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### 0.0.1 Thrust agility tests

As mentioned in Section ??, for the thrust agility tests a step in thrust force is applied for heading of  $0^\circ$ ,  $45^\circ$ ,  $90^\circ$ ,  $135^\circ$ ,  $180^\circ$ ,  $-135^\circ$ ,  $-90^\circ$ , and  $-45^\circ$ . This gives a plot of responsiveness of the thruster system. Due to lack of setpoint measurements, power feedback from MARINTEK is used to determine when the steps were applied.

For the agility plots the total response is considered. That is, the time constant found include the dead time, such that the total system response is plotted in the agility plots. That is, the time constant found is the time of 0.632 of the response (see Section ??).

Time constants from the tunnel thruster are highly inaccurate, because of low sampling (1 Hz). Both the start of the step, and the time where the response is at 0.632 of the response is quite uncertain. Still, the time constants found give an indication on the responsiveness of the tunnel thruster, so they are included.

#### Agility tests with no yawing moment applied

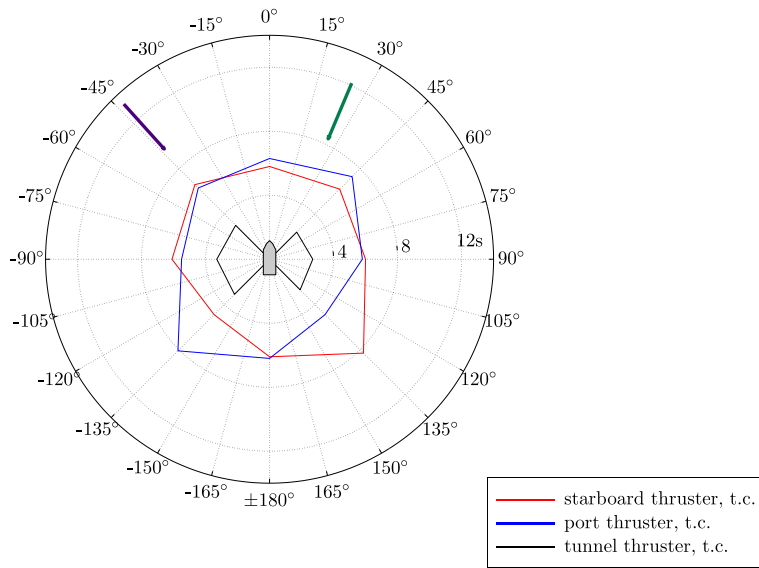
For no yawing moment, two thrust agility tests were performed. One where half of maximum available thrust was applied, and one where maximum thrust was applied. The environmental conditions for both these two tests were about equal. The wind speed and direction has been found from the DP data, and the current and waves were found before the tests were performed. The current is the DP current read from the DP system on board the vessel (the operator station).

The environmental conditions are found in Table (1), and the thrust time constants are found in Figure (1), and (2) for half and full thrust, respectively. On the radial axis time in seconds is plotted, and the time constant is shown for the two main thrusters (port and starboard), and the tunnel thruster. For direction  $0^\circ$ , and  $180^\circ$  the tunnel thruster is not applicable.

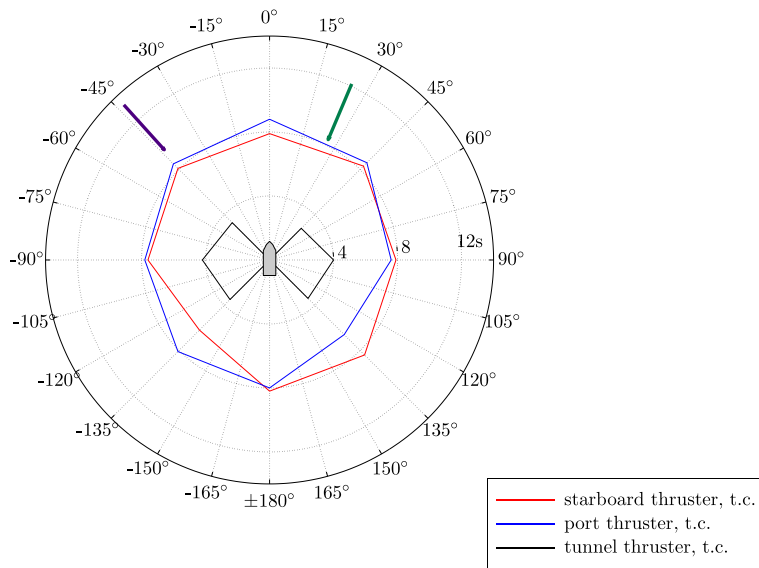
**Table 1:** Environmental conditions thrust agility, no yawing moment

Environment	
Wind, speed	
<i>Average</i>	<i>Std.</i>
3.3	0.5
Wind, direction [ $^\circ$ ]	
<i>Average</i>	<i>Std.</i>
22.9	9.0
Waves	
<i>H<sub>s</sub> [m]</i>	<i>Direction [<math>^\circ</math>]</i>
0.1	South/SW
Current	
<i>Speed [m/s]</i>	<i>Direction [<math>^\circ</math>]</i>
0.2	318

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**Figure 1:** Agility plot, thrust time constant, no yawing moment - half thrust. Wind of  $3.3 \frac{m}{s}$  (green) and current of  $0.2 \frac{m}{s}$  (purple)



**Figure 2:** Agility plot, thrust time constant, no yawing moment - full thrust. Wind of  $3.3 \frac{m}{s}$  (green) and current of  $0.2 \frac{m}{s}$  (purple)

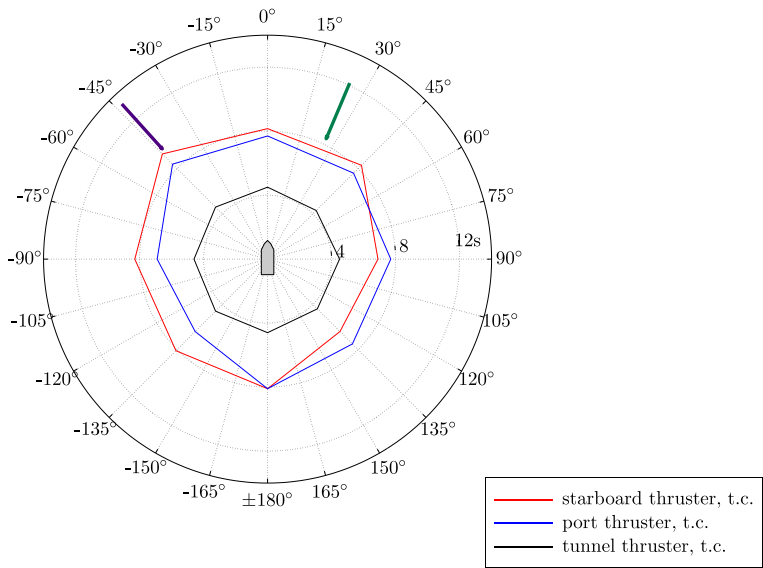
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### Agility test with applied yawing moment

A thrust agility tests was performed with an applied yawing moment of 100%. The thrust applied was 100% of available thrust force. The environmental conditions has been found similarly to Section (0.0.1), and is found in Table (2), and the thrust time constants are found in Figure (3).

**Table 2:** Environmental conditions thrust agility, with yawing moment

Environment	
Wind, speed	
<i>Average</i>	<i>Std.</i>
4.3	0.5
Wind, direction [°]	
<i>Average</i>	<i>Std.</i>
26.8	6.9
Waves	
<i>H<sub>s</sub> [m]</i>	<i>Direction [°]</i>
0.1	S/SW
Current	
<i>Speed [m/s]</i>	<i>Direction [°]</i>
0.2	318



**Figure 3:** Agility plot - thrust time constant, with yawing moment. Wind of  $4.3 \frac{m}{s}$  (green) and current of  $0.2 \frac{m}{s}$  (purple)

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