What's Up in Navigation Displays?

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Situation Awareness

When following a passage plan, where you are going to be is more important than where you are now. This is because you can not alter where you are now, but you may be able to influence where you will be in the future.

Where you will be in the future requires knowledge of your current situation and the correct interpretation of factors that affect your situation. This is called situation awareness and comprises of three elements; observing the situation, understanding the situation and predicting what the situation will become. (Endsley's situation awareness model of perception, comprehension and projection).

Situation awareness is required to execute and monitor a passage plan. At high speeds or in confined waters, the available time to make decisions is reduced. This time-critical workload requires sharper situation awareness.

Electronic Chart Systems

The marine industry has enjoyed many instrumentation and human factors advances that improve situation awareness and support decision making.

Electronic Chart Systems (ECS) are computer based navigation displays that integrate position information onto a chart display. ECS delivers automation in navigation by conducting the three phases of situation awareness. The ECS can display where the vessel is situated, her course, speed, rate of turn and with an understanding of these instrument observations, predict the vessel's future position.

(Sole reliance on the ECS's prediction disengages the bridge team from the initial two stages of situation awareness: observing and understanding the current situation.)

The ECS's situation awareness must be easily integrated into the bridge team to be shared with those executing and monitoring the passage. In addition to the appreciation of range and the proximity of dangers, the observer must understand the orientation of the ECS display in relation to the bridge view.

Orientation of instrument displays

Information presented in North Up requires mental rotation to re-align the information to the observer's operating orientation, Head Up. This mental rotation is a skill refined in experienced navigators. In times of high workloads, this re-alignment may cause confusion, especially on southerly courses (see fig. 1).

With the ocean and coastal navigation background of pilots and cartographers, the marine industry generally chooses North Up orientation in all situations including the critical environment of pilotage waters.

There is very compelling research suggesting that

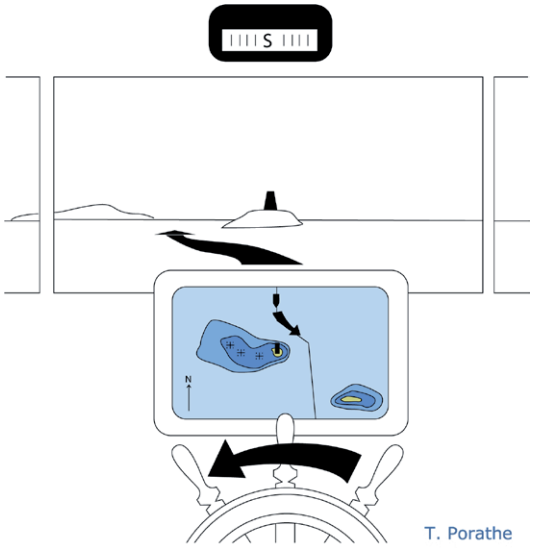

Fig 1: North Up ECS display

Head Up is the better orientation in pilotage waters. Head Up orientation delivers improved situation awareness, faster decision making and less errors, a fact recognised in the aviation industry. Such advantages make Head Up orientation safer in pilotage waters.

The user friendliness of different chart presentations has been researched by Dr. Thomas Porathe, an assistant professor in information design at Mälardalen University, Sweden.

Dr Porathe identifies that for track keeping in confined waters, Head Up is a better chart orientation than North Up (see fig 2). The best display though, is a three dimensional ego-centric Head Up display (see fig 3).

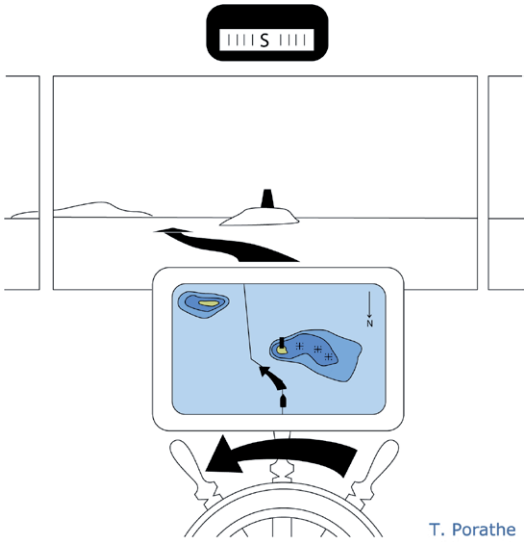

Fig 2: Head Up ECS display

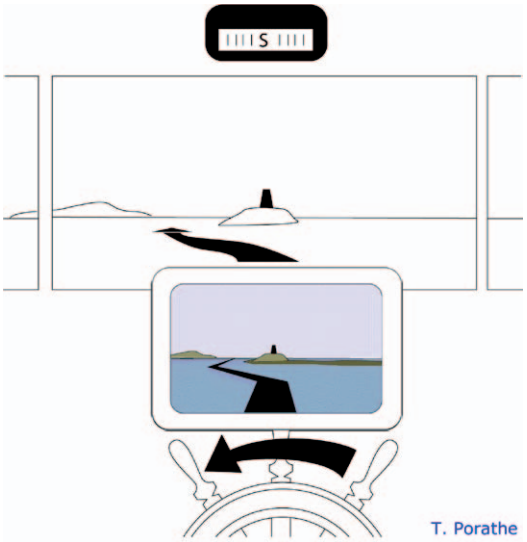

Fig 3: 3D Ego-Centric Head Up ECS display

The ease of reading and following a planned track on a three dimensional ego-centric Head Up display is supported by the simplicity of reading car navigators. (see fig 4)

Fig 4: Car navigator simplicity

Improving passage situation awareness

There is scope to enhance passage monitoring by adopting practices that improve situation awareness. This requires a shift away from North Up presentation and a reliance on ECS to a Head Up presentation using eyes, radar and ECS.

Appraisal & Planning

A passage plan should be developed on an ECS on North Up.

Passage plans are made up of a series of segments comprising straight tracks or turns. For each segment, visual and radar cues should be sought. For straight tracks, visual transits ahead and radar parallel indexing should be established for the segment. For turns, visual wheel-over lines and radar concentric indexing techniques should be included into the plan.

It may seem un-necessary to have indexing measures on the ECS display that show you where you are anyway. The presence of reference points and indexing lines/circles on the ECS helps situation awareness by allowing the observer to independently monitor and predict the vessel position by observing the relative movement of fixed objects. Additionally having these indexing techniques on the ECS brings range into the context and allows for identical radar set-up.

With the radar actively engaged in monitoring the passage and in part, duplicating the ECS's display, integrity testing is introduced into the system and redundancy should the ECS fail. (The different information sources of the two displays should be appreciated with the radar, inherently Head Up, displaying what it detects is around the vessel and the ECS, inherently North Up, displaying what it has been told is around the vessel.)

For each leg and turn of the passage, an appropriate reference point and reference point distance should be ascertained and displayed on the ECS.

For straight tracks between two waypoints, a parallel index line should be drawn. The reference point used for the parallel indexing is marked by a virtual reference point. This virtual reference point will give a <u>stabilised</u> trail whilst the vessel is between the two waypoints of that leg (see fig 5).

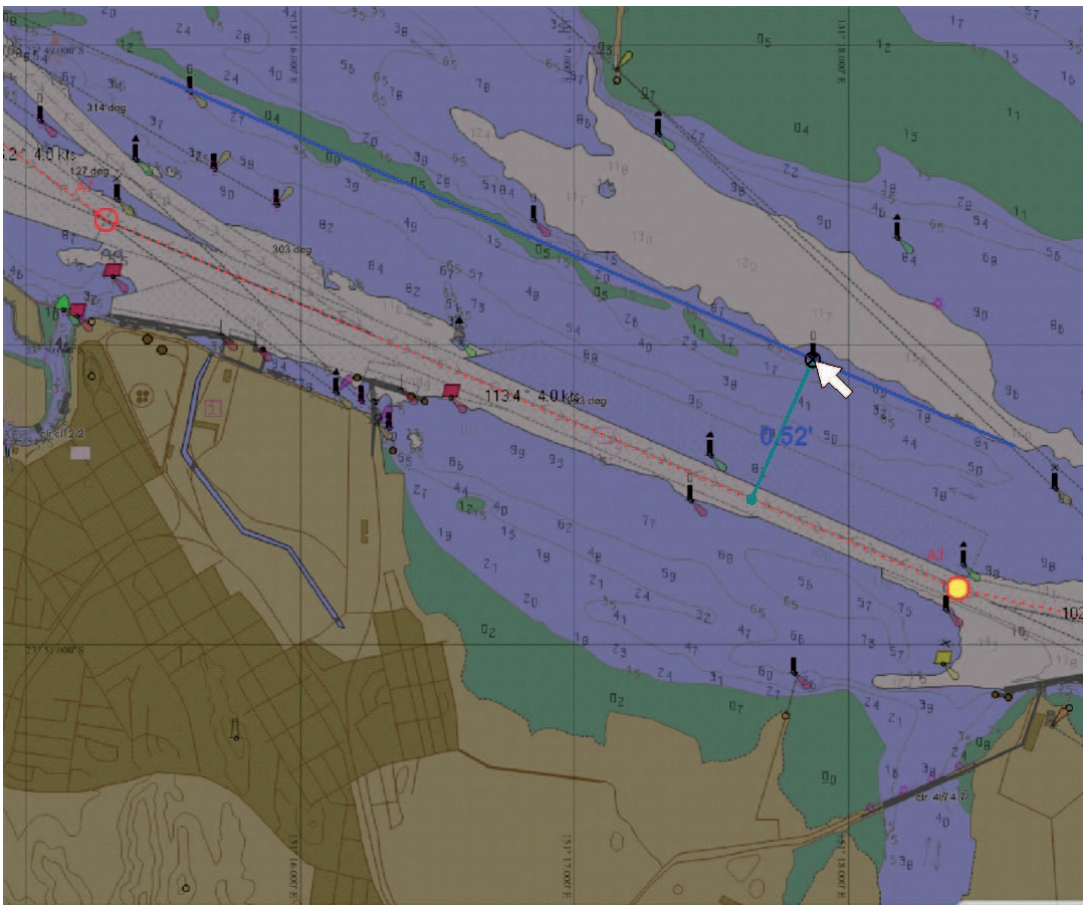

Fig 5: Generating an index line and virtual reference point for parallel indexing.

Similarly, for turns, a concentric index ring should be established and shown for monitoring turns. The appropriate turn radius selected by moving the turn centre icon out (see fig 6).

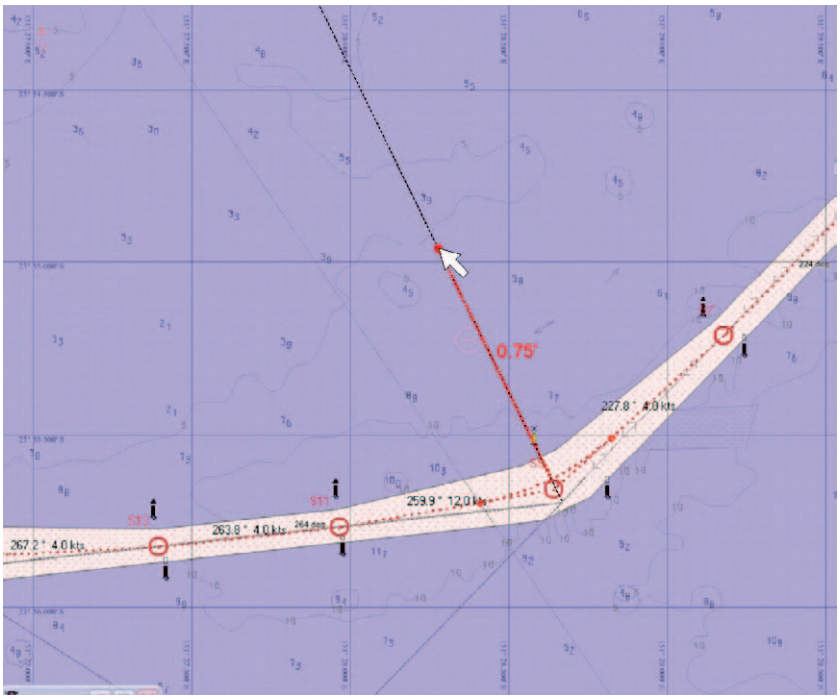

Fig 6: Selecting an appropriate turn radius

A suitable reference point is then selected and is marked by a virtual reference point which will additionally generate the concentric indexing ring and the reference point's bearing from the turn centre (see fig 7). This virtual reference point will give an <u>un-stabilised</u> trail whilst the vessel is between the two waypoints of that turn segment.

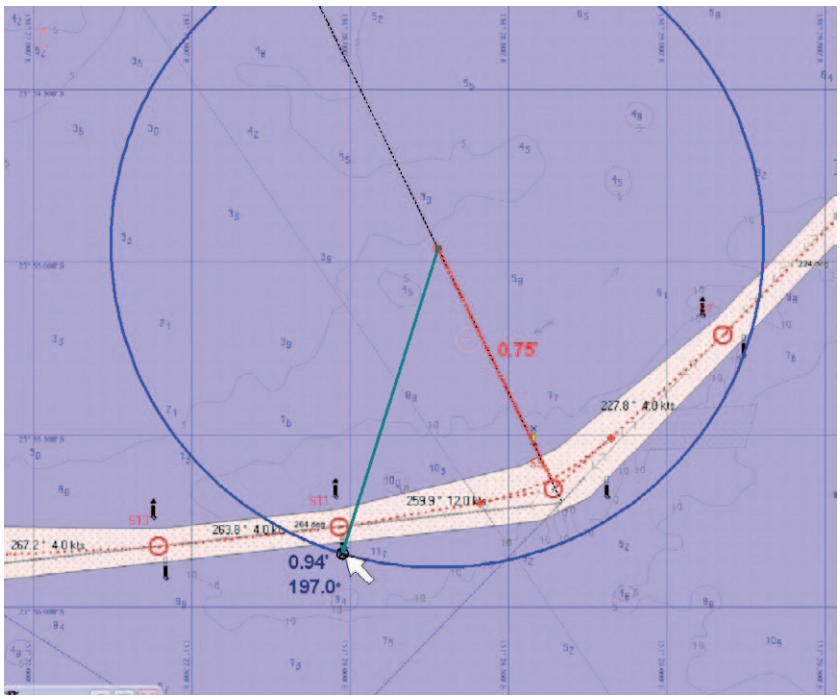

Fig 7: Generating a virtual reference point, concentric indexing ring and reference point bearing.

The completed passage plan developed on the ECS contains a series of :

- waypoints
- reference point and reference point distance for parallel indexing each leg
- reference point, reference point distance and bearing for concentric indexing each turn.

For pilotage waters, the data from the plan should be in a format that can be sent to visiting ships prior to taking on a pilot. At the very least, the data should include a list of waypoints and turn radii used.

Execution & Monitoring

On commencing the pilotage passage, the orientation of the radar and ECS are aligned to a bridge team, Head Up

If in doubt about a bridge team's orientation, it is worth noting that the concept of port and starboard, ahead and astern are all Head Up referenced and instrumentation on the bridge is displayed accordingly (see fig 8).

Fig 8: Head Up orientation on a bridge

On each passage segment, the parallel/concentric indexing lines/rings along with the corresponding virtual reference point are automatically displayed on the ECS, this display being activated on approach to the segment's initial waypoint.

On the straight track segments, the ECS displays the parallel index line for that segment and a *stabilised* trail from the virtual reference point. On the radar, a parallel index line at the same distance is set to monitor the vessel's passage against the planned track and *stabilised* relative trails engaged (see fig 9).

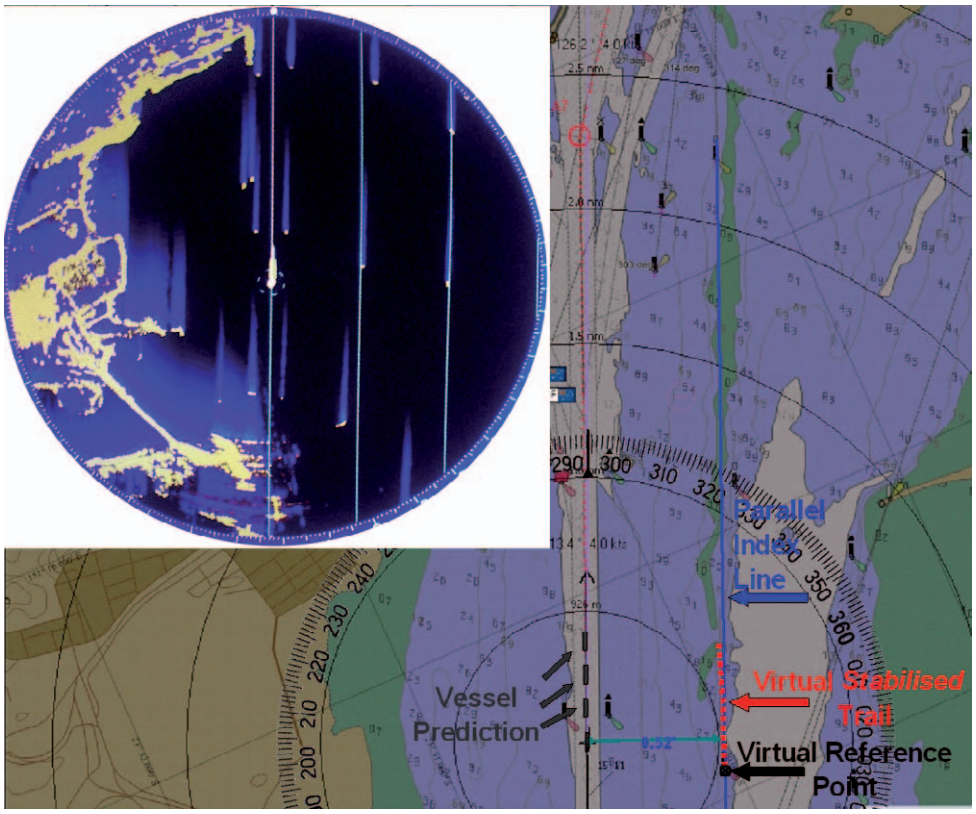

Fig 9: Straight segment and virtual stabilised trails

On the turn segments, the ECS displays the concentric index ring and reference point bearing for that segment and an *un-stabilised* trail from the virtual reference point. On the radar, a concentric ring and stabilised EBL line are set up with the same parameters as the ECS and *unstabilised* relative trails engaged. (see fig 10)

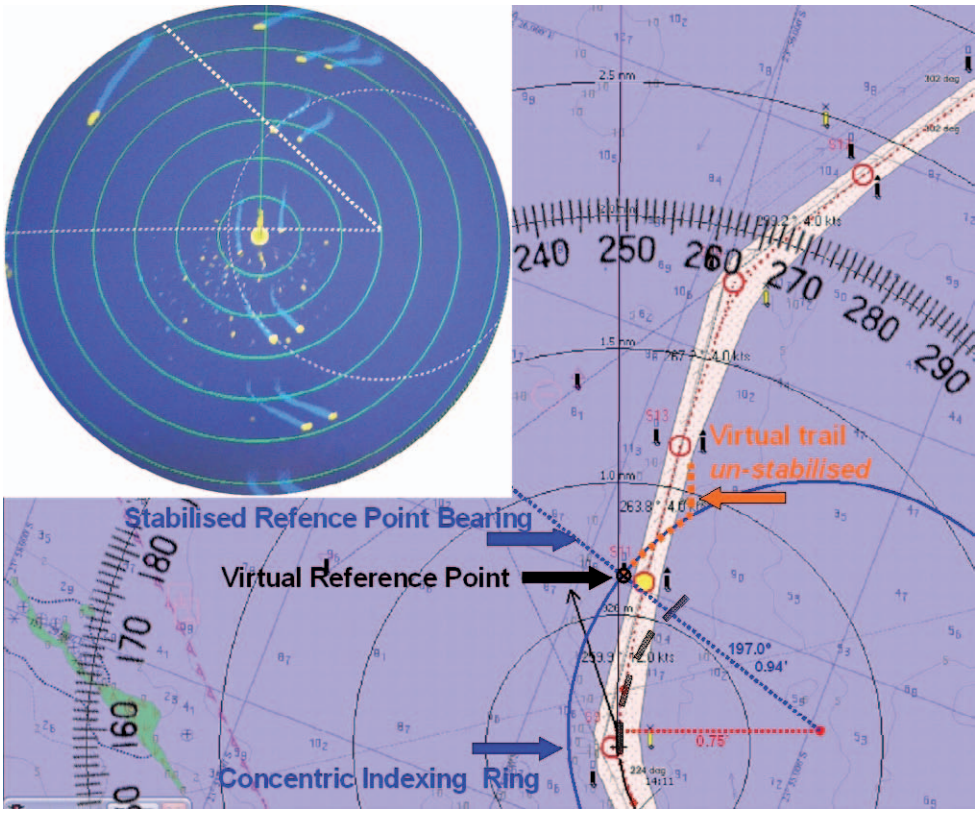

Fig 10: Turn segments and unstabilised relative trails.

.Whilst the presentation of the indexing on the ECS is automated, the radar indexing parameters are manually set, keeping the bridge team engaged and aware of ranges and proximities.

On passage, the views from eyes, radar & ECS display should all agree and compliment each other to provide the bridge team good situation awareness.

Consistent with the ego-centric Head Up approach, any departure from the planned track should be ego-centrically displayed or described as “track to starboard/port” rather than the track-centric “left/right of track”.

Currently, different marine displays indicate cross track error in different ways, so for the same cross track error, one display may show a red arrow to port and another display, a green arrow to starboard. There would be advantages if the marine industry had a standard similar to the ego–centric approach in aviation with Course Deviation Indicators (see fig 11).

Fig 11: Aircraft Horizontal Situation Indicator (HSI)

System Requirements

The system requirements to allow for this proposed practice are:

- ECS
- capabilities extended to offer parallel and concentric indexing
- virtual reference points capable of leaving stabilised or unstabilised trails
- Perspective viewing to generate 3D perspective ego-centric Head Up display.

Radar – on Head Up

- the option of stabilised or unstabilised relative trails.
- The ability to easily set up parallel and concentric indexing

With the advent of e-navigation, these characteristics warrant consideration as well as a standardisation of descriptions amongst navigational displays.

Conclusion

When following a passage plan, better situation awareness is achieved by operating navigational displays on Head Up. Better situation awareness provides safer conduct of vessels.

Head Up is the display orientation for use in time-critical, high workload, track keeping navigation, whereas North Up is for low workload navigation.