It is an object of the invention to provide system that overcomes or at least reduces the problems indicated above.

The foregoing and other objects are achieved by the features of the independent claims. Further implementation forms are apparent from the dependent claims, the description and the figures.

According to a first aspect, there is provided a tugboat for assisting a marine vessel to maneuver, the tugboat comprising:

- an engine driving one or more propulsors with a controllable direction of thrust,
- a towing line for establishing a pulling connection between an assisted vessel and the tugboat,
- a first sensor arrangement configured for sensing the size and direction of the pulling force that the towing line exerts on the tugboat,
- a second sensor arrangement configured for sensing the orientation of the tugboat,
- a controller configured to receive a signal from the first sensor arrangement and a signal from the second sensor arrangement,
- the controller being informed of the size and direction of thrust generated by the one or more propulsors,
- the controller being configured to determine a safety threshold is exceeded on the basis of:
    - sensed size and direction of thrust,
    - sensed size and direction of the pulling force, and
    - sensed orientation of the tugboat.

By providing a tugboat with a controller informed of the forces acting on the tugboat and of the orientation of the tugboat it becomes possible to create an automatic system of preventing capsizing and/or sinking of the tugboat due to e.g. excessive force on the towing line.

In a first possible implementation form of the first aspect

the controller is configured to reduce the size of the thrust and/or changes the direction of thrust when the controller has determined that the tugboat has exceeded the safety threshold.

In a second possible implementation form of the first aspect
the tugboat is provided with an arrangement for disconnecting the tugboat from the towing line in response to a command from the controller, the arrangement preferably comprising a device for severing the towing line.

In a third possible implementation form of the first aspect
the controller is configured to sever the towing line when the controller has determined that the tugboat has exceeded the safety threshold.

In a fourth possible implementation form of the first aspect
the first and second safety thresholds are a risk of the tugboat capsizing and/or wherein the first and second safety thresholds are a risk of the tugboat sinking.

In a fifth possible implementation form of the first aspect
the controller is configured to determine that the tugboat is at the risk of capsizing or sinking on the basis of a computer model that simulates the behavior of the tugboat.

In a sixth possible implementation form of the first aspect
the tugboat is an autonomously operating tugboat, an unmanned tugboat and/or a remote-controlled tugboat.

In a seventh possible implementation form of the first aspect
the controller is provided with a mathematical model of said tugboat.
According to a second aspect, there is provided a method of operating a tugboat, the method comprising
determining the size and direction of thrust created by the propulsors of the tugboat,

determining the size and direction of a pulling force applied to the tugboat by a towing line,
determining the orientation of the tugboat, and
determining if the combination of the size and direction of thrust and the size and direction of pulling force and the orientation of the tugboat exceeds a safety threshold.

In a first possible implementation form of the second aspect the method further comprises adjusting the size and/or direction of the thrust in order to prevent the tugboat from exceeding a safety threshold.

In a first possible implementation form of the second aspect the method further comprises severing the towline and the tugboat when a safety threshold is exceeded.

These and other aspects of the invention will be apparent from and the embodiment(s) described below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present disclosure, the invention will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 is a side view of an assisted vessel and a plurality of tugboats during an assist operation,
Fig. 2 is a top view of the assisted vessel and plurality of tugboats of Fig. 1 during an assist operation with one additional tugboat on the side of the assisted vessel,
Fig. 3 is a top view of the assisted vessel and a plurality of tugboats of Fig. 1 during an assist operation with two additional tugboats on the side of the assisted vessel,
Fig. 4 is a system diagram of a system with a remote control unit for a pilot, a remote control unit for a control center and a control unit for each tugboat in the system,
Fig. 5 is a side view of a tugboat with a crane arm in a rest position,
Fig. 6 is a side view of the tugboat of Fig. 5 in a lifted position holding a towing line,
Fig. 7 is a top view of the tugboat of Fig. 5 with the crane in a rest position,

CLAIMS

1. A tugboat for assisting a marine vessel to maneuver, said tugboat comprising:
- an engine driving one or more propulsors with a controllable direction of thrust,
- a towing line for establishing a pulling connection between an assisted vessel and the tugboat,
- a first sensor arrangement configured for sensing the size and direction of the pulling force that the towing line exerts on the tugboat,
- a second sensor arrangement configured for sensing the orientation of the tugboat,
- a controller configured to receive a signal from said first sensor arrangement and a signal from said second sensor arrangement,
- said controller being informed of the size and direction of thrust generated by said one or more propulsors,
- said controller being configured to determine if a first safety threshold is exceeded on the basis of:
    - sensed size and direction of thrust,
    - sensed size and direction of the pulling force, and
    - sensed orientation of the tugboat.

2. A tugboat according to claim 1, wherein said controller is configured to reduce the size of the thrust and/or changes the direction of thrust when the controller has determined that the tugboat has exceeded said first safety threshold.

3. A tugboat according to claim 1 or 2, wherein said tugboat is provided with an arrangement for disconnecting the tugboat from said towing line in response to a command from said controller, said arrangement preferably comprising a device for severing said towing line.

4. A tugboat according to claim 3, wherein said controller is configured to sever said towing line when the controller has determined that the tugboat has exceeded a second safety threshold that is higher than said first safety threshold.

5. A tugboat according to any one of claims 1 to 4, wherein said first and second safety thresholds are a risk of said tugboat capsizing and/or wherein said first and second safety thresholds are a risk of said tugboat sinking.

6. A tugboat according to any one of claims 1 to 5, wherein said controller is configured to determine that said tugboat is at the risk of capsizing or sinking on the basis of a computer model that simulates the behavior of said tugboat.

7. A tugboat according to any one of claims 1 to 6, wherein said controller is provided with a mathematical model of said tugboat.

8. A method of operating a tugboat, said method comprising
determining the size and direction of thrust created by the propulsors of said tugboat,
determining the size and direction of a pulling force applied to said tugboat by a towing line,
determining the orientation of said tugboat, and
determining if the combination of the size and direction of thrust and the size and direction of pulling force and the orientation of said tugboat exceeds a safety threshold.

9. A method according to claim 8, further comprising adjusting the size and/or direction of said thrust in order to prevent said tugboat from exceeding a safety threshold.

10. A method according to claim 8 or 9, further comprising severing the towline a safety threshold is exceeded.