Where is my Pivot Point?

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In recent years, there has been much discussion on the pivot point (PP): What is it? Where is it located? This paper builds on previous publications to give a mathematical definition of the location of the pivot point that corresponds to the intuitive feeling of seafarers.

The pivot point is the point around which the ship appears to be turning for an observer standing on board the ship. This point is known to be usually located at about 1/4 or 1/3 of the ship length from the bow. It is also well known that this location is not constant and depends on external factors such as use of tugs, bow thrusters, ship acceleration or deceleration, ship motion ahead or astern, etc. In fact, the location of the pivot point results from a reaction to a very large number of factors acting on the ship.

Fortunately, as Dr Seong-Gi Seo of Warsash Maritime Academy's Ship-handling Centre concluded (*Seaways*, August 2011): 'The pivot point is a geometrical property'. This means that it must be possible to compute the position of the pivot point from a given track *after the event*. In other words, we can consider the track as the *result* of all hydraulic forces on the ship movement and we do not need go into the question of *why* the ship has moved in a certain way, perhaps due to an unnoticed gust of wind or a local current or any other reason.

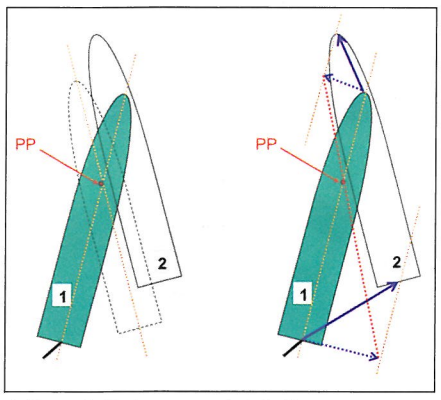
So, let us consider a ship track. The ship moves from position 1 to position 2 (see Fig 1, bottom left). The pivot point is defined as usual by the apparent point of rotation. If we consider a vector from bow-1 to bow-2 and a vector from stern-1 to stern-2, we fully define the movement of the ship from position 1 to position 2.

If we draw a connecting line between the transversal component of both vectors, the intersection with the ship's axis will be located exactly on the apparent point of rotation. That is the pivot point (see also John Clandillon-Baker in *The Pilot*, November 2011). This vector approach is simple and pragmatic; it allows us to compute the pivot point of *any* ship movement.

Let us see what happens for an object (with length L) moving along a perfect circle (I speak of an 'object' because we can artificially control its drift) (see Fig 2, below).

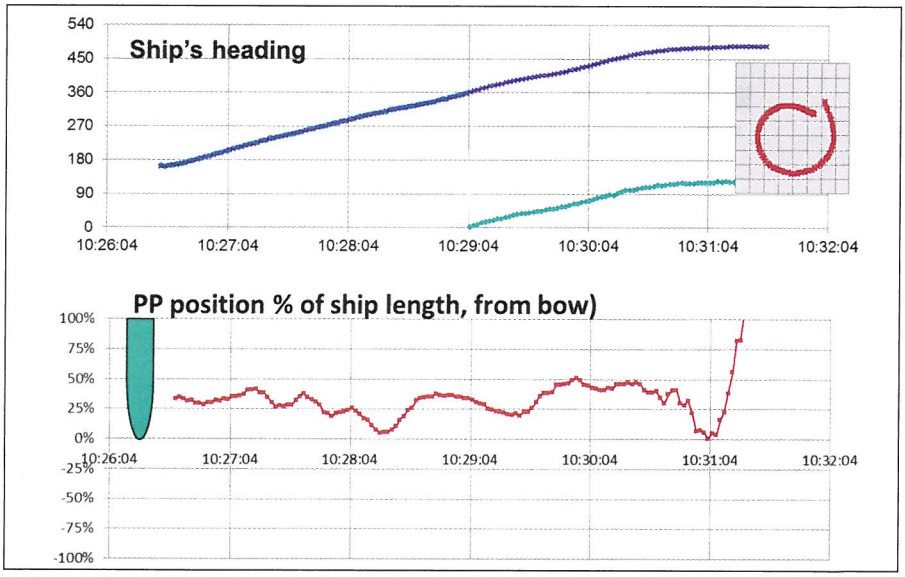
The heading of this object is changing constantly in a perfectly regular manner and the position of the pivot point is shown as a percentage of the ship length, starting from the bow (positive if behind the bow and negative if in front of the bow). This object is moving at a speed of about 4.5 knots on a circle with a diameter of 4 L. If the drift is 0°, the pivot point will of course be in the middle of the object. If the drift is about 5°, the pivot point is found at 33% of the ship length from the bow. If the drift is more than 15°, it will be ahead of the bow.

This sounds pretty close to what seafarers feel on a real ship. However, the drift angle is a parameter that cannot be chosen freely in the real world. So, let us



▲ Figure 1: Vector approach definitions

▲ Figure 2: Position of the pivot point during perfect turning circle



▲ Figure 3: Position of the pivot point during real turning circle

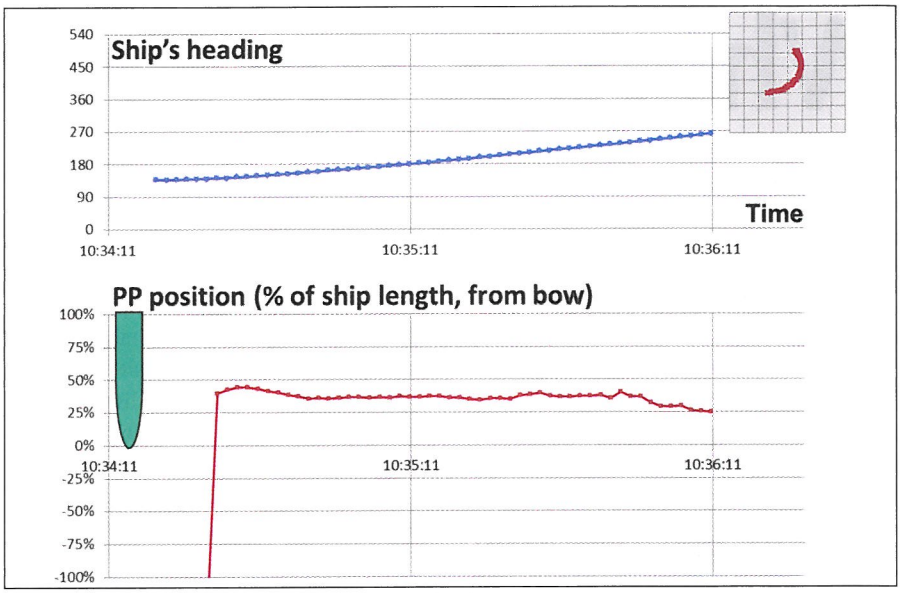
have a look at a track measured on one of Port Revel's manned model ships (255,000 dwt fully loaded tanker at scale 1:25) (see Fig 3).

The heading is not completely constant as it undergoes small variations due to small changes in the forces acting on the ship (eg local water depths, bank effects, wind gusts, currents, etc). As a result, the pivot point moves quite a lot, even after some filtering of signals. Nevertheless, the PP is located around 25-35% of the ship length from the bow for most of the time – exactly what seafarers would expect.

In an accelerating turn, the ship is started with full rpm and full rudder.

Observations show that the ship moves on a kind of spiral track as shown above, reaching a speed of nearly 6 knots after about 10 minutes real time.

The pivot point is expected to be at the centre of the ship (50% from the bow) during the first stage of the manoeuvre, as this would correspond to the ship turning around her own centre before any speed ahead is made. This can be seen above on the left-hand side of figure 4, where the pivot point is located at 40 to 45% of the ship's length from the bow. After a short time, it moves to a fairly steady position around 35% of length from the bow.



▲ Figure 4: Position of the pivot point during an accelerating turn

Being able to compute the position of the pivot point from a given track at any time enables us to check whether the 'seafarer's intuition' is in agreement with the calculated position. However, this knowledge will probably not change the way seafarers handle ships because it is unlikely that it will ever be possible to *predict* the exact location of a pivot point on a real ship at any time, since this is a result of all the forces that are going to act on the ship in the very near future.

In that sense, shiphandling will always remain a kind of *art* that can only be improved by practical experience.

Further information can be found on: www.portrevel.com

■ The author wishes to thank Nigel Allen FNI, Southampton Pilot, and Gordon Maxwell, Senior Lecturer Warsash Ship Handling Centre