

NAVIGATIONAL AID SYSTEM WITH DYNAMIC TIDE

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Abstract

Nowadays, maritime transportation becomes one of the most important to the trade and industry of many countries. In any transportation, safety must be the main concern. As seawater is dynamic, the navigation happens to be difficult without any equipment or guidance such as Global Positioning System (GPS) and Electronic Chart Display and Information System (ECDIS). ECDIS are rapidly gaining popular acceptance as powerful for increasing navigational safety and augmenting situational awareness. However, most of the ECDIS do not represents the actual depth of water. It is the goal of this study to develop a system that will be able to update the water depth depending on tidal levels at given date and time, with various size of vessels draft and determines locations of the sea that is safe for vessels to sail through. Although there are several factors that should be taken into account to ensure adequate under keel clearance, this study only take the draft of the vessel as a main factor. Other factors that may cause the changes in under keel clearance are excluded. This system was developed using Microsoft Visual Basic 6.0 and Map Objects 2.0 to visualize the spatial data and with tidal data prediction in Microsoft Access database. Therefore, users without Geographic Information System (GIS) exposure can easily use this system. Mapping technique in GIS added an excellent visualizing, which can provide information in decision-making in order to know the right passage without jeopardize the vessels. The result of this system is the map location of the sea that has sufficient depth levels for vessels with different sizes to sail through. Safe depths are marked as blue points and locations without safe depths are marked with red points. For planning purposes, calculation of tide can be made and this will produce a graph showing the times of sufficient tide in blue and times of insufficient tide in red. The benefit of this system would be an improvement in port safety because the actual depth of water and safely navigable area for a vessel of particular draft is displayed on the system in real time.

Keywords: navigational aid, dynamic tides

1.0 INTRODUCTION

Basically, every vessel sailing in or out from port will used special path which is call channel. The channel is provided by the port management. Typically, a channel is dredged to a defined depth so that it has a minimum depth of water to ensure the safety for every vessel. This channel is maintain by the port management through dredging works once in every six or three months depending on the sedimentation movement at the area. However, there is certain area the channel is not provided because the natural depth of the area is adequate for vessel safety as well as the channel itself (e.g. Port Klang). In normal practice there will be pilotage services for any vessel entering or departing from the anchorages area to the port berth and vice-versa.

Furthermore, each vessel will definitely depend on navigational chart as guidance for safe transit along port approach channels. The navigational chart is one of the most fundamental tools available to the mariner. The electronic chart system is a relatively new technology that provides significant benefits in term of navigation safety to improve operational efficiency. It shows water depths,

locations of dangers to navigation, locations and characteristics of man-made aids to navigation and other features useful to the mariner. The water depths indicate by the chart is referred to chart datum. Since the water depth in the navigational chart does not indicate the actual depth, this study will create digital navigational chart with actual depth by making a link with tidal prediction data because the movement of high tide is important, mostly when the port approach channel is subject to tidal variations. In other words, this system should be able to update sea level depths based on current tide levels.

As we know, tides are unique oceanographic phenomena in the sense that the tidal motion can be predicted with a high degree of accuracy. The art of tidal prediction is based on the knowledge of the harmonic constants of the tidal oscillations and the astronomical arguments i.e. the position of the sun and the moon. The harmonic constants can be determined by the harmonic analysis of long records of sea level or current obtained either by field observations or by numerical modeling (Foreman, 1978).

This system would be an improvement in port safety because the actual depth of water and safely navigable area for a vessel of a particular draft is displayed on this electronic chart in real time. The area chosen for this study is Port Klang. It is one of the busiest ports in Malaysia. However, the electronic chart created in this study does not comply with the International Maritime Organization (IMO) requirements for SOLAS class vessels. This is because the software Esri MapObjects is not the special package for hydrography (or vessel navigation). Some of the symbols in nautical chart are not available to create using this software. Those that comply with the IMO are known as Electronic Chart Display and Information System (ECDIS), and all other types of electronic charts, regarded generically as Electronic Chart System (ECS). The main objective of this paper is to develop an example on implementation of tidal prediction data in electronic navigational chart. As a result, an electronic nautical chart with new navigation tools has been developed where it can display and map safe passage area in real time on the charts. Furthermore, the tidal passage planning function allows course to steer calculations to be produced when route planning is provided.

2.0 STUDY AREA

Port Klang is Malaysia's principle gateway and busiest port. It is well sheltered by surrounding islands that forms a natural enclosure. Port Klang is served by three major gateways called North Port, South Port (Southpoint) and Westport. There are 18 berths in Northport, 8 in Southport and 19 in Westport. Port Klang can be approached via Southern or Northern entrance. The Northern Pulau Angsa dredged channel which is 153m wide is maintained at a declared depth of 11.3 metres below Admiralty Chart Datum (ACD) while Southern Pintu Gedung access channel is 365 meters wide and is dredged to 15 metres below ACD.

Nevertheless, there is certain area the channel is not provided because the natural depth of the area are adequate for vessel safety as well as the channel itself. If the vessel approaches via the southern entrance (Pintu Gedung) to the North Port or South Port, it is approximately 9.8 km where by there is no channel provided and vessel depends on the natural depth. Besides that, the recommended under keel clearance practice in Port Klang for navigational channels within port waters are:-

- 1.0 metres for vessel of LOA not exceeding 200 metres and/or draft not exceeding 10 metres.
- 1.5 metres for vessel of LOA exceeding 200 metres and/or draft exceeding 10 metres
- 1.0 metres for all vessels in Labuhan Gurap and Anchorage Reach channels.
- 10% from maximum draft.

According to O'Brien (2002), the major factors in determining under keel clearance are vessel's squat, wave response allowance, survey and siltation allowance, keel allowance and tide level variation. However, most of the port in Malaysia used the above values as it takes into account all the mentioned factors as a safety precaution.

2.1 Structure and Tools

This PortNav system consist of 2 tools that can be used and assist port in planning purposes. The tools are safe passage mapper and tide required calculation. In addition, it can plot vessel position too. By changing the parameter input, vessel draft, date and time (post or real time) and under keel clearance value, the depth point in the electronic chart will split the charted depth point in two colours, red and blue. Appendix 1 shows the main menu of the whole application.

2.1.1 Safe Passage Mapper Tools

It is a tool that is capable to update sea level depths based on the current (real time) tide levels as the database of tidal prediction has been stored in the system. This system then map locations of the sea that has sufficient depth levels that are safe for vessels with different sizes to sail through. Locations with safe depth are marked as blue points and without safe depths are marked with red points. The flow chart of the process used for performing safe passage mapping is shown in Appendix 2.

2.1.2 Tide Required Calculation

This tool could benefit in planning a shipping time for safe vessel navigation. For most of the vessels, sometimes they have to carry less cargo than they could to minimize their draft. This operation obviously is not economic as it might be. By using this tool, the users only have to input the draft value, and select the date planning for their trip, under keel clearance value and the minimum charted depth at the area. Afterward a calculation will be made and this will produce a graph showing the times of sufficient tide in blue and times of insufficient tide in red. The flow chart of the process used for performing safe passage mapping is shown in Appendix 3.

2.2 Data Acquisitions

The study area chosen is Port Klang. The nautical chart MAL 5300, 5307 and 5322 and tidal prediction data from Royal Malaysia Navy for the year 2005 was used for this study. For combining multiple layers on the same display, data must be in the same reference system. Any data in the Esri Shapefile Format (*.shp), Military Image Format (*.mif), CAD Drawing Format (*.dwg/*.dxf) and Standard Image Format can be used in this system. Besides that, symbol properties for each layer added can be edited by double click on the layer we want.

2.3 Application Development

In this study an electronic nautical chart was developed to represent the locations that have enough depth and safely navigable area for a vessel of a particular draft. MapObjects component was added to a format in Visual Basic 6.0 project file and used to develop the application. The following functions can be implemented in a program built with MapObjects control (ESRI, 1999):

- Display a map with multiple layers
- Pan and zoom throughout a map
- Identify features on a map by pointing at them
- Draw graphic features
- Select features within a specified distance of other features, etc.

The map control is the main object of the MapObjects. The map control is a container for the maps. Maps are displayed on this container. The main properties are Coordinate System, Extent, FullExtent,

Mouse Pointer and Visible. The main methods are DrawShape, ExportMap, Pan, Refresh and TrackRectangle. The main events are AfterLayerDraw, BeforeLayerDraw, MouseDown and MouseMove. Before adding any vector layer, a data connection must be established. A data connection represents a connection to a source of geographic data. In this study, a folder containing Esri Shapefile Format (*.shp), Military Image Format (*.mif), CAD Drawing Format (*.dwg/*.dxf) and Standard Image Format, is the data source.

A connection can return a GeoDataSets collection. Each member of the collection, referred to as GeoDataset, represents a discrete set of geographic data that can be retrieved from the data source. A Geographic data in a GeoDataset is used by assigning it to the GeoDataset property of a new MapLayer object. The Connect method of the DataConnection object will attempt to connect to the data source specified in the Database property.

2.4 Application Examples

The results from the selected areas, Southern entrance of Port Klang where the natural depth of the area are adequate for navigation purposes is shown in Figure 1. The examples are on the 20th September 2005 and post time function is selected. The users later have to input the information of the vessels, draft value, post time or real time and the under keel clearance value. In this example the input is for vessel with 7m draft and 1.5m under keel clearance. After the calculate button is press, the system will verify the input value and then search the tide values in the tide database according to the date and time selected. Afterward it will perform calculation to identify the safe depth and display the location of safe depths for passage in blue color and locations without safe depths in red color. The depth will change from time to time depending on the users input or will change automatically if user select real time.

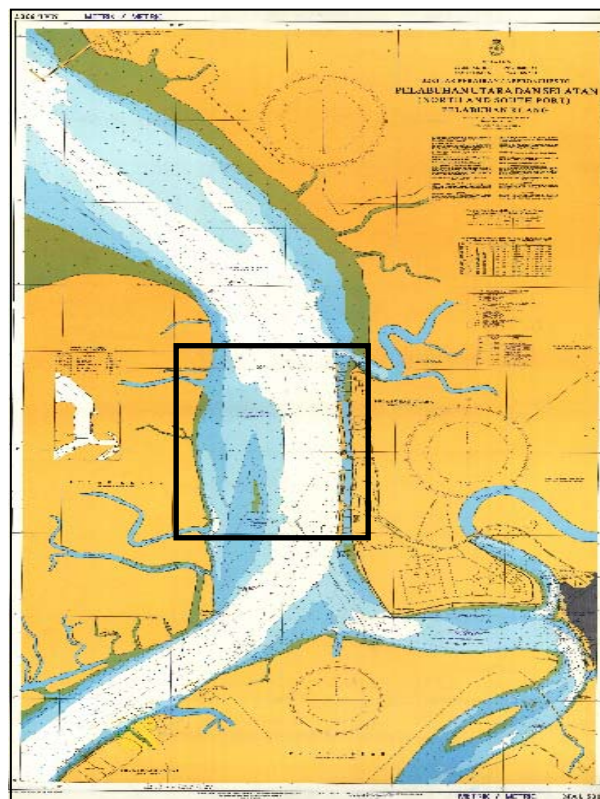


Figure 1: MAL 5307 Approaches to South and North Port, Pelabuhan Klang

The depth points will be updated every minute if the real time checked box is selected and the tidal value is display on the safe passage window. Figure 2 shows at 0401 the locations of safe areas (blue point) are small and Figure (3) shows the safe depth for the same area 18 hours later at 2201. The area has becomes wider for vessel passage.

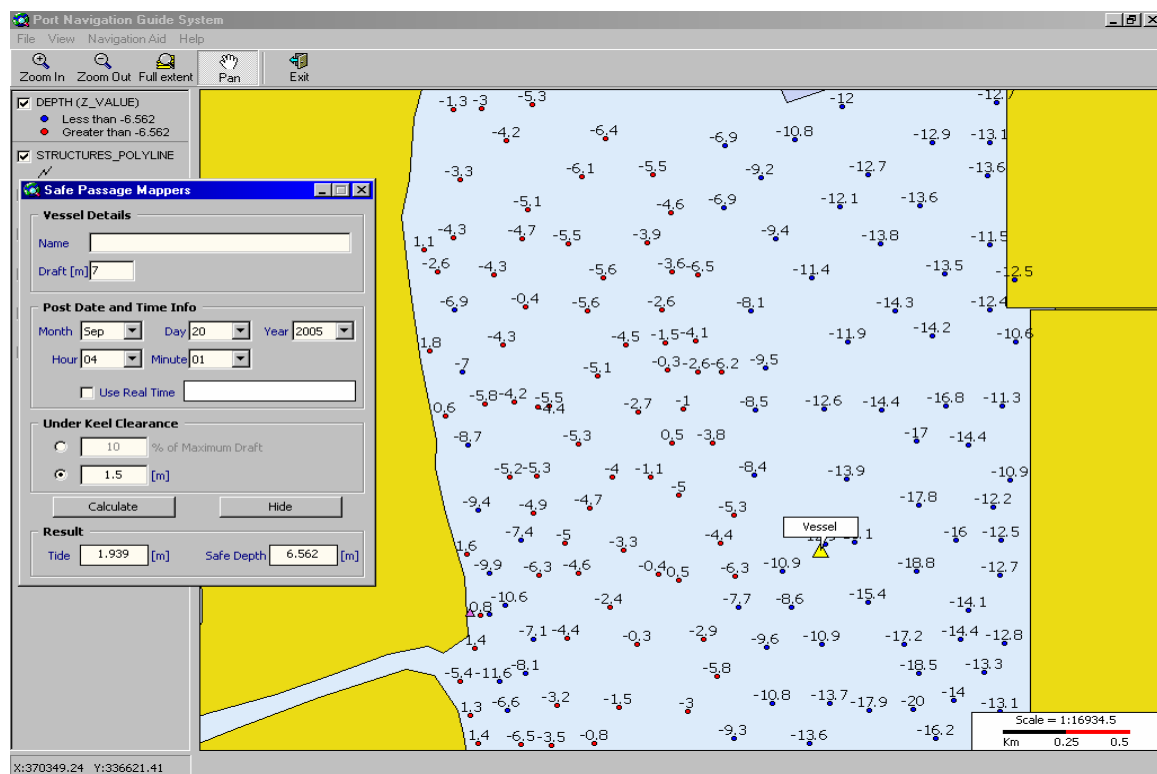


Figure 2: 20th September 2005 0401 with 7m draft and 1.5m under keel clearance

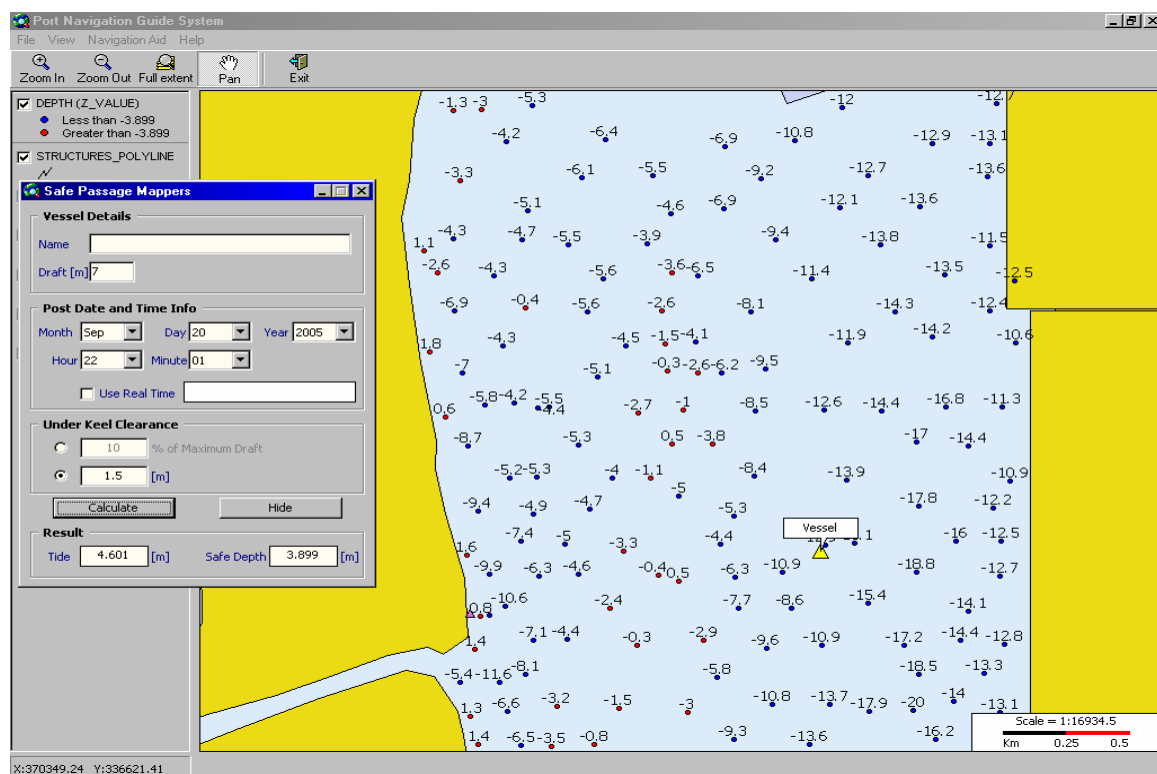


Figure 3: 20th September 2005 2201 with 7m draft and 1.5m under keel clearance

Figure 4 shows the tide required calculation for the Port Klang area. Assuming the vessel has a draft of 7m (user input), the minimum charted depth while transiting at the port will be 5m (user input). Later the minimum amount of water required between the keel and the sea floor (under keel clearance) is chosen at 10 percent of maximum draft. To find the tide required, the following calculation is made as in Table 1.

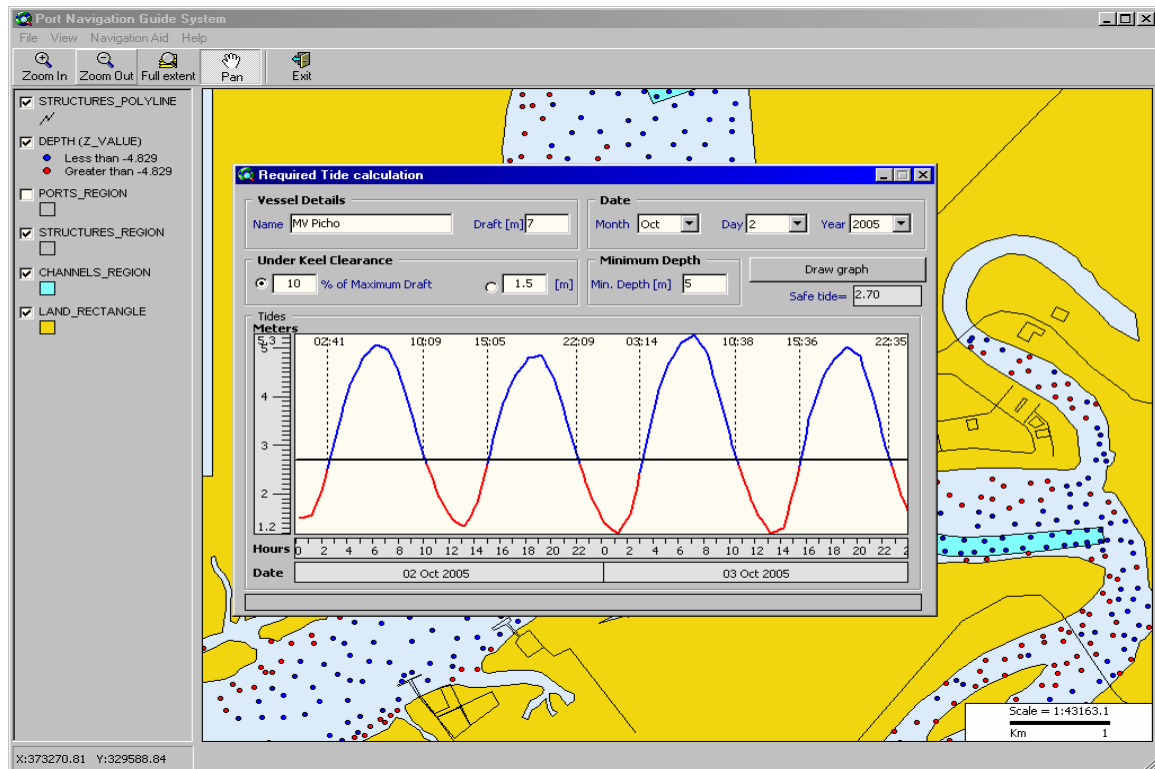


Figure 4: Tide required calculation as on 2nd October 2005 with 7m draft and under keel clearance 10% of draft.

Table 1: Example of Tide Required Calculation

DRAFT	7.0 m
UKC REQUIRED	10% of draft
DEPTH REQUIRED	7.7 m
MINIMUM DEPTH IN PORT AREA	5.0 m
TIDE REQUIRED	2.7 m

If the tide is required at 2.7 m, then the level line is set by the operator. This will produce a graph showing the times of sufficient tide in blue and times of insufficient tide in red. As a result for 2nd October 2005, to get the tide required at 2.7 m, the time are 0241 to 1009 and 1505 to 2209. This benefit could ease the planning process for any vessel by knowing the best time to navigate.

3.0 FUTURE DIRECTION

Considering the foregoing results, followings recommendation are suggested:

- Future enhancement include integration the results of this study with the GPS (Global Positioning System) technology in terms of upgrading this study to real-time navigation. Currently this system could be used for planning purposes such as to know the best date and time to start navigation with the maximum vessel draft.
- Include integration of the tool with real-time tidal height feeds. Therefore this system could be updated automatically into the tide database.
- The charted depth values should be able to change with the effect of tide prediction database as this study is only able to show changes of the charted depth point with blue colors for safe passage and red unsafe.

4.0 CONCLUSION

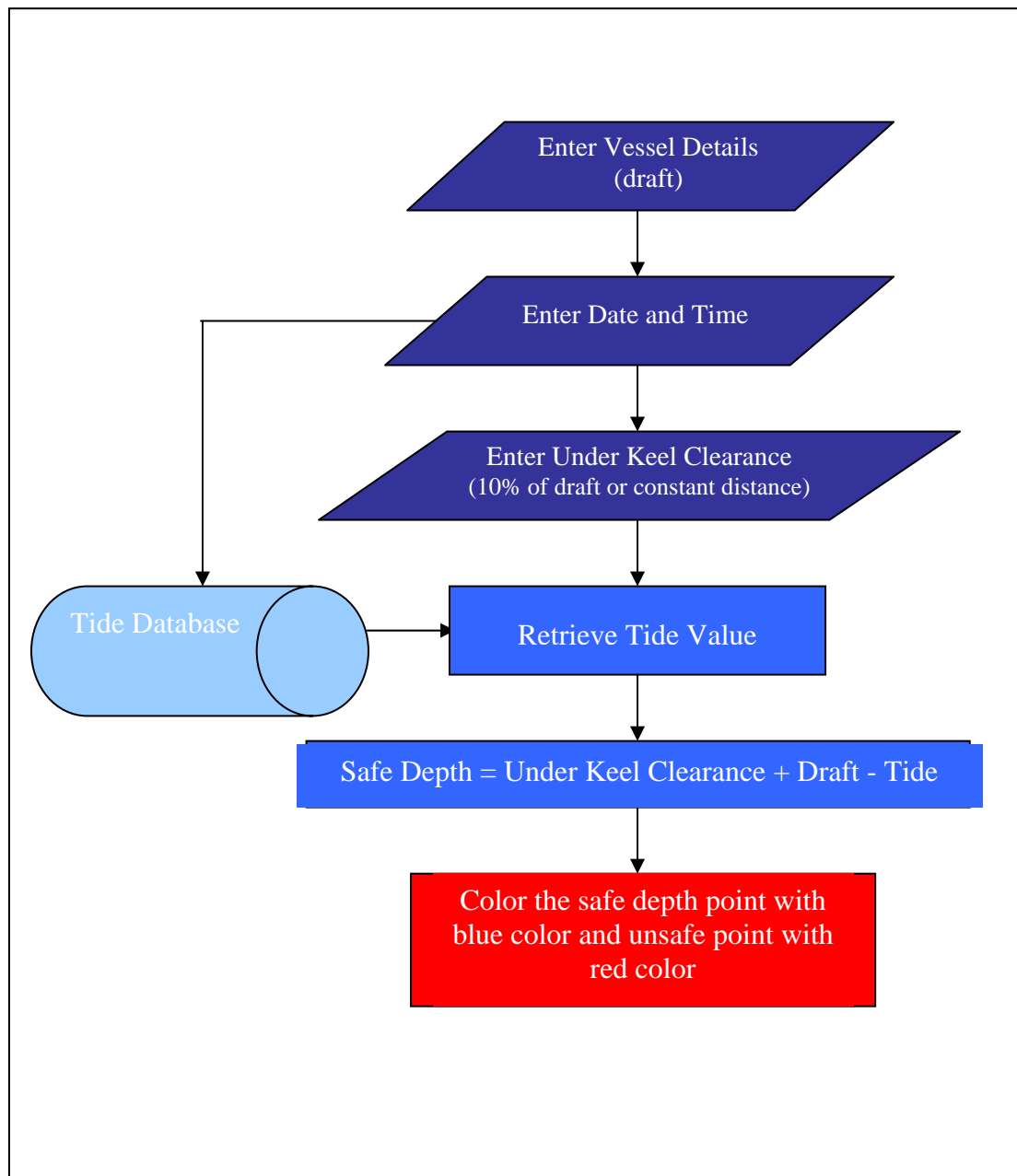
Although the marine accident is not the critical problem for Malaysia waterway, but when it does happen, it takes a substantial toll. Furthermore, it will surely affect the image of the port navigation system. As we know, maritime commerce is critical to the health of the Malaysia economy, therefore we should put a step forward to minimize the number of maritime accident with an accurate and current data for port efficiency and safety. This paper has presented a new tool for port navigation that was created to improve planning and safety in Port Klang. The advantage of this application would be an improvement in port safety because the actual depth of water and safely navigable area for vessel of a particular draft is displayed on an electronic navigational chart. Potential benefits of this application are however not limited to port applications only. It can be applied and used by harbour pilots for vessel navigation as well as marine geographic information systems for environmental management and emergency response management.

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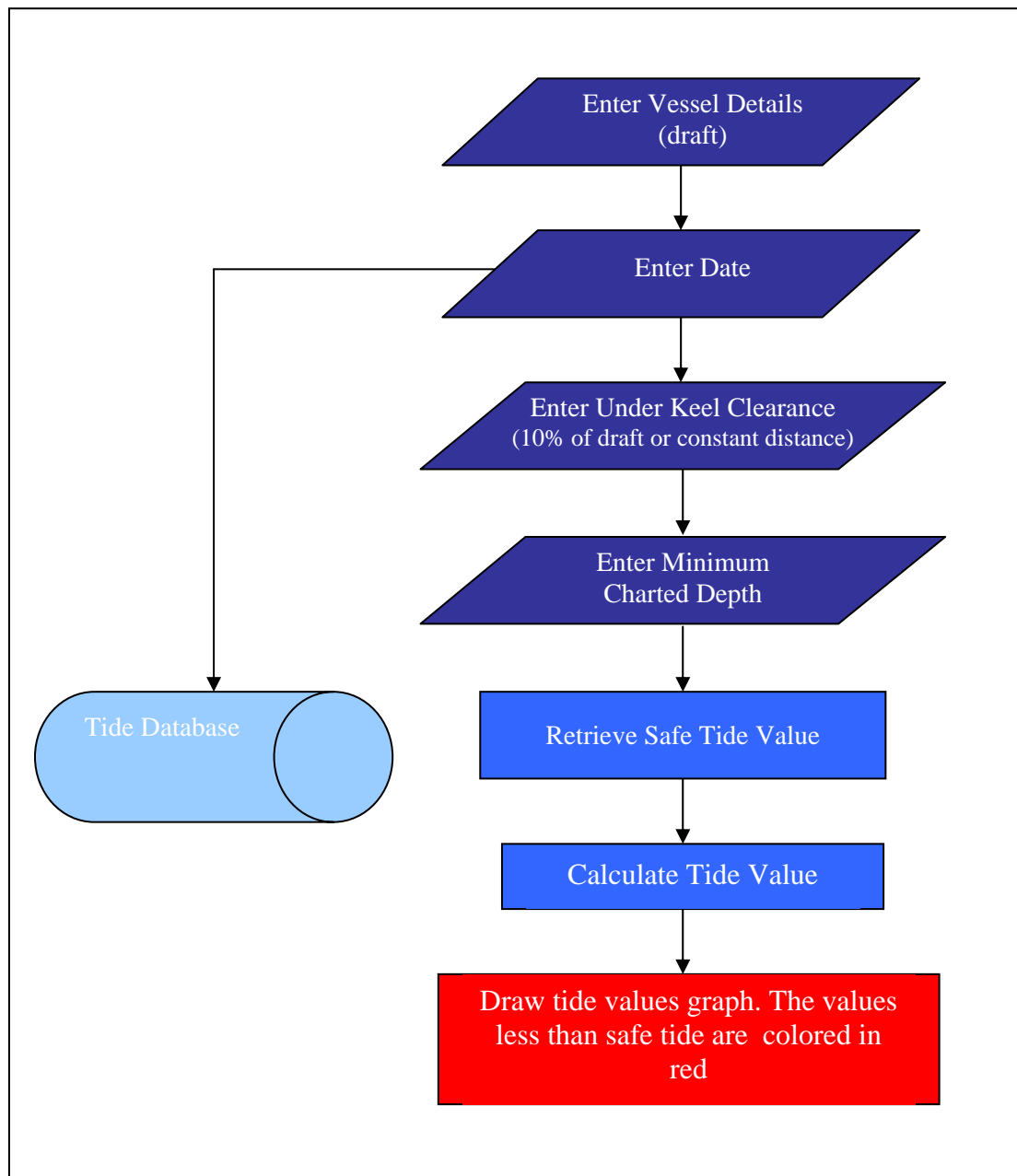
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Appendix 2: Safe Passage Mapper Flowchart



Appendix 3: Tide Required Calculation Flowchart



Appendix 1: The system structure main menu

