

Claims

1. A marine vessel safety system which ensures that a remote and autonomous marine vessel enters a safe state in the event of at least one malfunction in any vessel operation systems and components of the marine vessel, the marine vessel safety system comprises:
 - at least one vessel monitoring system, configured to monitor the vessel operation systems and components of the marine vessel,
 - a plurality of decision-making systems, each comprising at least one malfunction evaluation system configured to detect any malfunction in the vessel operation systems and components of the marine vessel and to evaluate the detected malfunction,
 - a safe-state control system, configured to be activated by any one of the malfunction evaluation systems in the event where any of the malfunction evaluation systems detect any malfunction in the vessel operation systems and components, and to execute a set of control commands, which forces the vessel in to a safe state.
2. A marine vessel safety system according to claim 1, wherein the at least one decision-making system comprises at least one decision-making system positioned on-board the R&A marine vessel.
3. A marine vessel safety system according to claim 1, wherein the at least one decision-making system comprises at least one decision-making system positioned in a location remote from the R&A marine vessel.
4. A marine vessel safety system according to any one of the preceding claims, where the at least one malfunction evaluation system comprises a vessel monitoring system.

5. A marine vessel safety system according to any one of the preceding claims, where the vessel monitoring system is independent from any other system in the marine vessel.
6. A marine vessel safety system according to any one of the preceding claims, where the vessel monitoring system is autonomous.
7. A marine vessel safety system according to any one of the preceding claims, where the vessel monitoring system is firmware programmed.
8. A marine vessel safety system according to any one of the preceding claims, where at least one of the vessel operation systems and components of the marine vessel is chosen from the group comprising:
 - engine control system,
 - propeller,
 - propulsion control system,
 - communication system,
 - navigation system,
 - water cooling system,
 - dynamic positioning system,
 - distress signal communication system,
 - route planning system,
 - situation awareness system,
 - collision avoidance system,
 - mission management system,
 - equipment health monitoring system,
 - energy management system,
 - integrated alarm system,
 - cyber security system such as intrusion detection system,
 - steering gear,

19/22

133129FMA

- autopilot,
- position reference systems,
- deck machinery systems,
- machinery recovery systems, and
- artificial chief engineer.

9. A marine vessel safety system according to any one of the preceding claims, where each state of each of the m vessel operation systems and components of the marine vessel is defined by a set of any number, n , of parameters, $m.1, m.2, m.3, m.4, \dots, m.n$.

10. A marine vessel safety system according to claim 9, where at least one of the parameters, in at least one of the sets of any number of parameters, represents a property of the respective vessel operation system or component of the marine vessel chosen from the group comprising:

- pressure,
- temperature,
- sound,
- voltage,
- frequency,
- gas-concentration,
- humidity,
- pH,
- connectivity capability,
- network activity,
- software component activity,
- CPU load,
- memory usage,
- connectivity activity,
- position, and
- latency.

11. A marine vessel safety system according to any of the claims 9 and 10, where the vessel monitoring system is configured to:
- monitor each set of parameters, $m.1, m.2, m.3, m.4, \dots, m.n$, defining the state of each of the vessel operation systems and components of the marine vessel.
12. A marine vessel safety system according to claim 11, where the at least one malfunction evaluation system comprises at least one malfunction trigger algorithm.
13. A marine vessel safety system according to claim 12, where the at least one of malfunction trigger algorithm is configured to:
- compare each set of parameters $m.1, m.2, m.3, m.4, \dots, m.n$ with a set of allowable threshold values $T_{m.1}, T_{m.2}, T_{m.3}, T_{m.4}, \dots, T_{m.n}$ defined as a set of ranges, each set of ranges is associated with a particular set of parameters $m.1, m.2, m.3, m.4, \dots, m.n$, and if any one of the parameter values $l_{m.1}, l_{m.2}, l_{m.3}, l_{m.4}, \dots, l_{m.n}$ in the set of parameters is outside the corresponding allowable threshold value $T_{m.1}, T_{m.2}, T_{m.3}, T_{m.4}, \dots, T_{m.n}$ defined in the set of ranges, then send a malfunction signal to a logical comparator, which outputs an activation signal to the safe state control system.
14. A marine vessel safety system according to any one of the preceding claims, where the malfunction evaluation system, evaluates the detected malfunction in light of the state of at least one other amongst the vessel operation systems and components of the marine vessel.
15. A marine vessel safety system according to any one of the preceding claims, where the malfunction evaluation system, comprises at least one system chosen from the group comprising:
- route planning system,
 - situation awareness system,

- collision avoidance system, and
- dynamic positioning system.

16. A marine vessel safety system according to any one of the preceding claims, where said set of control commands executable by the safe-state control system is chosen based on any of the sets of parameters that defines the states of the vessel operation systems and components of the marine vessel.

17. A marine vessel safety system according to any one of the preceding claims, where said set of control commands executable by the safe-state control system comprises at least one control command which determines at least one of the following:

- vessel rudder position,
- vessel propulsion levels,
- activation of a dynamic positioning system,
- activation of a distress signal communication system,
- activation of a route planning system,
- activation of a situation awareness system,
- activation of a collision avoidance system,
- activation of a machinery recovery system,
- notification of a remote operator,
- activation of a sound signal,
- activation of a flashing light signal,
- activation of a light signal,
- activation of a loudspeaker announcement, and
- disconnect remote control.

18. A marine vessel safety system according to any one of the preceding claims, where at least one safe state is defined amongst the actions chosen from the group comprising:

- the marine vessel proceeds to the next waypoint,
- the marine vessel stops and enters DP-mode,
- the marine vessel returns to the previous waypoint,
- the marine vessel navigates back to its last known safe position,
- the marine vessel navigates to the nearest available safe position,
- the marine vessel drops an anchor,
- the marine vessel shuts down some machinery,
- the marine vessel shuts down all machinery,
- the marine vessel stops propellers and drifts, and
- the marine vessel maintains its relative position relative to an object.