Navigational efficiency in marine traffic operations in the port of Keelung
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Abstract

In order to ease a complex marine traffic problem a Traffic Separation Scheme was established in the approaches to Keelung in 1990. The paper analyses the effectiveness of this measure and makes recommendations for improving navigational efficiency at Keelung.

1 Introduction

The port of Keelung plays an important role in the economy of Taiwan. During the past twenty years the size of vessels using the port has increased, and there has been a shift towards containerization. In 1994, 8,026 merchant vessels visited the port generating in excess of forty movements a day. In addition there was extensive naval and fishing vessel activity. In 1990 a Traffic Separation Scheme (TSS) was established in the port approaches in an attempt to simplify traffic movement (Figure 1). This paper addresses the effectiveness of the TSS and makes recommendations for further measures to improve navigational efficiency at Keelung.

2 The Traffic Problem

The port approaches, which are to the west of Keelung Island, are generally deep leaving no safe area for anchorage other than close inshore. The width of the traffic lanes is constrained to 700 metres providing little room for manoeuvring within the lanes, yet the pilot station for inbound vessels is located on the right hand side and about one mile from the landward termination of the inbound lane. While no official anchorage exists the area to the west and inshore of the pilot station is used by vessels wishing to anchor while awaiting the pilot. Merchant ship entry to the port, under pilotage, is by daylight only and under adverse weather conditions the pilot may not board until the ship has reached the breakwaters inbound. Fishing vessels frequently disregard the TSS and naval vessels have notional priority over other shipping movements. As a result the traffic situation in the inner approaches can be confused and hazardous.
3 Research Methodology

An eclectic methodology was adopted in the study both to identify the nature of the existing situation and to test possible improvement measures. Radar survey and extensive sampling of professional opinion, coupled with casualty analysis relating to periods before and after the introduction of the TSS, were used to assess the existing situation. The use of visual simulators, at Taiwan Ocean University and the University of Plymouth, provided a unique opportunity to compare existing marine traffic operations against a modified model. The modified model incorporated limited vessel traffic service functions and channel markers, neither of which existed in the live situation. Most significantly, the experiment enabled evaluation of the difference between Taiwanese ship masters having familiarity with the port and foreign ship masters having no prior knowledge of the port. In addition to analysis of ship tracks, subject perceptions were used to gain a measure of effectiveness.

4 Existing Situation

Casualty analysis revealed that between 1987 and 1991 sixty one vessels
were involved in collision, grounding or contact incidents. The detail, which appears in Table 1, shows that during 1991, the first full year of TSS operation, the accident ratio rose above the average for the five year period. These figures relate to merchant vessel incidents only and exclude fishing vessels or naval vessels where they were involved. Further analysis showed that inbound vessels were at greatest risk, and container vessels, which comprised 55.6% of the merchant traffic, were coincidentally involved in 55.7% of the accidents. Lin[3]

Table 1: Casualty statistics Keelung 1987-1991, Lin [2]

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<tbody>
<tr>
<td>Collision</td>
<td>7(12)</td>
<td>5(9)</td>
<td>6(12)</td>
<td>5(8)</td>
<td>6(10)</td>
<td>29(51)</td>
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<tr>
<td>Grounding</td>
<td>2(2)</td>
<td>1(1)</td>
<td>0(0)</td>
<td>1(1)</td>
<td>0(0)</td>
<td>4(4)</td>
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<tr>
<td>Contact</td>
<td>1(1)</td>
<td>1(1)</td>
<td>0(0)</td>
<td>1(1)</td>
<td>3(3)</td>
<td>6(6)</td>
</tr>
<tr>
<td>Total</td>
<td>10(15)</td>
<td>7(11)</td>
<td>6(12)</td>
<td>7(10)</td>
<td>9(13)</td>
<td>39(61)</td>
</tr>
<tr>
<td>Incoming Ships</td>
<td>6,977</td>
<td>7,243</td>
<td>7,572</td>
<td>7,623</td>
<td>7,514</td>
<td>36,929</td>
</tr>
<tr>
<td>Ratio</td>
<td>0.215%</td>
<td>0.152%</td>
<td>0.158%</td>
<td>0.131%</td>
<td>0.173%</td>
<td>0.165%</td>
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<tr>
<td>Remark:</td>
<td>1. Number of cases (Number of ships involved in the cases).</td>
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<td></td>
<td>2. Ratio = Number of ships/incoming ships.</td>
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</table>

The radar survey, which was carried out over a continuous 96 hour period, provided full data on 78 inbound vessels, 40 of which had to anchor before entering, and 69 outbound vessels, only one of which stopped after clearing the breakwater. Incomplete data was obtained from a number of vessel movements. The distribution of vessels passing a base line representing the outer limits of the TSS is given in Figure 2. It clearly indicates that many vessels either ignore or have difficulty in complying with the requirements of the scheme.

The radar survey further revealed that 17% of inbound vessels were delayed more than thirty minutes, while waiting at the pilot station. The drifting of such vessels denies other ships the use of limited sea room.

Interpretation of the questionnaire used to obtain expert opinion regarding risk in the approaches to Keelung highlighted the following contributing factors:

a. Ship shore communications were defective.
b. Two or three ships were often advised to meet at the pilot station at the same time without being given any sequence for port entry.
c. There were often long waiting times at the pilot station before the pilot boarded.
d. There was no official merchant ship anchorage.
e. Fishing and naval vessel movements were unpredictable.
f. Traffic regulations were frequently contravened with ships even anchoring in the lanes.
g. In adverse sea conditions ships had to enter port before the pilot boarded.

5 Simulator Experiments

The validity of simulation in navigation research has been confirmed, among others, by Curtis and Barrett [5] and by Hansen and Jakobsen [6]. The experiments in this work were designed to assess existing traffic operation at Keelung under constant conditions, and then to test the use of additional aids and VTS functions in improving navigational efficiency. In particular it was sought to determine:
a. the extent to which provision of additional visual aids could improve lane discipline;
b. whether the configuration of the lanes provided enough sea room for safe manoeuvring;
c. the potential of movement information and sequence control in maintaining separation between vessels;
d. the role of pilotage and the location of the pilot station.

Each subject of the simulation experiments faced four situations, namely arriving and leaving Keelung under existing navigational conditions, and arriving and leaving under modified conditions. The modifications applied comprised provision of racon equipped light buoys at the outer ends of the inbound and outbound lanes, and provision of advice by radio relating to weather conditions, traffic movement, time of pilot boarding and operational sequence. The scenario for the modified inbound situation is shown in Figure 3.

![Figure 3: Scenario of modified inbound experiment, Lin [7].](image)

In all four situations analysis was made of ship's speed, ship's position from lane centre line, from other vessels and from fixed hazards, when crossing evenly spaced data lines. Figure 4 illustrates the data line basis for the inbound tracks.

In addition to measuring subject performance, subject opinion was further tested through questionnaires.
Figure 4: Data line for analysis of inbound ship tracks [8].

6 Conclusions

The nature of navigation in the approaches to Keelung, the identification of risk and means of addressing that risk have been identified through this programme of work. It is shown that:

a. modifications to the TSS would improve navigational efficiency. In particular provision of a racon fitted buoy at the outer end of the scheme would assist in lane identification, and manoeuvring room within the lanes would be increased safely by reducing the separation between inbound and outbound lanes.

b. under strong wind and current conditions maintaining position, at slow speed, within the inbound lane is not easy. Delays at the pilot station could be eliminated by adopting formal sequence control of all shipping movements.

c. shore based radar monitoring of shipping movements and provision of advice on traffic and environmental conditions can reduce risk.

A revised TSS for Keelung based on this study is given at Figure 5.
Figure 5: Recommend Keelung TSS, Lin [9].

References


2. ibid, p36.

3. ibid, p37.

4. ibid, p66.


7. Reference 1, p100.

8. ibid, p111.

9. ibid, p157.