DEVELOPMENT OF SAFE NAVIGATION SYSTEM FOR TIDAL RESTRICTION AREA

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Abstract

The sea moves: the land usually stays still. As seawater is dynamic, vessel navigation will be difficult without any equipment or guidance such as Global Positioning System (GPS), Nautical Chart, Electronic Chart Display and Information System (ECDIS) or even any of the aid to navigation system. 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 sizes 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 the under keel clearance is adequate, this study focuses on the draft only 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 output of this system is a map showing locations 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, tide required calculation 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 result, while still requiring work (especially on ship navigation), 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 and can be of assistance especially at tidal restriction area.

Keywords: Navigational, under keel clearance, dynamic tides.

1.0 Introduction

Normally, 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. Therefore, the channel has a minimum depth of water to ensure the safety for every vessel. This channel maintain by the port management through dredging works once in three or six months depending on the sedimentation movement at the area. However, there is certain area the channel does not provided because the natural depths of the area are adequate for vessel safety as well as the channel itself (e.g. Port Klang). Normally, 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 terms of navigation safety and improved 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 updates 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 for a long time ahead. 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 demonstration 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. As we know there are two basic types of electronic chart systems. This is because the software Esri MapObjects is not the special package for hydrography (or vessel navigation) used. Some of the symbols in nautical chart are not available to create with this software. Those that comply with the IMO 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 in this paper has been to develop an example on implementation of tidal prediction data in electronic navigational chart. As a result, an electronic nautical charts with new navigation tools has been developed where it can displayed and mapped safe passage area in real time on the charts. Furthermore, the tidal passage planning function allowing course to steer calculations to be produced when route planning is also provided.

2.0 Area of Study

Port Klang is Malaysia’s principle gateway and busiest port. It is well sheltered by surrounding islands which 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 meters below Admiralty Chart datum (ACD) while Southern Pintu Gedung access channel is 365 meters wide and is dredged to 15 meters below ACD.

Nevertheless, there is certain area the channel does not provided because the natural depths 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 about approximately 9.8 km which is no channel provided but its all depend on the natural depth. Besides that, the recommended under keel clearance practice in Port Klang for navigational channels within port waters are:-

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

According to O'Brien 2002, the major factors in determine under keel clearance are vessel's squat, wave response allowance, survey and siltation allowance, heel allowance and tide level variation. However, most of the ports in Malaysia are using the above values as it already took into account all the mentioned factors as safety precaution.

2.1 Structure and Tools

This PortNav system consists of two tools that can be use 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 colors, i.e. red and blue. Appendix 1 shows the main menu of the whole application.

2.1.1 Safe Passage Mapper

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 in stored in the system. This system then maps 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 charted depth values are able to change with the effect of tide prediction database, meaning that it will show the actual depth on the screen and will update every minutes. . 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, they sometimes have to carry less cargo than they could to minimize their draft. This operation, obviously 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. Nautical chart MAL 5300, 5307 and 5322 and tidal prediction data from the 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 form in Visual Basic 6.0 project file and used to develop the application. The following functions can be implemented in the program built with MapObjects control:

- 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 and more… (ESRI, 1999)

The map control is the main object of the MapObjects. The map control is a container for the maps. The 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. 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 depths 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 7 m draft and 1.5 m 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 users select real time.

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 hours 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 hours which are wider for vessel passage.

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

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

It is the tide required at 2.7 m that the level line is set to 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 are at time 0241 hours to 1009 hours and 1505 hour to 2209 hours. This benefit could ease the planning process for any vessel by knowing the best time to navigate.

3.0 Future Direction

Considering the result, the followings recommendations are suggested:

- Future enhancement includes integrating 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 fix 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.

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. We should plan a step forward to minimize the number of maritime accident with the accurate and current data for port efficiency and safety. This paper has presented new tools for navigation that was created for improving 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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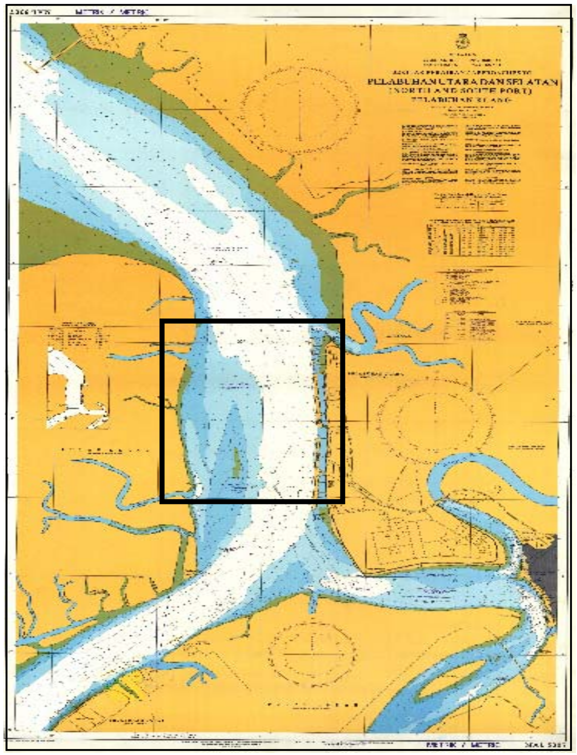


Figure 1: MAL 5307 Approaches to South and North Port, Port Klang

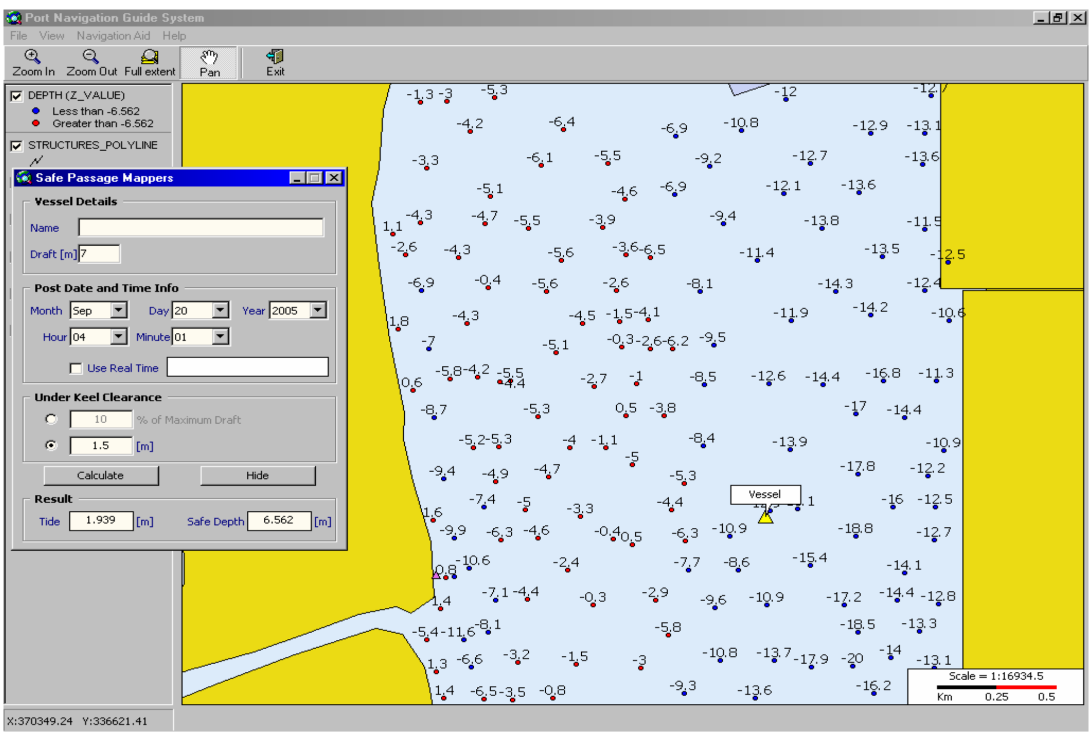


Figure 2: 20th September 2005 0401 with 7m draft and 1.5m under keel clearance

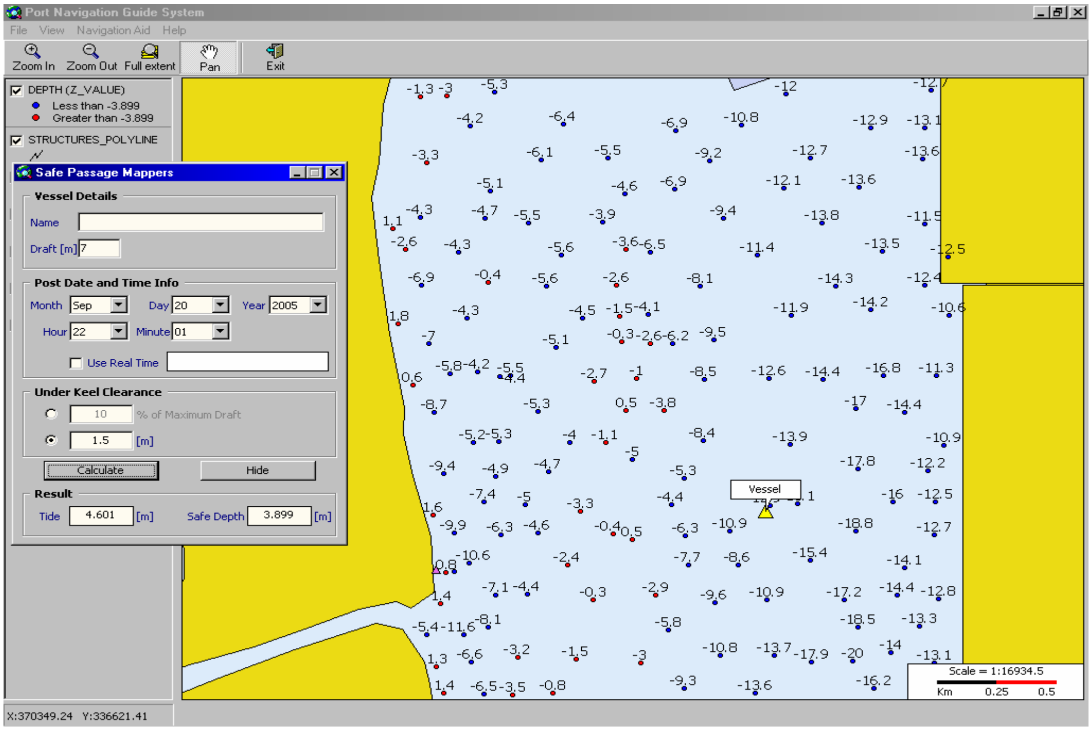


Figure 3: 20th September 2005 2201 with 7m draft and 1.5m under keel clearance

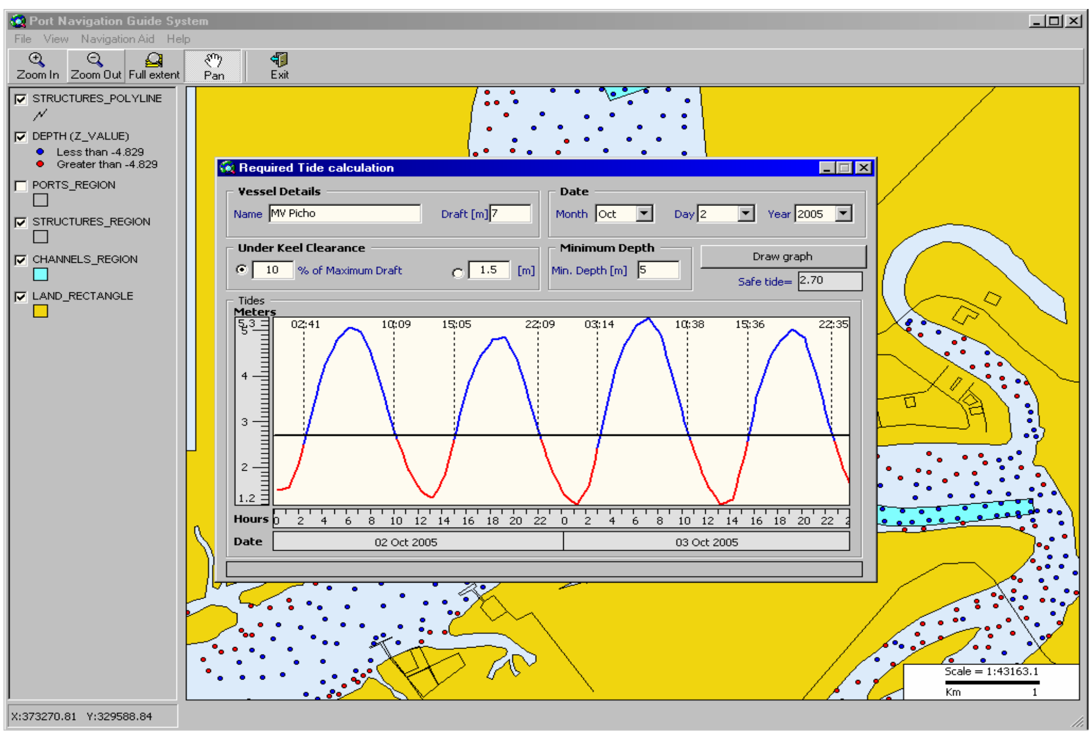
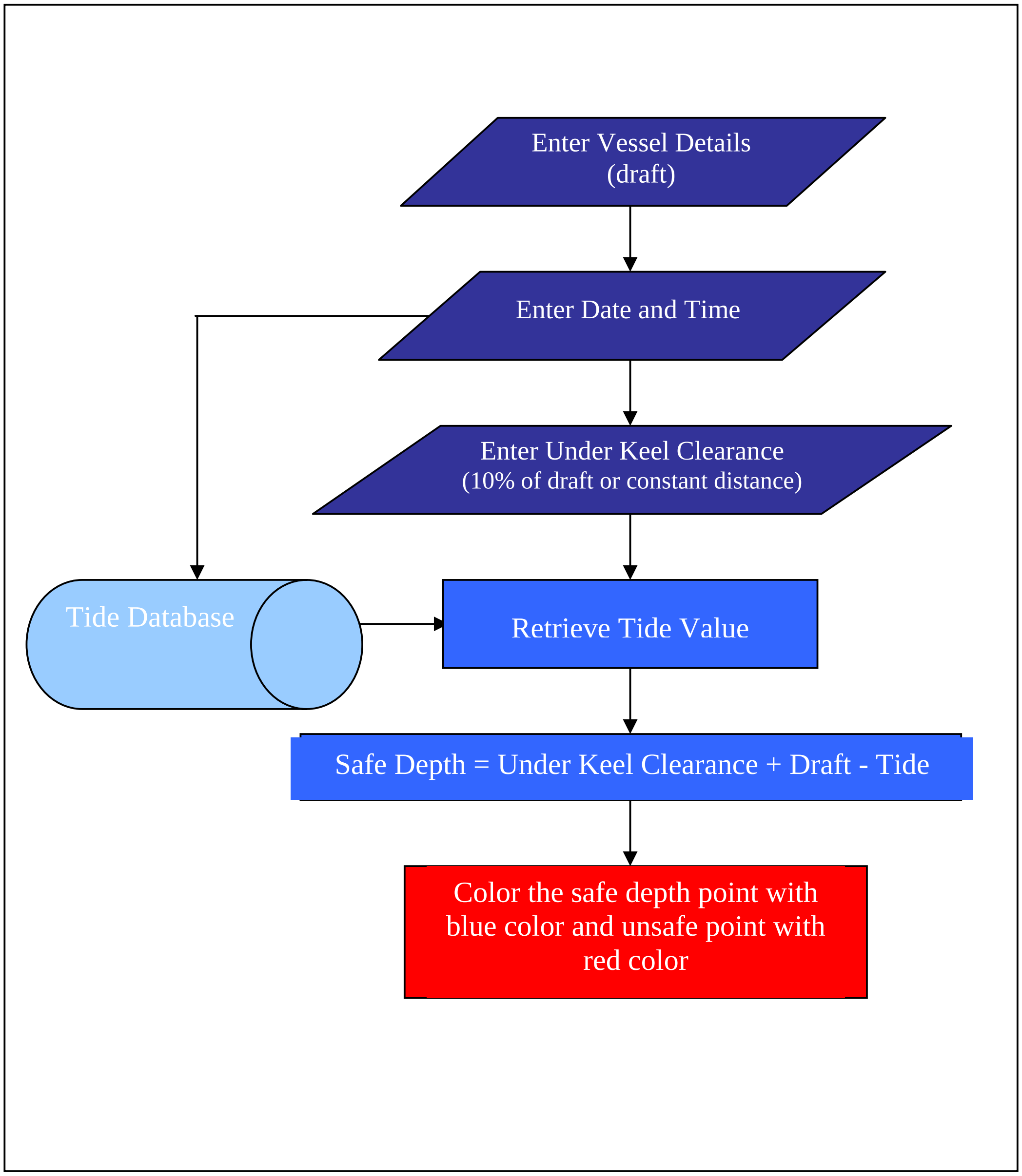
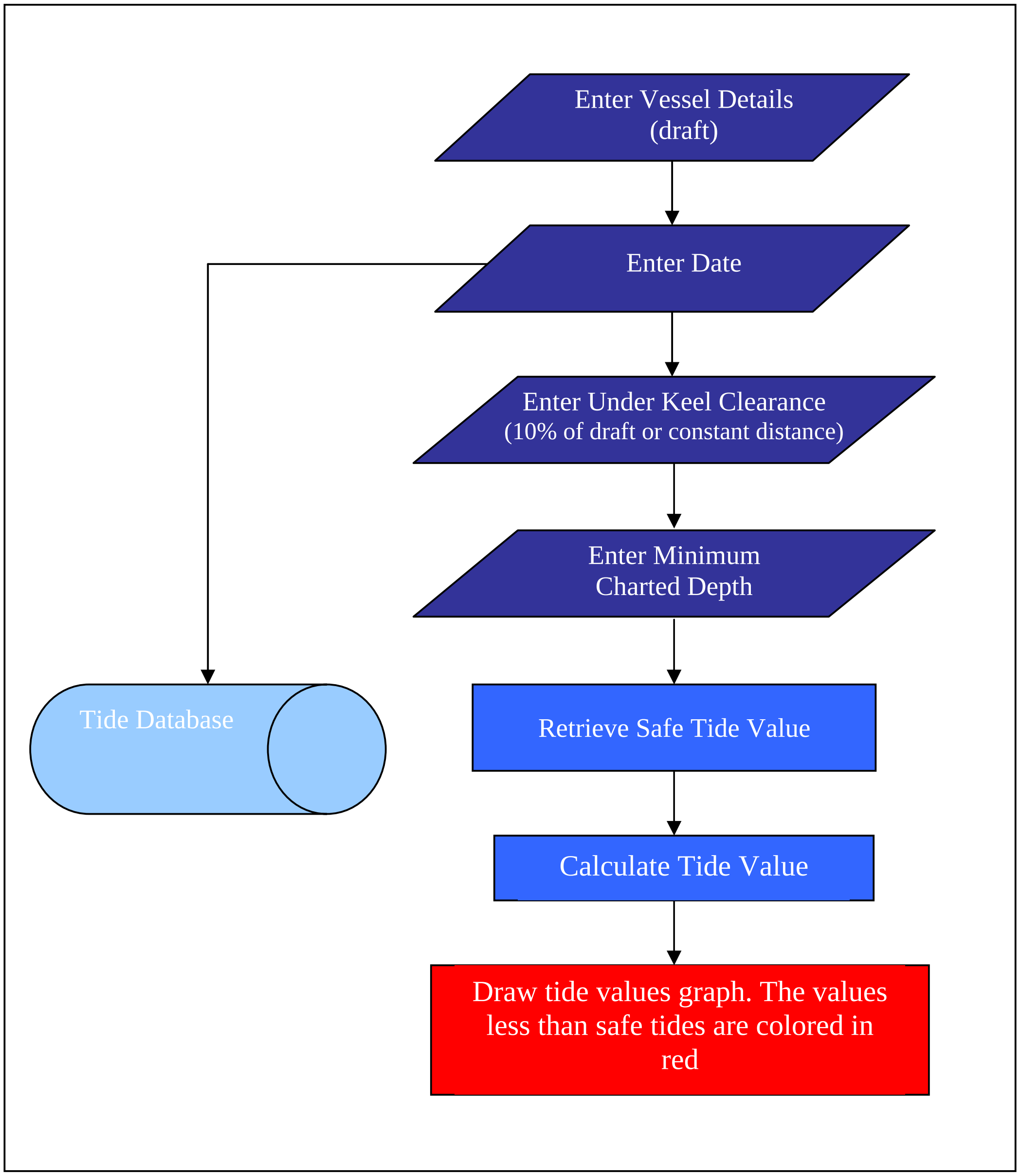


Figure 4: Tide required calculation as on 2nd October 2005 with 7m draft and under keel clearance 10% of draft.

Appendix 2: Safe Passage Mapper Flowchart



Appendix 3: Tide Required Calculation Flowchart



Appendix 1: The system structure main menu