the marine vehicle and the target meets a threshold, use at least part of the first position data and at least part of the set of magnetic detection data to perform a target detection enabling estimating position of the at least one target;

(ii) perform a target detection with last magnetic detection data obtained in a given sub-period of time together with previous magnetic detection data obtained before said given sub-period of time, wherein the target detection takes into account the previous magnetic detection data with a lower weight than the last magnetic detection data;

(iii) perform a target detection at a given instant time with last magnetic detection data obtained only in a sub-period of time of the period of time ending at this given instant of time.

10. The system of any one of claims 1 to 9, configured to perform at least one of (i) or (ii):

(i) using the estimate of the position of the target to control operation of the at least one detection system, or

(ii) controlling the at least one detection system to orient its field of view based on the estimate of the position of the target.

11. The system of any one of claims 1 to 10, configured to perform (i), (ii) or (iii):

(i) perform target detection at a given position of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a given set of a plurality of position estimates, and

process at least part of the given set of a plurality of position estimates to determine an estimate of the position of the target;

(ii) perform target detection at a given position of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of

the detection system, thereby obtaining a given set of a plurality of position estimates, and process at least part of the given set of a plurality of position estimates to determine an estimate of the position of the target, wherein said processing enables obtaining at least one of a single position estimate of the target, a second set of position estimates associated with a smaller dispersion than the given set of a plurality of position estimates, or a position estimate of the target associated with an uncertainty which is smaller than an uncertainty associated with the given set of a plurality of position estimates;

(iii) perform target detection at a given position of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a given set of a plurality of position estimates, and process at least part of the given set of a plurality of position estimates to determine an estimate of the position of the target, wherein said processing includes at least one of determining data informative of a symmetry of at least part of the given set of a plurality of position estimates, determining data informative of a center of at least part of the given set of a plurality of position estimates, or determining data informative of an average of at least part of the plurality of the position estimates of said given set.

12. The system of any one of claims 1 to 11, configured to perform at least one of (i) to (vi):

(i) perform target detection at different positions of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, and

process at least part of the plurality of sets of position estimates to obtain tracking data informative of the target;

(ii) perform target detection at different positions of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determine data informative of an average of at least part of the plurality of the position estimates of each of set of said of plurality of sets, and use said data to generate tracking data informative of the target;

(iii) perform target detection at different positions of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determine data informative of a center of at least part of each set of the plurality of sets of position estimates, and use said data to generate tracking data informative of the target;

(iv) perform target detection at different positions of the marine vehicle relative to the target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determine data informative of a symmetry of at least part of each set of the plurality of sets of position estimates, and use said data to generate tracking data informative of the target;

(v) perform target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, processing at least part of the plurality of sets of position estimates to obtain tracking data informative of the target, and compare the tracking data with tracking data provided by the detection system;

(vi) perform target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, compare one or more geometrical properties of at least part of the set of a plurality of position estimates with one or more expected geometrical properties, and use the comparison to determine tracking data of the target.

13. The system of any one of claims 1 to 12, configured to:

perform a first target detection based on the magnetic detection data, without using first position data of the detection system, to obtain a set of target position estimates,

use the set to orient a field of view of the detection system, thereby obtaining the first position data, and

use the first position data and the magnetic detection data to perform said target detection.

14. The system of any one of claims 1 to 13, configured to use said estimate of the position of the target to perform at least one of:

(i) controlling the marine vehicle to avoid a collision with the target;

(ii) performing an ascension of the marine vehicle to periscope depth;

(iii) obtaining a map of one or more surface targets;

(iv) obtaining a map of one or more seabed targets;

(v) performing underwater mine detection;

(vi) determining position of the marine vehicle, said determining using a priori knowledge of the position of the target.

15. The system of any one of claims 1 to 14, configured to perform (1) to (4) for different positions of the marine vehicle:

(1) obtain first position data comprising position of one or more first areas determined by the at least one detection system,

(2) obtain magnetic detection data of the at least one magnetic detection system,

(3) use the first position data to determine a set of one or more three-dimensional search areas, and

(4) use at least part of the magnetic detection data to perform a target detection in the set of one or more three-dimensional search areas to obtain one or more position estimates of the target.

16. The system of any one of claims 1 to 15, wherein:

(i) the marine vehicle is an underwater vehicle, wherein the detection system and the magnetic detection system are mounted on the underwater vehicle, or

(ii) the marine vehicle is an underwater vehicle, wherein the detection system and the magnetic detection system are towed by the underwater vehicle; or

(iii) the marine vehicle is an underwater vehicle, wherein at least part of a system comprising the detection system and the magnetic detection system is mounted on the underwater vehicle, and another part of said system is towed by the underwater vehicle; or

(iv) the marine vehicle is a ship, wherein the detection system and the magnetic detection system are towed by the ship.

17. A system comprising one or more processing circuitries configured to:

obtain first position data comprising position of one or more first areas determined by at least one underwater detection system associated with a marine vehicle, the one or more first areas potentially comprising one or more targets,

obtain magnetic detection data of at least one underwater magnetic detection system associated with the marine vehicle,

use the first position data to determine a set of one or more three-dimensional search areas, and

feed the magnetic detection data to a detection algorithm to perform a target detection within a space defined based on the set of one or more three-dimensional

search areas, the target detection enabling estimating a position of at least one target within said set of one or more three-dimensional search areas.

18. The system of claim 17, wherein at least one of (i) to (vi) is met :

(i) the first position data comprise range and azimuth of each of the one or more first areas, but do not comprise elevation of each of the one or more first areas;

(ii) said at least one target detection includes using the magnetic detection data to search for one or more targets within a plurality of sub-areas of each three-dimensional search area of the set;

(iii) said space corresponds to said set of one or more three-dimensional search areas;

(iv) the system is configured to use the first position data to determine, for at least one given first area of the one or more first areas, a given three-dimensional search area comprising the given first area, with a larger volume than the given first area, thereby obtaining a set of one or more three-dimensional search areas, and feed the magnetic detection data to the detection algorithm to perform a target detection within the space, wherein said space is defined based on the set of one or more three-dimensional search areas;

(v) the system is configured to said target detection is performed in a period of time comprising a relative motion between the marine vehicle and at least one target, in which the marine vehicle has not passed over the at least one target;

(vi) the system is configured to perform (1) to (4) for different positions of the marine vehicle relative to a target: (1) obtain first position comprising position of one or more first areas determined by the at least one detection system, (2) obtain magnetic detection data of the at least one magnetic detection system, (3) use the first position data to determine a set of one or more three-dimensional search areas, and (4) use at least part of the magnetic detection data to perform a target detection in the set of one or more three-dimensional search areas to obtain one or more position estimates of the target.

19. A non-transitory computer readable medium comprising instructions that, when executed by one or more processors, cause the one or more processors to perform:

obtaining first position data comprising position of one or more first areas determined by at least one underwater detection system associated with a marine vehicle,

obtaining magnetic detection data of at least one underwater magnetic detection system associated with the marine vehicle,

using at least part of the first position data to delimit a space,

using and at least part of the magnetic detection data to perform at least one target detection within said space using a detection algorithm, thereby enabling obtaining a set of a plurality of position estimates of at least one target, and

processing at least part of the set of a plurality of position estimates to determine an estimate of the position of the target.

20. The non-transitory computer readable medium of claim 19, comprising instructions that, when executed by the one or more processors, cause the one or more processors to execute at least one of (i) to (xii):

(i) said processing enables obtaining a single position estimate of the target;

(ii) said processing enables obtaining a second set of position estimates associated with a smaller dispersion than the set of a plurality of position estimates;

(iii) said processing enables obtaining a position estimate of the target associated with an uncertainty which is smaller than an uncertainty associated with the set of a plurality of position estimates;

(iv) said processing includes determining data informative of a symmetry of at least part of the given set of a plurality of position estimates;

(v) said processing includes determining data informative of a center of at least part of the given set of a plurality of position estimates;

(vi) said processing includes determining data informative of an average of at least part of the plurality of the position estimates of said given set;

(vii) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, and processing at least part of the plurality of sets of position estimates to obtain tracking data informative of the target;

(viii) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determining data informative of an average of at least part of the plurality of the position estimates of each of set of said of plurality of sets, and using said data to generate tracking data informative of the target;

(ix) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determining data

informative of a center of at least part of each set of the plurality of sets of position estimates, and using said data to generate tracking data informative of the target;

(x) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, determining data informative of a symmetry of at least part of each set of the plurality of sets of position estimates, and using said data to generate tracking data informative of the target; and

(xi) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, processing at least part of the plurality of sets of position estimates to obtain tracking data informative of the target, and comparing the tracking data with tracking data provided by the detection system;
(xii) performing target detection at different positions of the marine vehicle relative to a target, based on magnetic detection data of the magnetic detection system and on first position data of the detection system, thereby obtaining a plurality of sets of position estimates, comparing one or more geometrical properties of at least part of the set of a plurality of position estimates with one or more expected geometrical properties, and using the comparison to determine tracking data of the target.