A tugboat's power is typically stated by its engine's horsepower and its overall bollard pull. The largest commercial harbor tugboats in the 2000s-2010s, used for towing container ships or similar, had around 60-65 tons of bollard pull, which is considered as 15 tons above "normal" tugboats.

Tugboats are highly maneuverable, and various propulsion systems have been developed to increase maneuverability and safety. Most tugboats are propeller-driven. Kort nozzles have been added to increase thrust per kW/hp. Nozzle-rudders omit the need for a conventional rudder. Tugboats are typically provided with a so-called Z-drive or (azimuth thruster) which is a pod that can rotate 360° allowing for rapid changes in the thrust direction.

In addition or as an alternative tugboats have been provided with a Voith-Schneider propeller (VSP), also known as a cycloidal drive which is a specialized marine propulsion system. The VSP is highly maneuverable, being able to change the direction of its thrust almost instantaneously. It is widely used on tugboats. From a circular plate, rotating around a vertical axis, a circular array of vertical blades (in the shape of hydrofoils) protrude out of the bottom of the boat. Each blade can rotate itself around a vertical axis. The internal gear changes the angle of attack of the blades in sync with the rotation of the plate, so that each blade can provide thrust in any direction, very similar to the collective pitch control and cyclic in a helicopter.

Operational costs for tugboat operations i.e. vessel assist operations consist for a major part of expenses to crew. There is therefore a desire to reduce the expenses for operating tugboats.

SUMMARY

Embodiments of the invention seek 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 remote-controlled tugboat for assisting a marine vessel to maneuver, the tugboat comprising:

a towing line attached to the tugboat at one end and attachable to the marine vessel at another end;

a towing line force sensor; and

a control unit having a transmitter-receiver configured to wirelessly receive pilot-control thrust commands transmitted from at least one of a land-based control center and a mobile remote controller unit, said pilot-control thrust commands being for assisting the marine vessel to maneuver in dependence on sensor data from the towing line force sensor,

wherein the control unit is configured to command the tugboat based on the pilot-control thrust commands and said tugboat is configured to execute said pilot-control thrust commands to assist said marine vessel with a required tension on the towing line.

In a first possible implementation form of the first aspect, the remote-controlled tugboat comprises at least one of:

a positioning system, the tugboat being configured to transmit its position as determined by said positioning system wirelessly to said land-based control center;

a navigation system configured to sail said tugboat from a present position to a target position received from said land-based control center;

a controller configured to berth said tugboat autonomously, said controller being configured to accurately react to a near environment of the tugboat to avoid overloading of a berth or hull of the tugboat; and

a crane or robot arm, and a controller for controlling said crane or robot arm, said controller being configured to wirelessly receive instructions from said land-based control center for operating said crane or robot arm.

In a second possible implementation form of the first aspect, the remote-controlled tugboat is configured to follow the marine vessel at a substantially constant distance, preferably with a fixed relative position to the marine vessel, upon receipt of instructions from said mobile remote controller unit or from said land-based control center.

In a third possible implementation form of the first aspect, the remote-controlled tugboat is configured to execute said pilot-control thrust commands as vectors in relation to a hull of the marine vessel.

According to a second aspect, there is provided a land-based control center for controlling at least one tugboat, the tugboat comprising: a towing line attached to the tugboat at one end and attachable to a marine vessel at another end; and a towing line force sensor, the tugboat being suitable for assisting the marine vessel to maneuver, said land-based control center comprising:

a transmitter-receiver configured for wirelessly transmitting pilot-control thrust commands to said at least one tugboat for assisting the marine vessel to maneuver in dependence on sensor data from the towing line force sensor, the pilot-control thrust commands being received in a control unit of the at least one tugboat, the pilot-control

thrust commands being configured to wirelessly control said tugboat with a required tension in the towing line, and said pilot-control thrust commands comprising a vector in relation to a hull of the marine vessel.

By providing a control center for controlling at least one remote controlled tugboat the tugboat can be operated from a control center and the number of crew members needed on the tugboat can be reduced.

In a first possible implementation form of the second aspect, the vector determines a magnitude of the thrust to be applied to the hull of the marine vessel and a direction of the thrust to be applied relative to the hull of the marine vessel.

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

a remote-controlled tugboat according to the first aspect; and

a land-based control center according to the second aspect;

wherein the transmitter-receiver of the control unit of the remote-controlled tugboat is configured to wirelessly receive pilot-control thrust commands transmitted from the land-based control center.

In a first possible implementation form of the third aspect, the land-based control center is configured to wirelessly remote-control the tugboat to sail to a particular position for assisting the marine vessel to maneuver.

In a second possible implementation form of the third aspect, the tugboat is provided with:

an optical sensor arrangement or digital camera arrangement; and

a transmitter for wirelessly transmitting a signal of said optical sensor arrangement or digital camera arrangement to the land-based control center;

wherein the land-based control center is provided with:

a receiver for receiving the signal; and

display screens for displaying the signal, preferably in real-time and even more preferably in real-time and on a 360° circular array of display screens, to a human operator.

In a third possible implementation form of the third aspect, the tugboat is provided with:

an acoustic sensor arrangement, preferably a directional acoustic sensor arrangement with a 360° field of hearing in the horizontal plane; and

a transmitter for wirelessly transmitting the signal of said acoustic sensor arrangement to the land-based control center;

wherein the land-based control center is provided with:

a receiver for receiving the signal from said acoustic sensor arrangement; and

transducers for reproducing the signal, preferably real-time and even more preferably real-time and spatially, at the land-based control center.

In a fourth possible implementation form of the third aspect, the system further comprises the mobile remote controller unit for remotely controlling the remote-controlled tugboat, wherein the transmitter-receiver of the controller of the remote-controlled tugboat is configured to wirelessly receive pilot-control thrust commands transmitted from the mobile remote controller unit.

According to a fourth aspect, there is provided a method for controlling at least one tugboat for assisting a marine vessel to maneuver, from a remotely located control center, the method comprising:

providing at least one tugboat comprising: a towing line attached to the tugboat at one end and attachable to the marine vessel at another end; and a towing line force sensor;

providing a land-based control center located remotely from the at least one tugboat;

sending instructions wirelessly from the land-based control center to a given tugboat of the at least one tugboat for said given tugboat to sail to a particular position for assisting the marine vessel to maneuver;

receiving the instructions wirelessly on the given tugboat;

said given tugboat sailing to said particular position;

sending thrust commands, from said land-based control center or from a mobile remote controller unit in a vicinity of said particular position, to said given tugboat after the given tug boat has arrived at said particular position and in dependence on sensor data from the towing line force sensor; and

said given tugboat carrying out said thrust commands for assisting said marine vessel, with a required tension in the towing line, upon receipt of said thrust commands.

In a first possible implementation form of the fourth aspect, the thrust commands comprise a vector in relation to a hull of the marine vessel.

In a second possible implementation form of the fourth aspect, the method comprises operating, by a human pilot, said mobile remote controller unit to send the thrust commands therefrom, preferably whilst being located on said marine vessel.

In a third possible implementation form of the fourth aspect, the thrust commands are sent from the mobile remote controller unit, and control of the given tugboat passes from said land-based control center to said mobile remote controller unit when said given tugboat assists said marine vessel to maneuver.

In a fourth possible implementation form of the fourth aspect, the method further comprises the given tugboat autonomously sailing from its present position to the particular position, preferably including the given tugboat navigating autonomously from its present position to the particular position.

In a fifth possible implementation form of the fourth aspect, sending instructions wirelessly comprises sending instructions to the given tugboat to follow the marine vessel at a constant distance, preferably with no tension on the towing line.

In a sixth possible implementation form of the fourth aspect, the method further comprises: detecting optical and/or acoustical signals with one or more sensors on the given tugboat; and sending the optical and/or acoustical signals from the one or more sensors wirelessly to the land-based control center.

In a seventh possible implementation form of the fourth aspect, the method further comprises: sending instructions from the mobile remote controller unit, for example a portable remote control unit operated by a pilot on the marine vessel, to the given tugboat to deliver a free end of the towing line to a recipient on the marine vessel, particularly to a recipient at a particular position on the marine vessel;

and the given tugboat delivering the free end of the towing line to the recipient.

In an eighth possible implementation form of the fourth aspect, the method further comprises: sending instructions from the mobile remote controller unit, for example a portable remote control unit operated by a pilot on the marine vessel, to the given tugboat to reel in the towing line; and the given tugboat reeling in the towing line.

In a ninth possible implementation form of the fourth aspect, the method further comprises sending instructions from the mobile remote controller unit, for example a portable remote control unit operated by a pilot on the marine vessel, for a thrust command with a given size and direction to the given tugboat applying thrust of an initial size and direction to the marine vessel in accordance with the thrust commands received from the land-based control center; and the given tugboat applying thrust with the given size and direction as instructed from the mobile remote controller unit.

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,

CLAIMS

1. A remote-controlled tugboat for assisting a marine vessel to maneuver, the tugboat comprising:

a towing line attached to the tugboat at one end and attachable to the marine vessel at another end;

a towing line force sensor; and

a control unit having a transmitter-receiver configured to wirelessly receive pilot-control thrust commands transmitted from at least one of a land-based control center and a mobile remote controller unit, said pilot-control thrust commands being for assisting the marine vessel to maneuver in dependence on sensor data from the towing line force sensor,

wherein the control unit is configured to command the tugboat based on the pilot-control thrust commands and said tugboat is configured to execute said pilot-control thrust commands to assist said marine vessel with a required tension on the towing line.

2. A remote-controlled tugboat according to claim 1, comprising at least one of:

a positioning system, the tugboat being configured to transmit its position as determined by said positioning system wirelessly to said land-based control center;

a navigation system configured to sail said tugboat from a present position to a target position received from said land-based control center;

a controller configured to berth said tugboat autonomously, said controller being configured to accurately react to a near environment of the tugboat to avoid overloading of a berth or hull of the tugboat; and

a crane or robot arm, and a controller for controlling said crane or robot arm, said controller being configured to wirelessly receive instructions from said land-based control center for operating said crane or robot arm.

3. A remote-controlled tugboat according to claim 1 or 2, wherein the remote-controlled tugboat is configured to follow the marine vessel at a substantially constant distance, preferably with a fixed relative position to the marine vessel, upon receipt of instructions from said mobile remote controller unit or from said land-based control center.

4. A remote-controlled tugboat according to any preceding claim, wherein the remote-controlled tugboat is configured to execute said pilot-control thrust commands as vectors in relation to a hull of the marine vessel.

5. A land-based control center for controlling at least one tugboat, the tugboat comprising: a towing line attached to the tugboat at one end and attachable to a marine vessel at another end; and a towing line force sensor, the tugboat being suitable for assisting the marine vessel to maneuver, said land-based control center comprising:

a transmitter-receiver configured for wirelessly transmitting pilot-control thrust commands to said at least one tugboat for assisting the marine vessel to maneuver in dependence on sensor data from the towing line force sensor, the pilot-control thrust commands being received in a control unit of the at least one tugboat, the pilot-control thrust commands being configured to wirelessly control said tugboat with a required tension in the towing line, and said pilot-control thrust commands comprising a vector in relation to a hull of the marine vessel.

6. A land-based control center according to claim 5, wherein the vector determines a magnitude of the thrust to be applied to the hull of the marine vessel and a direction of the thrust to be applied relative to the hull of the marine vessel.

7. A system for assisting a marine vessel to maneuver, the system comprising:

a remote-controlled tugboat according to any one of claims 1 to 4; and

a land-based control center according to claim 5 or 6;

wherein the transmitter-receiver of the control unit of the remote-controlled tugboat is configured to wirelessly receive pilot-control thrust commands transmitted from the land-based control center.

8. A system according to claim 7, wherein the land-based control center is configured to wirelessly remote-control the tugboat to sail to a particular position for assisting the marine vessel to maneuver.

9. A system according to claim 7 or 8,

wherein the tugboat is provided with:

an optical sensor arrangement or digital camera arrangement; and

a transmitter for wirelessly transmitting a signal of said optical sensor arrangement or digital camera arrangement to the land-based control center;

wherein the land-based control center is provided with:

a receiver for receiving the signal; and

display screens for displaying the signal, preferably in real-time and even more preferably in real-time and on a 360° circular array of display screens, to a human operator.

10. A system according to any one of claims 7 to 9,

wherein the tugboat is provided with:

an acoustic sensor arrangement, preferably a directional acoustic sensor arrangement with a 360° field of hearing in the horizontal plane; and

a transmitter for wirelessly transmitting the signal of said acoustic sensor arrangement to the land-based control center;

wherein the land-based control center is provided with:

a receiver for receiving the signal from said acoustic sensor arrangement; and

transducers for reproducing the signal, preferably real-time and even more preferably real-time and spatially, at the land-based control center.

11. A system according to any one of claims 7 to 10, further comprising the mobile remote controller unit for remotely controlling the remote-controlled tugboat,

wherein the transmitter-receiver of the controller of the remote-controlled tugboat is configured to wirelessly receive pilot-control thrust commands transmitted from the mobile remote controller unit .

12. A method for controlling at least one tugboat for assisting a marine vessel to maneuver, from a remotely located control center, said method comprising:

providing at least one tugboat comprising:

a towing line attached to the tugboat at one end and attachable to the marine vessel at another end; and

a towing line force sensor;

providing a land-based control center located remotely from the at least one tugboat;

sending instructions wirelessly from said land-based control center to a given tugboat of said at least one tugboat for said given tugboat to sail to a particular position for assisting the marine vessel to maneuver;

receiving said instructions wirelessly on said given tugboat;

said given tugboat sailing to said particular position;

sending thrust commands, from said land-based control center or from a mobile remote controller unit in a vicinity of said particular position, to said given tug boat after the given tug boat has arrived at said particular position and in dependence on sensor data from the towing line force sensor; and

said given tug boat carrying out said thrust commands for assisting said marine vessel, with a required tension in the towing line, upon receipt of said thrust commands.

13. A method according to claim 12, the thrust commands comprising a vector in relation to a hull of the marine vessel.

14. A method according to claim 12 or 13, comprising operating, by a human pilot, said mobile remote controller unit to send the thrust commands therefrom.

15. A method according to any one of claims 12 to 14, wherein the thrust commands are sent from the mobile remote controller unit, and

wherein control of the given tugboat passes from said land-based control center to said mobile remote controller unit when said given tugboat assists said marine vessel to maneuver.