Port navigation risk assessment

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The dynamics of navigation, shiphandling and collision avoidance intrinsically link a master, bridge team and their vessel with a port's safety support structures in the context of the tides, currents, wind, hazards and other vessels in confined waters. On the bridge, there is a heightened level of readiness to meet the increased level of external threats, the vessel is made ready for immediate manoeuvre or emergency anchoring, the workload is shared and a pilot is embarked. The port entry passage plan is executed and adjustments are made for actual conditions encountered.

Passage planning is risk management

Just as a master prepares a passage plan for a harbour approach, understanding the safety environment and the navigation hazards managed by mariners is key to identifying appropriate aids to navigation, channel dimensions, and traffic management systems to minimise the likelihood of vessel grounding and collision. Channel design is well supported by guidance such as that provided by PIANC internationally or WHAMS in the United States. Manoeuvring assessment is also in hand through the use of technology such as BMT SeaTech's *PC Rembrandt*. Traffic flow and collision risk can be analysed using *WebStat* by GateHouse, *Voyage Traffic Planning and Simulation System* by SimPlus or other Geographic Information System based products. BMT Fleet Technology's *Buoy Ranging Software* enables the selection and placement of buoys and the estimation of serviceability. However, it is only recently that the analysis of an appropriate level of aids to navigation and traffic services is advancing to the same level of sophistication. This was made possible by modeling navigation risk on how a master plans and executes a passage in restricted waters.

Risk-based aids to navigation design

As vessel designs and traffic characteristics change, the port must consider the appropriateness of existing navigation constraints and more precisely assess if support is sufficient or restrictions are excessive. Navigation hazards in port approaches have successfully been assessed from the vessel and master perspective with the support of software that provides a measure of positioning quality for different combinations of aids to navigation. The Excel spreadsheet method, *design minimal de sécurité* or DMS, developed by Brad Judson, Stéphane Julien and others demonstrates navigation risk for each planned track for a design vessel in various environmental conditions. Limiting factors such as wind, depth, vessel speed and draught become obvious.

The concept of assessing navigation risk in DMS is similar to that of determining an anchor swinging circle and safety margin. The swinging circle of a vessel at anchor is a function of the scope of cable, depth of water, height of tide, wind and current. The safety margin extends this area depending upon risk and one of the factors is the ability to accurately position the vessel by visual aids to navigation, radar and GPS. The safety margin is not just a function of the manoeuvring capability of the vessel and the master; nor is it just the stated accuracy of GPS or ECDIS, it also a function of the quality of positioning with confirmation by a secondary method and the proximity to shoals. A high quality position might be the visual reference to transit ranges showing the vessel to be on track and confirmation by radar or ECDIS that a master is on the correct set of ranges, for example.

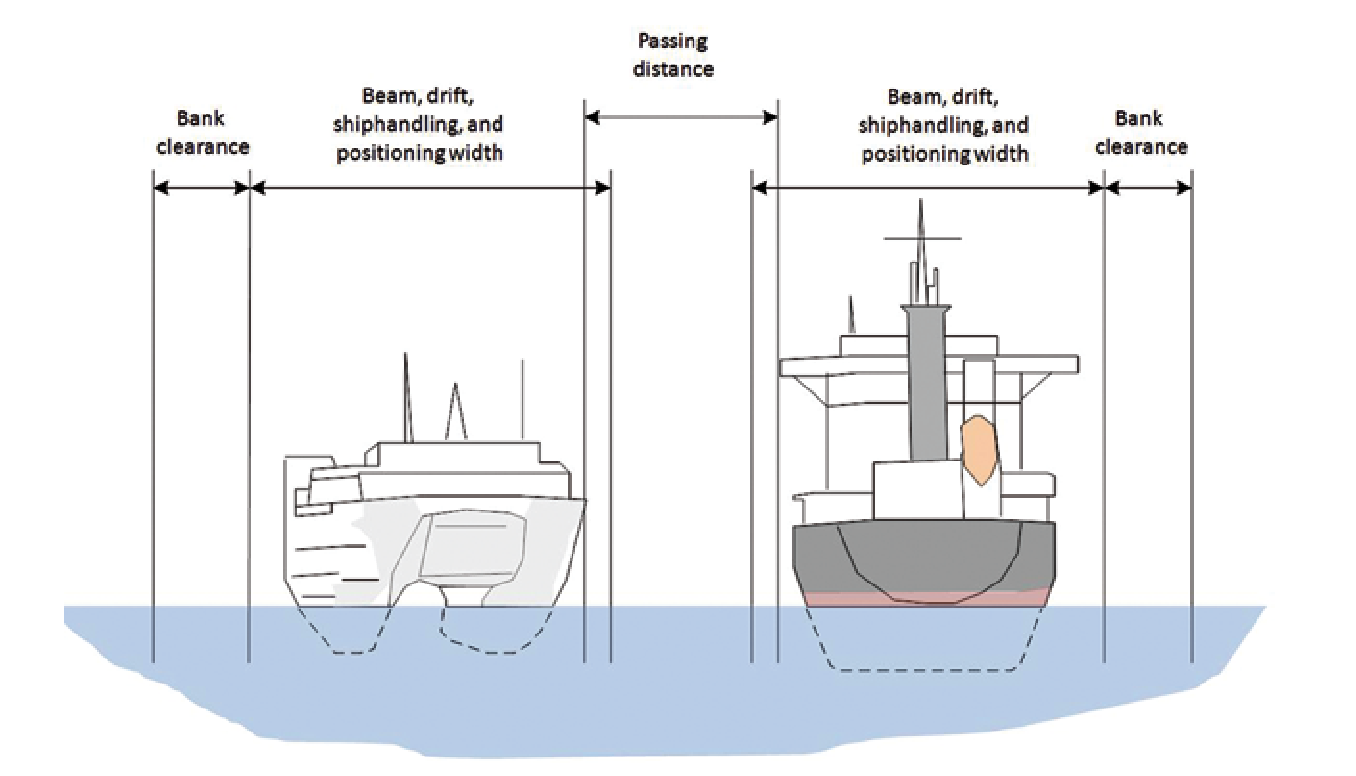

Figure 1. Navigation risk factors.

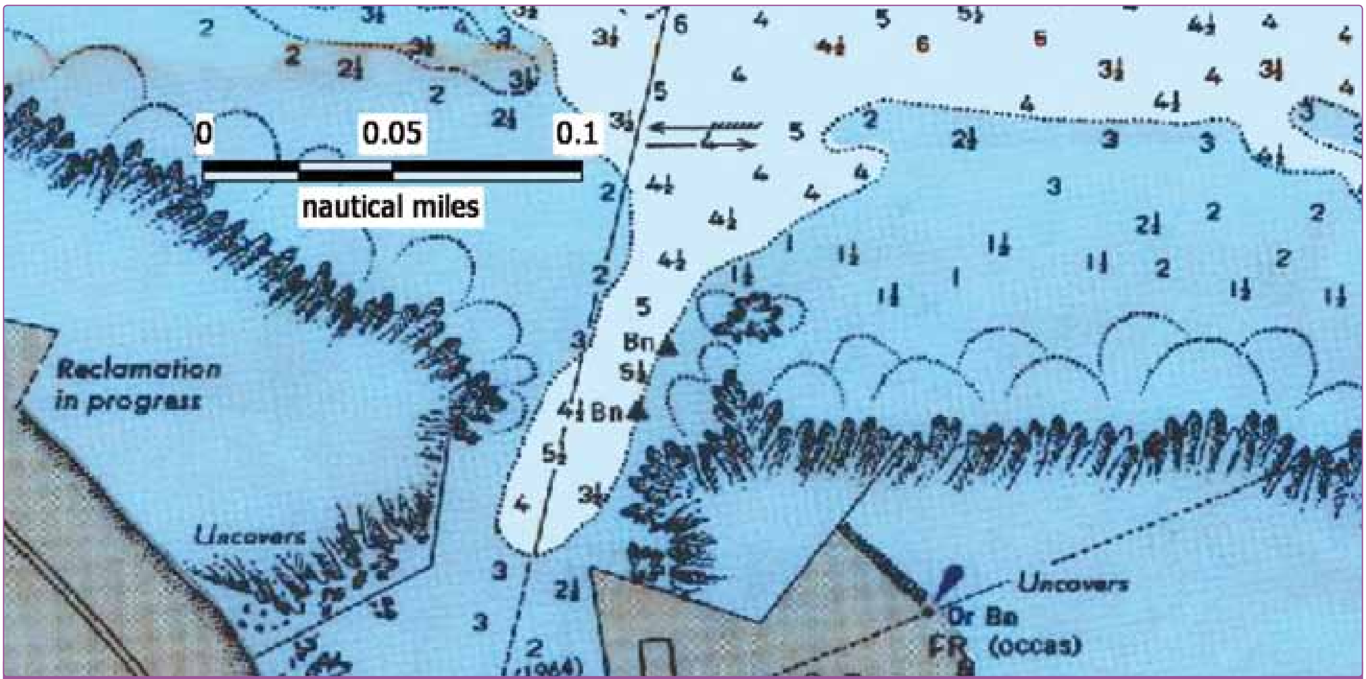

Figure 2. Avatiu Harbour, Rarotonga.

Just as a safe speed for collision avoidance is qualified by factors described in Rule 6 of the *Collision Regulations*, there are, of course, a set of factors to be considered for "grounding avoidance" (Figure 1). A vessel underway will require room to manoeuvre: to accommodate for variation in the coursekeeping ability of the vessel and the helmsman; to provide for the advance and transfer in the execution of a turn; and to allow for drift or crab to compensate for wind and current. The dimensions of the vessel are considered along with passing distance as well as bank or squat effects. A residual navigation risk results from the addition of aids to navigation or other management services given the natural hazards in a waterway. A safety measure is then determined as the ratio of the channel width to the required sea room.

Since the development of the DMS methodology in 1999, the technique was used to assess aids to navigation and hazards in the Bosporus by the IMO; the St. Lawrence River by the Canadian Coast Guard; and a more recent Port of Montreal study. However, its application to navigation conditions found in South Pacific port approaches demonstrated its validity and usefulness for navigation risk measurement to a wider range of world ports.

Navigation risk in port approaches

Because the method enables the assessment of navigation on a track by track basis, risks can be compared for different parts of a waterway, risks can be assessed for different vessels or environmental conditions, different combinations of aids to navigation can be analysed or one waterway can be compared to another. The application of this navigation risk technique to 29 ports and approaches in the South Pacific by Anderson and Judson for the South Pacific Regional Environmental Programme helped pacific island countries and territories to position a network of spill response stocks and provided a critical risk-based rationale leading to port and waterway improvement.

The *Marine Pollution Risk Assessment for the Pacific Islands Region* provided a first look at port navigation risk in the South Pacific. With a focus on the management of pollution risk, hazards to shipping were identified for each port or its approach in the region. To simplify the analysis for 29 ports, a safety measure was determined for the single most restrictive track on a port approach.

Port visits were made by this author and other participants in the study. Harbour approach charts and sailing directions were obtained and typical design vessels were used when constructing passage scenarios. Usual but challenging across track currents and higher winds were applied, manoeuvring dimensions were calculated and navigation quality was assessed for the given aids to navigation configuration and topography for the port approach.

The results from two South Pacific ports from the study are presented here to contrast a hazardous port approach with a port that has a much safer configuration.

Rarotonga

Avatiu Harbour, Rarotonga is the main port for the Cook Islands and is frequented by resupply and fishing vessels. Cruise ships must anchor offshore and shuttle passengers into the harbour. Vessels are restricted to a draught of 6m and a length overall of 90m. As with many harbour approaches in the South Pacific a vessel must transit through a narrow gap in an offshore coral reef and is subjected to cross-currents, wind and surge effects (Figure 2).

A leading range and lateral beacons provide the primary navigational reference to transit the reef. Vessels may only transit the reef passage in daylight. Although the port is regularly visited by vessels in the order of 3,000 tonnes, the transit is considered hazardous in the best conditions and occasionally pilots will decline to bring a vessel in. For the analysis, a small coastal vessel of 100 tonnes was chosen for reference. It became apparent that only a minimal current or wind could be applied across the track before the manoeuvring room was excessively constrained. It was estimated that a 13.4m safety margin was required to account for the drift angle of the reference vessel and 14m was necessary for bank clearance, squat and coursekeeping. Since it is safer to favour a track just to east of the range transit line given the lateral references provided by beacons and the predominant current setting a vessel to the west, a positioning quality of 23m was assessed using the positioning quality decision tree within DMS. By summing the widths required for the physical cross section of the vessel and drift angle, the shiphandling width and the positioning quality, an overall channel width of 50m represented a safe design width for the small reference vessel. Given that the approach channel is only 35m wide, the Avatiu passage was assigned a less than ideal safety measure of 35/50 or 0.7. Obviously vessels enter the port with no margin for error. Indeed, a recent proposal by the Asian Development Bank (ADB)

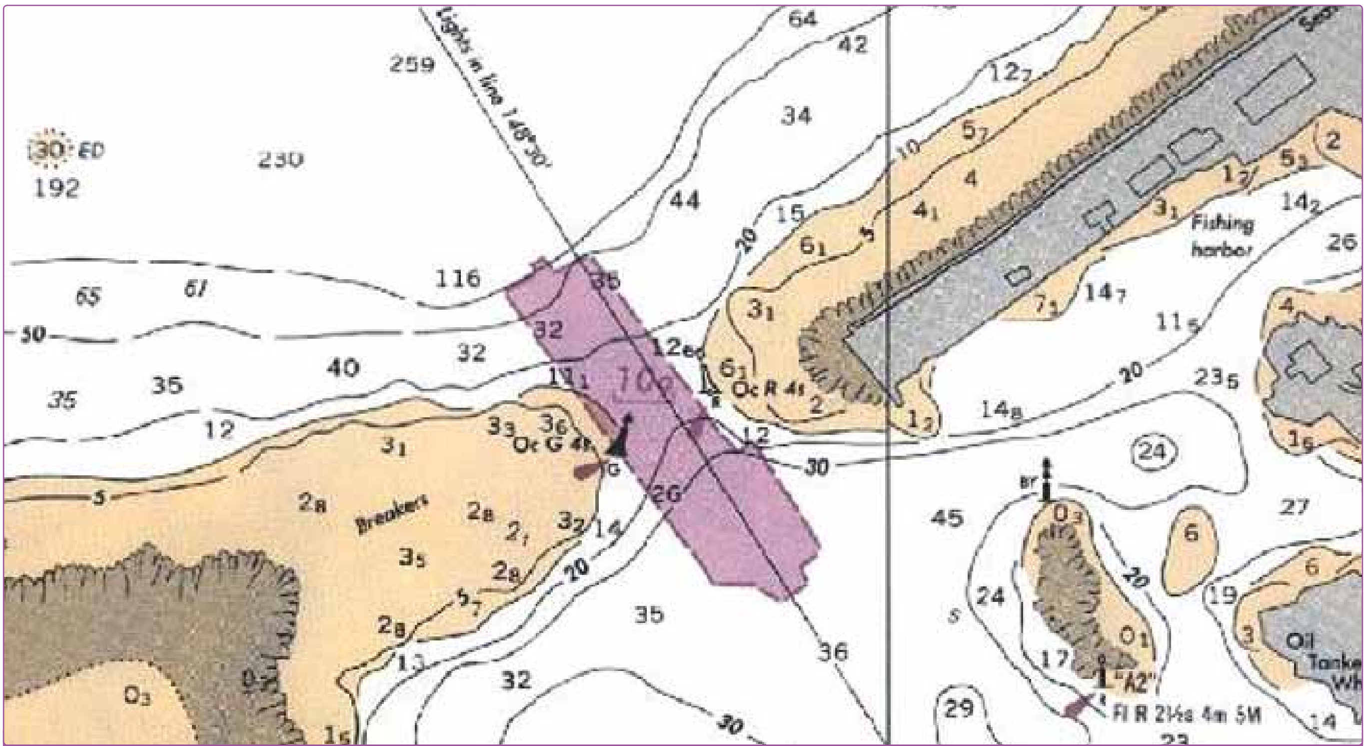

Figure 3. Passe de Papette, Tahiti.

recommended widening the harbour entrance by about 10m as "the port is at the margin of safe operations for international cargo vessels currently serving the Cook Islands" (ADB Project 40287, 2008). This would result in a safety margin of 45/50 or 0.9 for the reference vessel which would substantially increase the safety of the approach; however, the navigation risk must be reassessed considering a vessel of 3,000 to 4,000 tonnes.

Papeete

Like Avatiu, the Passe de Papeete to the Port of Papette, Tahiti is a reef passage to a tropical port; however, with a channel depth of 12 metres and width of 104 metres, the port can accommodate much larger vessels (Figure 3). As the main seaport for French Polynesia, Papette is frequented by cruise ships, cargo vessels, tankers and yachts. For the navigation risk assessment, a tanker of 32,000 tonnes was chosen as the reference vessel to transit the entrance channel.

With an across track current of 1 knot and cross winds of 15 knots, it was estimated that 42m in width was required to account for the drift angle of the vessel and 45m was necessary for bank clearance, squat and coursekeeping. A range, three fixed aids, two lateral buoys and multiple natural radar targets provide an optimum positioning quality of 15m. Overall, the estimated safe channel width was equal to that existing in the approach passage. Since shallow draft interisland ferries regularly transit the entrance channel with other traffic, an analysis of navigation risk for simultaneous two-way traffic would likely confirm the safety of this practice and identify any wind, current, speed and visibility constraints.

Awareness and control of risk

One cannot confidently accept a risk with a high level of uncertainty but sometimes luck is what makes the difference between success and an unwanted outcome where the risk is taken anyway. Awareness and control of risk by the master and pilot in real time by managing workload with the presence of additional officers, bringing the vessel to a higher state of readiness and proceeding at a safe speed is a buffer to compensate for the changes in risk in the final passage into a port. But this safety margin all but disappears in ports that are not continuously striving to improve their performance or vessel operators that risk vessel loss or business disruption.

ABOUT THE AUTHOR

Brad Judson is a Principal Consultant with BMT. He has completed over 50 risk studies, most providing guidance on maritime safety solutions, since receiving a Master Foreign-Going qualification in 1989 and completing an MA in Geography in 1992. As a member of the Nautical Institute, Mr. Judson's interests include the combination of safe navigation practice with risk analytics and geospatial analysis.

ABOUT THE COMPANY

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