CLAIMS

1. A method for determining the speed through water of a vessel for optimisation of vessel operation, using a sensor system, comprising:

- obtaining propeller revolutions per minute and at least one of torque at propeller, propulsion power, thrust and engine fuel consumption;
- obtaining speed over ground of the vessel; and
- using the obtained data and hydrodynamic modeling to determine the speed through water of the vessel.

2. A method according to claim 1, wherein at least one of the propeller revolutions per minute, torque at propeller, propulsion power, thrust and engine fuel consumption is a measurement value resulting from a corresponding indirect measurement based on vessel vibrations.

3. A method according to claim 1 or 2, further comprising
- obtaining data from one or more speed through water logs, and
- using the obtained data in determining the speed through water of the vessel and for calibrating speed through water log data.

4. A method according to any of the preceding claims, further comprising obtaining oceanographic current data and using said data in determining the speed through water of the vessel.

5. A method according to any of the preceding claims, wherein the speed through water is determined using a statistical state-space model.

6. A method according to any of the preceding claims, wherein the speed through water is determined in real time.

7. A method according to any of the preceding claims, where the speed through water of the vessel is calculated using the following state space formulation:

$$Q_t = f(\hat{v}_{w,t}, \Delta\hat{R}_t; \bar{\alpha}', \bar{\beta}', \bar{\gamma}) + \varepsilon_{1,t}$$

$$n_t = g(\hat{v}_{w,t}, \Delta\hat{R}_t; \bar{\alpha}', \bar{\beta}', \bar{\gamma}) + \varepsilon_{2,t}$$

$$v_{g,t} = \hat{v}_{w,t} + \hat{c}_t + \varepsilon_{3,t}$$

$$\hat{v}_{w,t} = \hat{v}_{w,t-1} + \eta_{1,t}$$

$$\hat{c}_t = \hat{c}_{t-1} + \eta_{2,t}$$

$$\Delta\hat{R}_t = \Delta\hat{R}_{t-1} + \eta_{3,t}$$

wherein f and g are functions defined by the relations

$$K_Q\left(\frac{v_w}{n}; \bar{\alpha}'\right) = \frac{Q}{n^2}$$

$$K_T\left(\frac{v_w}{n}; \bar{\beta}'\right) = \frac{R_{cs}(v_w; \bar{\gamma}) + \Delta R}{n^2}$$

and Q is torque of the propeller, v_g is speed over ground, n is propeller revolution per minute, ε is a random variable describing measurement noise, and η is a random variable controlling the evolution speed of the state, $\hat{v}_w$ is estimated speed through water, $R_{cs}(v_w; \bar{\gamma})$ is the calm sea resistance as a function of the speed through water, $\Delta\hat{R}$ is estimated extra resistance on top of calm sea resistance, $\hat{c}$ is estimated oceanographic current, and parameters α, β and γ are state variables estimated based on data.

8. A method according to claim 7, wherein K_Q and K_T are linear or quadratic functions.

9. A method according to claim 7 or 8, wherein the state space formulation is augmented with equations which take into account measured speed through water data and calibrate it:

$$v_{w,t} = e^{-\hat{x}_t}\hat{v}_{w,t} + \varepsilon_{4,t}$$

$$\hat{x}_t = \hat{x}_{t-1} + \eta_{4,t}$$

wherein v_w is the speed through water and $\hat{x}$ is a state variable related to calibrating the speed through water log data, ε is a random variable describing measurement noise, and η is a random variable controlling the evolution speed of the state.

10. A method according to any of the claims 7-9, wherein the state space formulation is augmented with an equation which takes into account the forecasted current:

$$c_t = \hat{c}_t + \varepsilon_{5,t}$$

wherein c is the oceanographic current forecast, $\hat{c}$ the estimated oceanographic current, and ε is a random variable describing measurement noise.

11. A method according to any of the claims 7-10, wherein the unknown parameters of the model are estimated using at least one dynamical state-space estimation technique.

12. A method according to any of the preceding claims, wherein the determined speed through water is used for optimising the operation of the vessel, where the optimisation is selected from a group comprising
- optimising time to clean the hull of the vessel,
- optimisation of steering of the vessel,
- optimising speed profile of a voyage, and
- optimising voyage route.

13. A sensor system (100) for determining speed through water of a vessel, the sensor system comprising:

- a first receiver (102) configured to receive propeller revolutions per minute and at least one of torque at propeller, propulsion power, thrust and engine fuel consumption;
- a second receiver (104) configured to receive speed over ground of the vessel; and

- at least one processor (110) configured to determine the speed through water of the vessel, based on the received data and hydrodynamic modeling.

14. A sensor system (100) according to claim 13, wherein the first receiver (102) is configured to receive at least one of the propeller revolutions per minute, torque at propeller, propulsion power, thrust and engine fuel consumption from a corresponding indirect measurement based on vessel vibrations.

15. A sensor system (100) according to claim 13 or 14, further comprising a third receiver (106) configured to receive oceanographic current data related to course of the marine vessel, wherein the processor (110) is further configured to use the received data in the calculation of the speed through water of the vessel.

16. A sensor system (100) according to any of the claims 13-15, wherein the processor (110) is further configured to render the speed through water.

17. A sensor system (100) according to any of the claims 13-16, further comprising a fourth receiver (108) configured to received data from speed through water log, the processor (110) being further configured to use the obtained data in determining the speed through water of the vessel and calibrating the speed through water log data.