

## The use of drag coefficients in hydrodynamics

Haslar, a maritime site in QinetiQ, provides research, experimentation and technical assurance using hydrodynamics facilities and ship and submarine design tools.

During my placement at QinetiQ Haslar, I conducted experiments assessing new concept designs of sea anchors (parachute-like devices used to slow down a ship) for an external customer. This involved towing scaled down sea anchors through water at set speeds to assess their hydrodynamic performance.

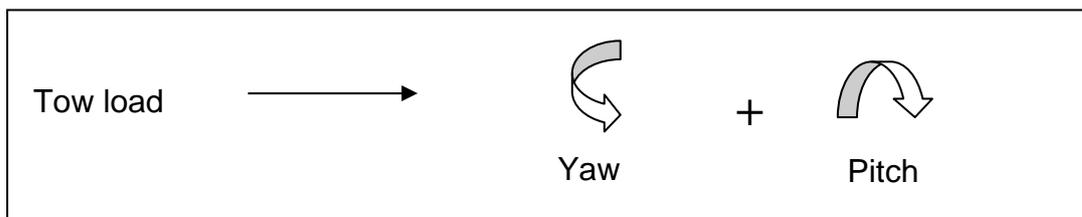
It was important to find out which sea anchor produced the greatest drag in order to know which type was the most effective and efficient anchor. This required taking experimental data, finding individual components, resolving forces and calculating drag coefficients.



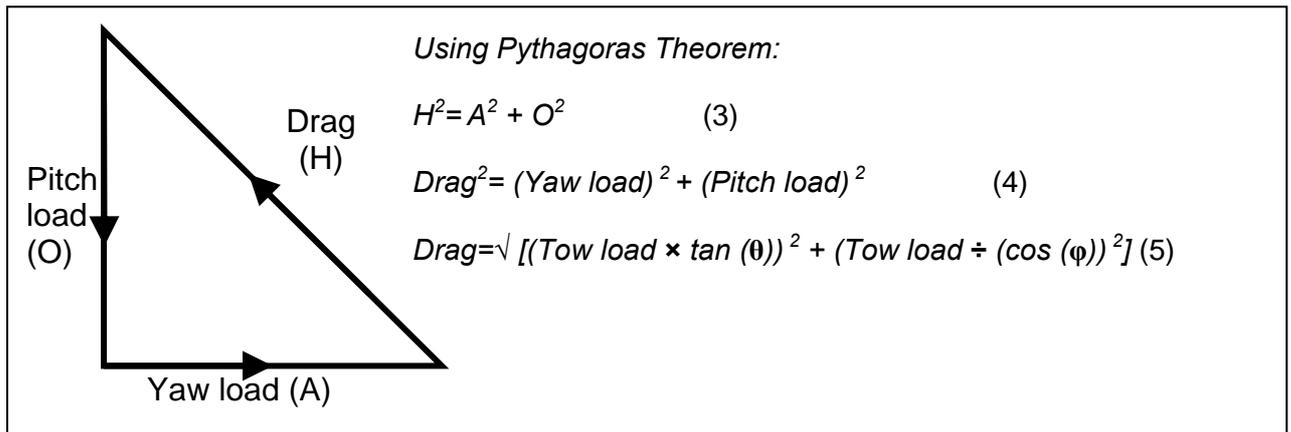
*A concept design sea anchor (folded in half)  
QinetiQ image*

### Resolving the tow load:

The mean tow load (or tow force, measured in Newtons) is resolved into components: yaw ('side to side rotation' about the z (vertical) axis) and pitch ('up and down rotation' about the y (lateral) axis).



<b>Yaw load= Tow load × tan (yaw angle (θ))</b>	(1)	(S <sup>O</sup> H C <sup>A</sup> H T <sup>O</sup> A)
<b>Pitch load= Tow load ÷ cos (pitch angle (φ))</b>	(2)	“



**The drag coefficient can then be found for each sea anchor:**

After the drag force has been found using equation (5), the drag coefficient can be calculated:

$$C_D = \frac{F_D}{\frac{1}{2} \rho v^2 A} \quad (6)$$

$F_D$  is the drag force (calculated using equation (5))

$\rho$  is the density of the fluid (in this case, water: 1000 kg/m<sup>3</sup> at 4°C)

$v$  is the speed of the object relative to the fluid (in this case, the speed the anchor is being towed at, ms<sup>-1</sup>)

$A$  is the reference area (in this case, the area of the sea anchor, m<sup>2</sup>).

A drag coefficient (a dimensionless value) allows direct comparison between each sea anchor.

**Full example: same size, different shape anchors towed at 0.2ms<sup>-1</sup>**

**Sea anchor 1:**

$$\text{Drag} = \sqrt{[(30.98 \times \tan(4.52))^2 + (30.98 \div (\cos(9.45)))^2]} \\ = 31.50 \text{ N}$$

$$\text{Drag coefficient: } \frac{31.50}{\frac{1}{2} \times 1000 \times 0.2^2 \times 0.6^2 \times \pi} \\ = 1.39$$

**Sea anchor 2:**

$$\text{Drag} = \sqrt{[(22.49 \times \tan(2.91))^2 + (22.49 \div (\cos(9.81)))^2]} \\ = 22.85 \text{ N}$$

$$\text{Drag coefficient: } \frac{22.85}{\frac{1}{2} \times 1000 \times 0.2^2 \times 0.6^2 \times \pi} \\ = 1.01$$

Sea anchor 1 has a larger drag coefficient and therefore is a more efficient anchor.