SECTION 4
DP PRINCIPLES
HUMAN-MACHINE INTERFACE

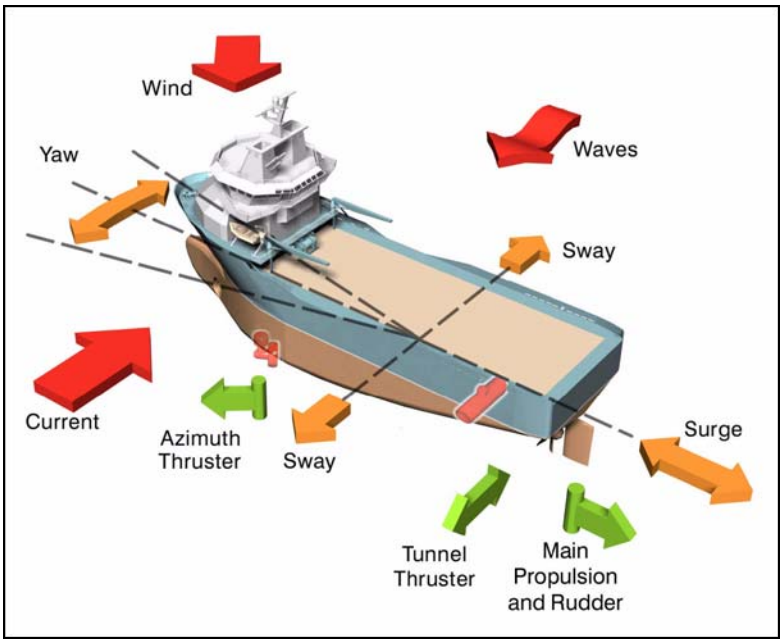
DP Principles

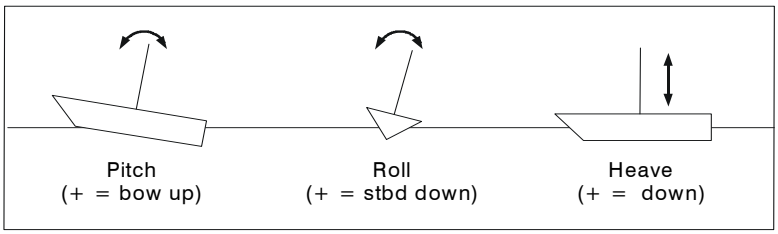
Basic Forces and Motions

A seagoing vessel is subjected to forces from wind, waves and current as well as from forces generated by the propulsion system.

The vessel's response to these forces, i.e. its changes in position, heading and speed, is measured by the position-reference systems, the gyrocompass and the vertical reference sensors. Reference systems readings are corrected for roll and pitch using readings from the vertical reference sensors. Wind speed and direction are measured by the wind sensors.

The K-Pos control system calculates the forces that the thrusters must produce in order to control the vessel's motion in three degrees of freedom - surge, sway and yaw - in the horizontal plane.

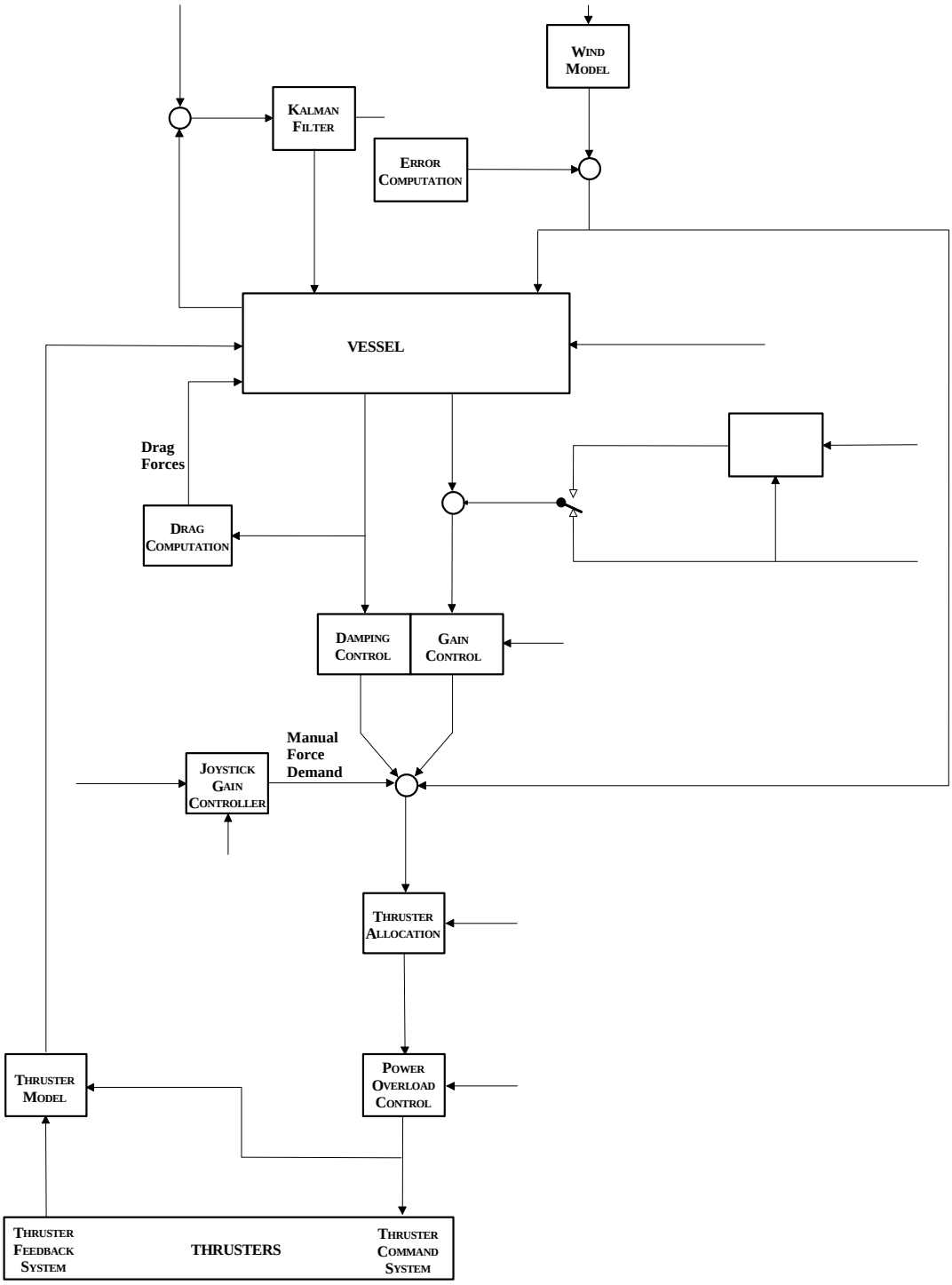




Sensors and Reference systems

DP block diagram

A simplified overview of the DP control system is illustrated in the following figure:



Vessel Model. The differences are multiplied by gain factors that are calculated and adjusted to optimize the station keeping capability with minimum power consumption.

The wanted speed is compared with the estimated speed from the Vessel Model. If the vessel is to maintain a stationary position, the wanted speed will be zero. This part of the force demand therefore acts as a damping factor in order to reduce the vessel's speed to zero.

Force demand for axes under manual control

When any of the axes are not under automatic control, you can use the joystick to manually control the force exerted by the thrusters/propellers in those axes.

Feed forward

In order to counteract changes in the external forces as soon as they are detected, rather than first allowing the vessel to drift away from the required position, the calculated EXTERNAL FORCES are fed forward as an additional force demand.

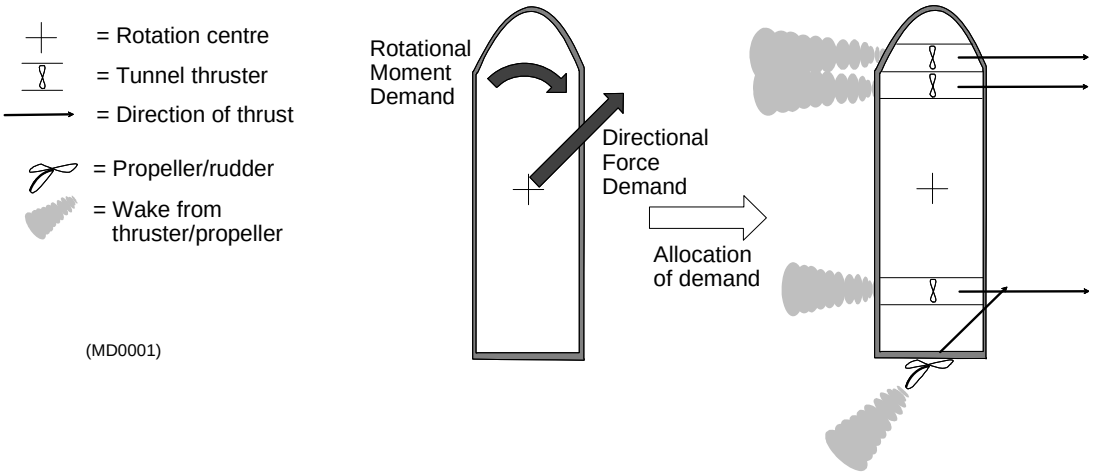
Thruster Allocation

The force demand in the surge and sway axes (the directional force demand), and in the yaw axis (the rotational moment demand), are distributed as pitch and/or rpm setpoint signals to each thruster/propeller.

The demand is distributed in such a way as to obtain the directional force and rotational moment required for position and heading control, while also ensuring optimum thruster/propeller use with minimum power consumption and minimum wear and tear on the propulsion equipment.

If it is not possible to maintain both the rotational moment and the directional force demand due to insufficient available thrust, priority is normally set to obtain the rotational moment demand (heading). If required, you can request that the priority is changed to maintain position rather than heading.

If a thruster/propeller is out of service or deselected, the "lost" thrust is automatically redistributed to the remaining thrusters/propellers.



Power Overload Control

The load on the main bus or on isolated bus sections is monitored, and power is reduced on the connected thrusters/propellers by reducing the pitch/rpm demand if the estimated load exceeds the nominal limit. The reduction value is shared between the connected thrusters/propellers in such a way that the effect on the position and heading control is minimised. This function acts as an addition to the vessel's own Power Management System (PMS). The power reduction criteria are set at lower overload levels than the load reduction initiated by the PMS system.

Reference System and Sensor Data Processing

Measurements of a vessel's position and heading at any point in time are essential for dynamic positioning.

Several different position-reference systems are normally used with the DP system. The first position-reference system selected and accepted for use with the DP system becomes the reference origin (the origin of the internal coordinate system).

HMI - User Interface

Operator station

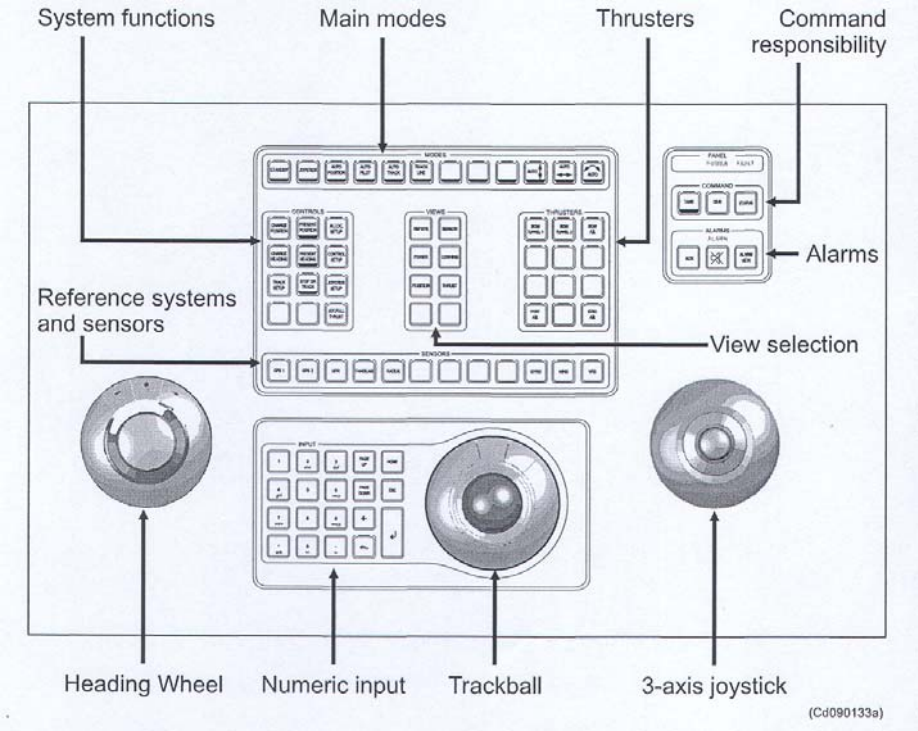
The K-Pos DP operator station includes a high-resolution colour flat screen for monitoring and operation of the system, and an operator panel with push buttons, lamps and joystick controls.

The K-Pos DP operator station

The power switch and adjustment controls for the display are placed on the right hand side of the screen. The use of the power switch and adjustment controls is described in the Hardware Module Description for the screen.

Operator panel

The operator panel provides:
- Dedicated buttons (most of these have status lamps)
- Keypad
- Trackball
- 3-axis joystick
- Heading wheel and buttons



K-Pos DP operator panel

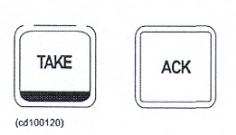
Push buttons

Several push buttons with status lamps are provided on the operator panel for activation of main modes, position-reference systems, thrusters and functions. The accompanying status lamps indicate activation of a particular function, mode or system.

Other frequently-used functions, such as selection of display views and dialog boxes, may also have dedicated push buttons on the operator panel.

The buttons are grouped according to their main function. For safety reasons, some of the buttons must be pressed twice within four seconds to invoke action. These buttons are indicated by a white line along the lower edge.

*Examples of buttons: double press (**TAKE** button for taking command) and single press (**ACK** button for acknowledging messages)*



Note that the appearance of push buttons may vary from vessel to vessel.

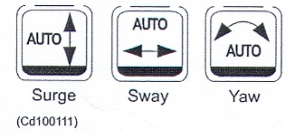
Modes

The **MODES** button group contains buttons for selecting the main operational modes. Status lamps indicate the current mode.

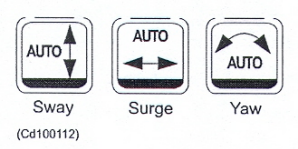
Three additional buttons allow you to select individual axes for automatic control. These are referred to as the **SURGE**, **SWAY** and **YAW** buttons throughout this manual.

Next figure shows the button arrangement for an OS where the operator looks in the alongships direction whilst looking at the screen.

Surge, sway and yaw buttons on an OS that is orientated in the alongships direction



Next figure shows the button arrangement for an OS where the operator looks in the athwartships direction whilst looking at the screen.



Sway, surge and yaw buttons on an OS that is orientated in the athwartships direction

Controls

The **CONTROLS** button group contains buttons for accessing system functions and dialog boxes.

Views

The **VIEWS** button group contains buttons for selecting the view to be displayed in the main working area of the screen.

Thrusters

The **THRUSTERS** button group contains buttons for enabling thrusters.

Sensors

The **SENSORS** button group contains buttons for enabling position-reference systems and for initiating dialog boxes related to other system sensors.

Command

The **COMMAND** button group contains buttons for transferring command to one Operator Station or operator terminal from another.

Alarms

The **ALARMS** button group contains indicators and buttons to display and acknowledge alarms and events. The **SILENCE** button, shown to the left, is used to silence the audible signal without acknowledging the Emergency or Alarm message that caused it.

For more information about messages and the **ALARMS** button group, see *Message system*.

Input

The **INPUT** keypad provides keys that are used to enter values or text into dialog boxes.

Joystick

In *Joystick* mode, the operator controls the positioning of the vessel using the three-axis joystick (integrated joystick and rotate controller).

To move the vessel in the surge and sway axes (alongships and athwartships directions), tilt the joystick. The direction in which the joystick is tilted determines the direction of applied thruster force, and the angle of tilt determines the amount of applied thruster force.

To turn the vessel (the yaw axis), rotate the joystick. The direction in which the joystick is rotated determines the direction of the rotational moment demand, and the angle through which the joystick is rotated determines the amount of

HEADING WHEEL

This is used for setting a new heading.

RATE OF TURN/TURN RADIUS

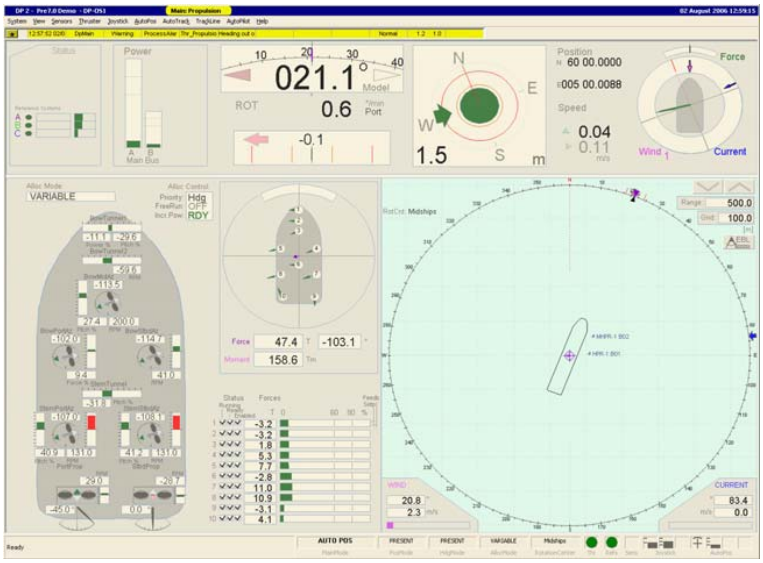
For adjusting the Rate Of Turn (ROT) or Turn Radius.

DISTANCE TO TURN

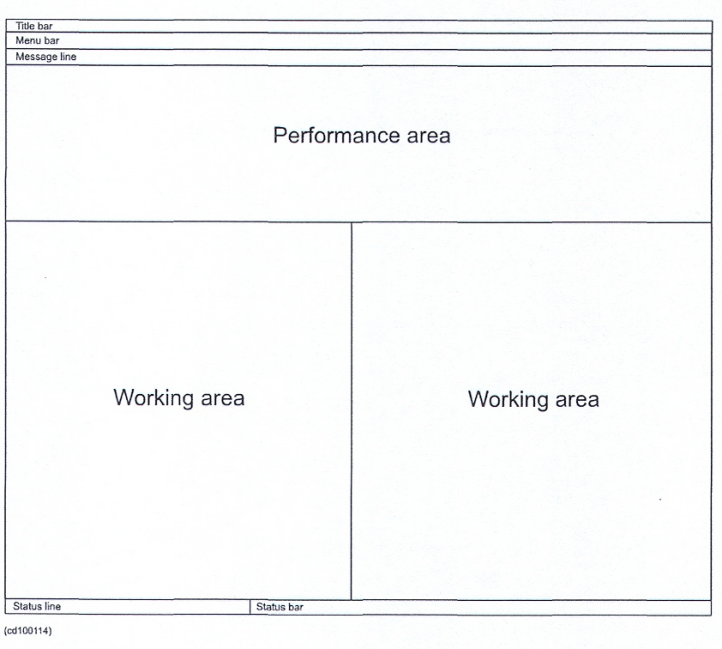
For adjusting the Distance To Turn.

Display layout

The display interface uses standard Microsoft Windows operating features such as menus and dialog boxes.



The display is divided into a number of predefined areas as shown in the following figure. In addition to these, dialog boxes are displayed whenever operator interaction is required.

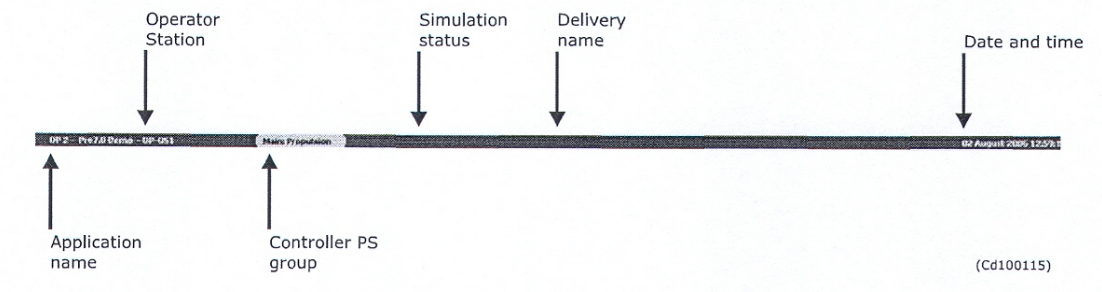


Title bar

The title bar identifies the K-Pos DP operator station and shows the current date and time.

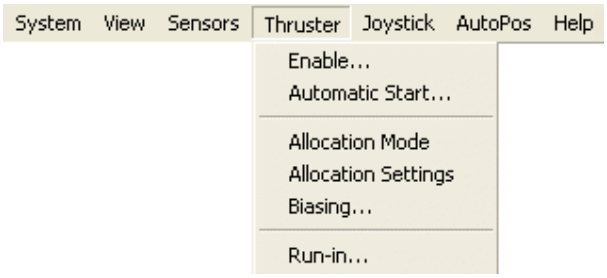
When this operator station has command, the Controller PS group and Command group field has yellow background colour. In our example the Controller PS group is **Main** (to which the operator station in question is connected) and the Command group is **Propulsion** (which the system controls).

When the Trainer is used, the text **SIMULATING** is displayed flashing.



Menu bar

The menu bar provides command menus allowing access to the available dialog boxes.

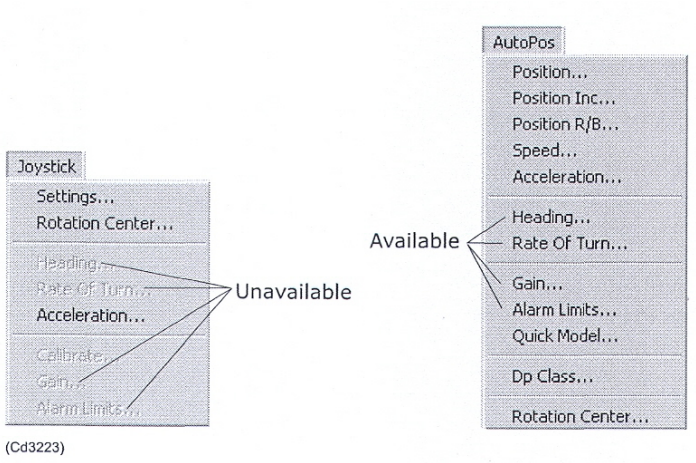


Menu bar (example)

Active and unavailable commands

Because some commands are relevant to several modes, these commands appear on more than one menu. For example, **Heading** appears on both the **Joystick** and **AutoPos** menu.

Some commands that are present on more than one menu are only available in the present mode menu. Unavailable commands have a dimmed appearance.



Commands that are present on more than one menu

Auto Position is the present mode in the example.

Message line

The message line shows the most recent emergency, alarm or warning message that has not yet been acknowledged. Right-clicking the message text opens the **System Messages** Help with the relevant message explanation displayed. See *Presentation of messages*.

Performance area

The performance area shows important performance information to allow immediate assessment of the situation. The content of this view changes automatically according to the selected main mode.

Several parts of the performance area are click-sensitive. When the cursor is moved over an indicator that is defined as click-sensitive, it changes to a pointing hand. At the same time a hotspot cursor text in a yellow frame (the tooltip) is displayed for a few seconds. This text explains the use of the click-sensitive object.

Orientation of the OS and effect on the Performance area

The Performance area shows information relative to the orientation of the Operator Station, so that it is easier to interpret what is seen on the screen. There are two possible orientations:
• The Operator Station is installed facing forward in the vessel (ahead), when looking at the display screen.
• The Operator Station is installed facing the stern of the vessel (aft), when looking at the display screen.
In this manual, the Performance area examples show the information with forward orientation. For aft orientation, the displayed information is the same, but it may be arranged differently to suit the orientation of the Operator Station.

Working areas

The working areas show operator-selectable display views.

Status line

The status line displays general help messages and advice for the operator. For example, when moving the cursor over an open menu, information about the menu commands is displayed in the status line.

Status bar

The status bar provides general system status information by means of indicators, some of which are click-sensitive. When the cursor is moved over an indicator that is defined as click-sensitive, it changes to a pointing hand. If you then click the left trackball button, a dialog box related to that indicator is opened.

Status bar (example)

Overview of labels on the status bar

MainMode

The present operational mode.

PosMode

The automatic position control mode: **PRESENT** or **NEW SETP** (new setpoint).

HdgMode

The automatic heading control mode: **PRESENT, SYS SEL** (system selected) or **NEW SETP** (new setpoint).

AllocMode

The present thruster allocation mode, for example **VARIABLE** (see *Thruster Allocation dialog box*).

RotCenter

Shows the present Rotation Center (see *Rotation center for automatic control* or *Rotation center for joystick maneuvering*).

Thr

An indication of the status of the thrusters:
• **Grey** — No thrusters are enabled.
• **Green** — At least one thruster is enabled.

Refs

An indication of the status of the position-reference systems:
• **Grey** — No position-reference systems are enabled.
• **Yellow** — At least one position-reference system is enabled, but there is no acceptable position information.
• **Green** — At least one position-reference system is enabled and the position information from at least one of them is accepted.

Sens

This is one of the click-sensitive areas. If you press the left trackball button while the cursor has the shape of an open hand, the **Sensors** dialog box is opened.

Joystick

Symbols describing the present joystick settings are grouped above this label.
Joystick Thrust level
Full or Reduced (see *Joystick settings*).
Joystick Precision level
High Speed, General or Low Speed (see *Joystick setting*).

AutoPos

Symbols concerning automatic control are grouped above this label.

Axis Control and Axis Damping Control
These are graphic indications of the axes that are under automatic control or damping control.

The descriptions of the surge and sway axes apply to a system with the vessel diagram displayed “bow up” (see *Orientation of the OS and effect on display views*).

The surge axis is under automatic or damping control.

The sway axis is under automatic or damping control.

The yaw axis is under automatic or damping control.

The axis control symbol is rotated according to the orientation of the Operator Station (see *Orientation of the OS and effect on display views*). Note that the mutual angle difference between the surge and sway axes is preserved.

Gain

Shows the present controller gain level. There are different symbols for the available combinations of controller mode and gain level. See *Display presentation of Controller Mode*.

Quick Model

Shows whether the Quick Model Update function is on (yellow) or off (grey) (see *Quick model update*).

DP Consequence Class

Shows the currently selected DP Class for the DP Online Consequence Analysis function:
- **Grey** — Off
- **2** — Class 2
- **3** — Class 3