CHAPTER 25

THE NAVIGATION PROCESS

INTRODUCTION

2500. Fundamentals

This chapter emphasizes the operational aspects of navigating in the open ocean. It is in this operational process that an individual navigator's experience and judgment become most crucial. Compounding this subject's difficulty is the fact that there are no set rules regarding the optimum employment of navigational systems and techniques. The navigation system's optimum use varies as a function of the type of vessel, the quality of the navigation equipment on board, and the experience and skill of the particular navigator.

For the watch officer, ensuring ship safety always takes priority over completing operational commitments and carrying out the ship's routine. This chapter discusses several basic safety considerations designed to minimize the probability of human error leading to a marine accident.

VOYAGE PLANNING

Voyage planning determines the safest and most efficient track for the ship to follow to ensure that the vessel completes its operational commitments. Constructing a planned track for a voyage is fundamentally important for ship's safety. The commanding officer and the navigator must carefully review and approve the track followed by the conning officer. Several ships' groundings have occurred because of unauthorized deviations from an approved track.

2501. Constructing A Voyage Plan Track

Construct the track using a navigation computer, a great circle (gnomonic) chart, or the sailings. This chapter will discuss only the navigation computer and the great circle chart. Chapter 24 covers the sailings. Use a navigation computer if one is available because the computer eliminates the plotting errors inherent in transferring the track from gnomonic to a Mercator projection.

When using a navigation computer, the navigator simply inputs the two endpoints of his planned voyage. The computer computes waypoints marking the great circle track between the two endpoints. The computer determines each track leg's distance and, given a speed of advance, calculates the times the vessel can expect to pass each waypoint. Construct the track on the Mercator chart by plotting the computer-generated waypoints and the tracks between them.

After adjusting the track as necessary to pass well clear of any hazard, choose a speed of advance (SOA) that ensures the ship will arrive on time at any required point. Given an SOA, mark the track with the ship's planned hourly positions. These planned positions are **points of intended movement (PIM's)**. The SOA chosen for each track leg is the **PIM speed**.

If a navigation computer is not available, use a gnomonic chart to plot a great circle route between points and to determine the position of resulting track points. Transfer these points to a Mercator chart as a succession of waypoints connected by rhumb lines. Figure 2501 illustrates this method. This figure shows a great circle route plotted as a straight line on a gnomonic chart and as a series of points when transferred to a Mercator chart. The arrows represent corresponding points on the two charts.

An operation order often assigns a naval vessel to an operating area. In that case, plan a track from the departure to the edge of the operating area to ensure that the vessel arrives at the operating area on time. Following a planned track inside the assigned area may be impossible because of the dynamic nature of a planned exercise. In that case, carefully examine the *entire* operating area for navigation hazards. If simply transiting through the area, the ship should still follow a planned and approved track.

2502. Following A Voyage Plan

Complete the planning discussed in section 2501 prior to leaving port. Once the ship is transiting, frequently compare the ship's actual position to the planned position and adjust the ship's course and speed to compensate for any deviations. Order courses and speeds to keep the vessel on track without significant deviation.

Often a vessel will have its operational commitments changed after it gets underway. If this happens, begin the voyage planning process anew. Ensure the ship's navigator and captain approve the new track corresponding to the new mission. The conning officer must understand that, unless transiting in an operating area as discussed above, he should never transit on a chart that does not have an approved track for him to follow.

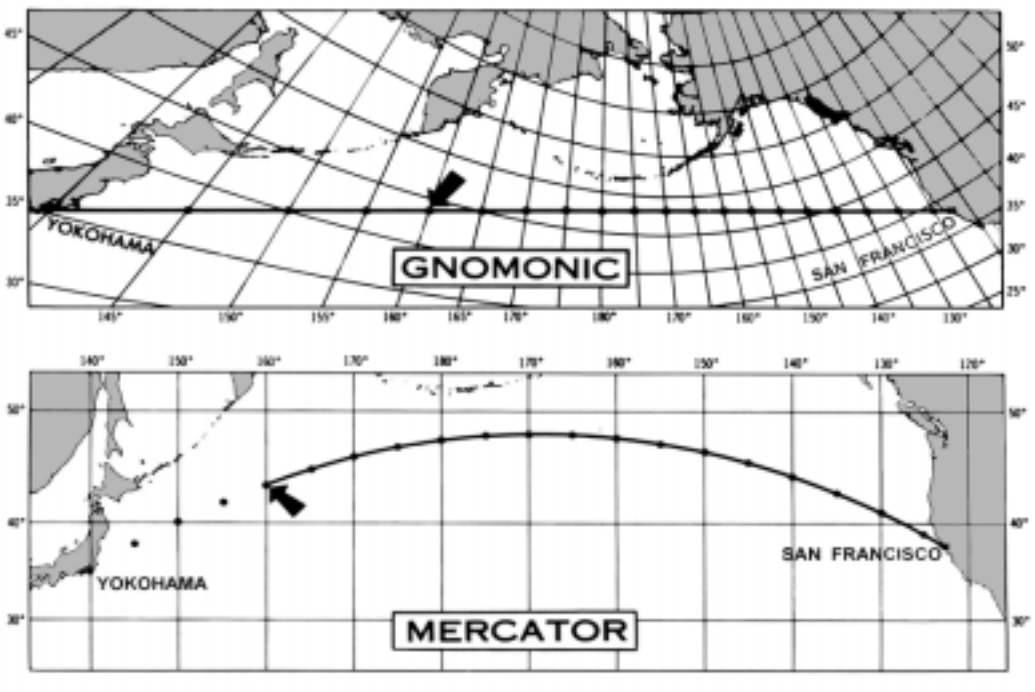

Figure 2501. Constructing a great circle track on a Mercator projection.

VOYAGE PREPARATION

2503. Equipment Inventory

Prior to getting the ship underway, inventory all navigation equipment, charts, and publications. The navigator should develop a checklist of navigation equipment specific to his vessel and check that all required equipment is onboard. The navigator should have all applicable Sailing Directions, pilot charts, and navigation charts covering his planned route. He should also have all charts and sailing direction covering ports at which his vessel may call. He should have all the equipment and publications required to support celestial navigation. Finally, he must have all technical documentation required to support the operation of his electronic navigation suite.

Complete this chart, publication, and equipment inventory well before the underway date and obtain all missing items before sailing.

2504. Chart Preparation

Just as the navigator must prepare charts for piloting, he must also prepare his charts for an open ocean transit. The following is a list of the minimum chart preparation required for an open ocean or coastal transit. Complete this preparation well before using the chart to maintain the plot.

Correcting The Chart: Correct all applicable charts through the latest *Notice to Mariners, Local Notice to Mariners*, and Broadcast Notice to Mariners. Ensure the chart to be used is the correct edition.

Plotting Approved Track: Section 2501 above discusses constructing the track. Mark the track course above the track line with a “C” followed by the course. Similarly, mark each track leg’s distance under the course line with a “D” followed by the distance in nautical miles. Mark the PIM’s at hourly intervals, and mark the time corresponding to each PIM.

Calculating Minimum Expected, Danger, And Warning Soundings: Chapter 8 discusses calculating minimum expected, danger and warning soundings. Determining these soundings is particularly important for ships passing a shoal close aboard. Set these soundings to warn the conning officer that he is passing too close to the shoal. Mark the minimum expected sounding, the warning sounding, and the danger sounding clearly on the chart and indicate the section

of the track for which they are applicable.

Marking Allowed Operating Areas: This chart preparation step is applicable to military vessels. Often an operation order assigns a naval vessel to an operating area for a specific period of time. There may be operational restrictions placed on the ship while within this area. For example, a surface ship assigned to an operating area may be ordered not to exceed a certain speed for the duration of an exercise. When assigned an operating area, clearly mark that area on the chart. Label it with the time the vessel must remain in the area and what, if any, operational restrictions it must follow. The conning officer and the captain should be able to glean the entire navigation situation from the chart alone without reference to the directive from which the chart was constructed. Therefore, put all operationally important information directly on the chart.

Marking Chart Shift Points: If the transit will require the ship to operate on more than one chart, mark the chart points where the navigator must shift to the next chart.

Examining 50nm On Either Side Of Track: Highlight any shoal water or other navigation hazard within 50nm of the planned track. This will alert the conning officer as he approaches a possible danger.

NAVIGATION ROUTINE AT SEA

2505. Frequency Of Position Determination

The table below lists recommended fix intervals as a function of navigation phase:

	Piloting	Coastal	Ocean
Frequency	3 min. or less	3-15 min.	30 min.

Shorten the suggested fix interval if required to ensure the vessel remains *at least two fix intervals from the nearest danger*. However, do not exceed the times recommended above. Choose a fix interval that provides a sufficient safety margin from all charted hazards.

Use all available fix information. With the advent of accurate satellite navigation systems, it is especially tempting to disregard this maxim. However, the experienced navigator never feels comfortable relying solely on one particular system. Supplement the satellite position with positions from Loran, celestial sights, radar lines of position, and visual observations. Evaluate the accuracy of the various fix methods against the satellite position; when the satellite receiver fails, the knowledge, for example, that Loran fixes consistently plotted 1 nm to the west of GPS can be helpful.

Use an inertial navigator if one is available. The inertial navigator may produce estimated positions more accurate than fix positions. Inertial navigators are completely independent of any external fix input. Therefore, they are invaluable for maintaining an accurate ship's position during periods when external fix sources are unavailable.

Always check a position determined by a fix, inertial navigator, or DR by comparing the charted sounding at the position with the fathometer reading. If the soundings do not correlate, investigate the discrepancy.

Chapter 7 covers the importance of maintaining a proper DR. It bears repeating here. Determine the difference between the fix and the DR positions at *every* fix and use this information to calculate an EP from every DR. Constant application of set and drift to the DR is crucial if the vessel must pass a known navigation hazard close aboard.

2506. Fathometer Operations

Use Figure 2506 to develop a standard procedure for operating the fathometer.

2507. The Modified Piloting Party

If operating out of piloting waters but near a navigation hazard, station a modified piloting party. As the name implies, this team does not consist of the entire piloting party. It could consist of only the navigator or assistant navigator, a plotter, and a recorder. Its purpose is to increase supervision of the navigation plot in areas that could pose a hazard to the vessel.

The navigator and captain should develop a standing order covering the stationing of a modified piloting party. A

Water Depth	Sounding Interval
Charted Water Depth < 100 ft.	Monitor fathometer continuously.
100 ft. < Charted Water Depth < 500 ft.	Take and record soundings every 15 minutes.
500 ft. < Charted Water Depth < 1000 ft.	Take and record soundings every 30 minutes.
Charted Water Depth > 1000 ft.	Take and record soundings every hour.

Figure 2506. Fathometer operating guidelines.

good rule is to station the modified piloting party when operating within 10 nm of a known hazard.

2508. Compass Checks

Determine gyro compass error at least daily as part of the at-sea routine. Check the gyro compass reading against the inertial navigator if the vessel has an inertial navigator. If the vessel does not have an inertial navigator, check gyro error using the celestial techniques discussed in Chapter 17. Report any error greater than 1° to the navigator and commanding officer.

Check the gyro repeaters and the magnetic compass against the gyro compass hourly and after each course change. When comparing the magnetic and gyro compasses, account for changes in variation and deviation. Report any repeater error greater than 1° to the commanding officer.

2509. Commanding Officer's Night Orders And Standing Orders

The Night Order book is the vehicle by which the captain informs the officer of the deck of the captain's orders for operating the ship. The Night Order book, despite its name, can contain orders for the entire 24 hour period after which the CO issues it.

The navigator may write the Night Orders pertaining to navigation. Such orders include assigned operating areas, maximum speeds allowed, required positions with respect to PIM, and, regarding submarines, the maximum depth at which the ship can operate. Each department head should include in the Night Order book the evolutions he wants to accomplish during the night that would normally require the captain's permission. The captain can add further orders and directions as required. When the captain signs the Night Order book, it becomes an official order to the Officer of the Deck.

The Officer of the Deck must not follow the Night Orders blindly. Circumstances under which the captain signed the Orders may have changed, rendering some evolutions ordered impractical to complete. The Officer of the Deck, when exercising his judgment on completing ordered evolutions, must always inform the captain of any deviation from the Night Orders as soon as such a deviation occurs.

The Commanding Officer's Night Orders are in effect only for the 24 hours after they are written; his Standing Orders are continuously in force. The captain sets the ship's navigation policy in these orders. He sets required fix intervals, intervals for fathometer operations, minimum CPA's, and other general navigation and collision avoidance requirements. The Officer of the Deck must follow the Commanding Officer's Standing Orders at all times. Report any deviation from these orders immediately to the Commanding Officer.

2510. Position Reports

If the captain requires position reports, deliver them at 0800, 1200, and 2000 each day. Prepare these reports approximately 30 minutes ahead of the time when they are due. Use the DR positions for the time of the report. For example, prepare the 2000 position report at 1930 using the ship's 2000 DR position. Often the captain will require additional information with these position reports. Some captains, for example, may want status reports on the engine room. Tailor each position report to contain the information the captain wants.

2511. Watch Relief Procedures

When a watch officer relieves as Officer of the Deck (OOD), he assumes the responsibility for the safe navigation of the ship. He becomes the Commanding Officer's direct representative in ensuring ship safety. As such, he must prepare himself fully prior to assuming the watch. The following list contains those items that, as a minimum, the relieving OOD must check prior to assuming the watch.

- **Conduct a Pre Watch Tour:** The relieving OOD should tour the ship prior to his watch. He should familiarize himself with any maintenance in progress. He should check for general cleanliness and stowage. He should order any loose gear that could pose a safety hazard in rough seas secured.

- **Check the Position Log and Chart:** Check the type and accuracy of the ship's last fix. Verify that the navigation watch has plotted the last fix properly. Ensure there is a properly constructed DR plot on the chart. Examine the DR for any potential navigation hazards. Check ship's position with respect to the PIM. Ensure that the ship is in the correct operating area, if applicable. Check to ensure that the navigation watch has properly applied fix expansion in accordance with the navigator's instructions.

- **Check the Fathometer Log:** Ensure that previous watches have taken soundings at required intervals and that the navigation watch took a sounding at the last fix. Verify that the present sounding matches the charted sounding at the vessel's charted position.

- **Check the Compass Record Log:** Verify that the navigation watch has conducted compass checks at the proper interval. Verify that gyro error is less than 1° and that all repeaters agree within 1° with the master gyro.

- **Read the Commanding Officer Night Orders:** Check the Night Order Book for the captain's directions for the duration of the watch.

- **Check Planned Operations:** For any planned operations, verify that the ship has met all operational prerequisites, that the ship is in the correct operating

area, and that all watchstanders have reviewed the operation order. If the operation is a complicated one, consider holding an operations brief with applicable watchstanders prior to assuming the watch.

- **Check the Broadcast Schedule:** Read any message traffic that could have a bearing on the upcoming watch. If the ship is on a broadcast schedule, find out when the radio operator received the last broadcast (military vessels only). Determine if the radio operator has any messages to transmit during the watch.

- **Ascertain the Contact Situation:** Check the radar and sonar contact picture, if so equipped. Determine which contact has the closest CPA and what maneuvers, if any, will be required to open CPA. Find out from the offgoing OOD if there have been any bridge-to-bridge communications with any vessels in the area. Check that no CPA will be less than the minimum set by the Commanding Officer's Standing Orders.

- **Review Watchstander Logs:** Review the log readings for all watchstanders. Note any out of specification readings or any trends in log readings indicating that a parameter will soon go out of specification.

After conducting the above listed checks, the relieving OOD should report to the on watch OOD that he is ready to relieve the watch. The on watch OOD then should brief the relieving OOD on the following:

- Vessel's present course and speed.
- Vessel's present depth (submarines only).
- Any evolutions planned or in progress.
- The status of the engineering plant.
- The status of repair on any out of commission equipment that effects the ship's operational capability.
- Any orders from the Commanding Officer not expressly given in the Night Orders.
- Status of cargo (merchant vessels only).
- Any hazardous maintenance planned or in progress.
- Any routine maintenance planned or in progress.
- Any planned ship's drills.

If the relieving OOD has no questions following this brief, then he should relieve the watch. Upon relieving the watch, he should announce to both the helmsman and the quartermaster that he has the deck and the conn. The quartermaster should log the change of watch in the ship's deck log.

Watch officers should not relieve the watch in the middle of an evolution or when casualty procedures are being carried out. Relieve the watch only during a steady state operational and tactical situation. This ensures that there is watchstander continuity when carrying out a specific evolution or combating a casualty.

THE DAY'S WORK IN CELESTIAL NAVIGATION

The advent of accurate electronic and satellite navigation systems has relegated celestial navigation to use solely as a backup navigation method. Seldom if ever will a ship undertake an ocean transit relying only on celestial navigation. Therefore, the navigator need not follow the entire routine listed below if celestial navigation is not his primary navigation source. Use only the steps of the celestial day's work that are necessary to provide a meaningful check on the primary fix source's accuracy. Should the electronic navigation system fail, however, and should celestial navigation become the primary means of navigation, this section provides a comprehensive procedure to follow.

2512. Celestial Navigation Routine

Complete a typical day's work in open celestial navigation as follows:

1. Plot the dead reckoning position.
2. Reduce celestial observations for a fix during morning twilight.
3. Wind the chronometer and determine chronometer error.
4. Reduce a sun sight for a morning sun line.
5. Calculate an azimuth of the sun for a compass check. The navigator normally obtains an azimuth at about the same time as he takes a morning sun observation. He may also check the compass with an amplitude observation at sunrise.
6. Observe the sun at local apparent noon. Cross the resulting LOP with an advanced morning sun line or with a longitude determined at LAN for a fix or running fix.
7. Reduce a sun sight during the afternoon. This is primarily for use with an advanced noon sun line, or with a moon or Venus line, if the skies are overcast during evening twilight.
8. Calculate an azimuth of the sun for a compass check at about the same time as the afternoon sun observation. The navigator may replace this azimuth with an amplitude observation at sunset.
9. Reduce celestial observations for a fix during evening twilight.

Chapter 7, Chapter 17, and Chapter 20 contain detailed explanations of the procedures required to carry out this routine.

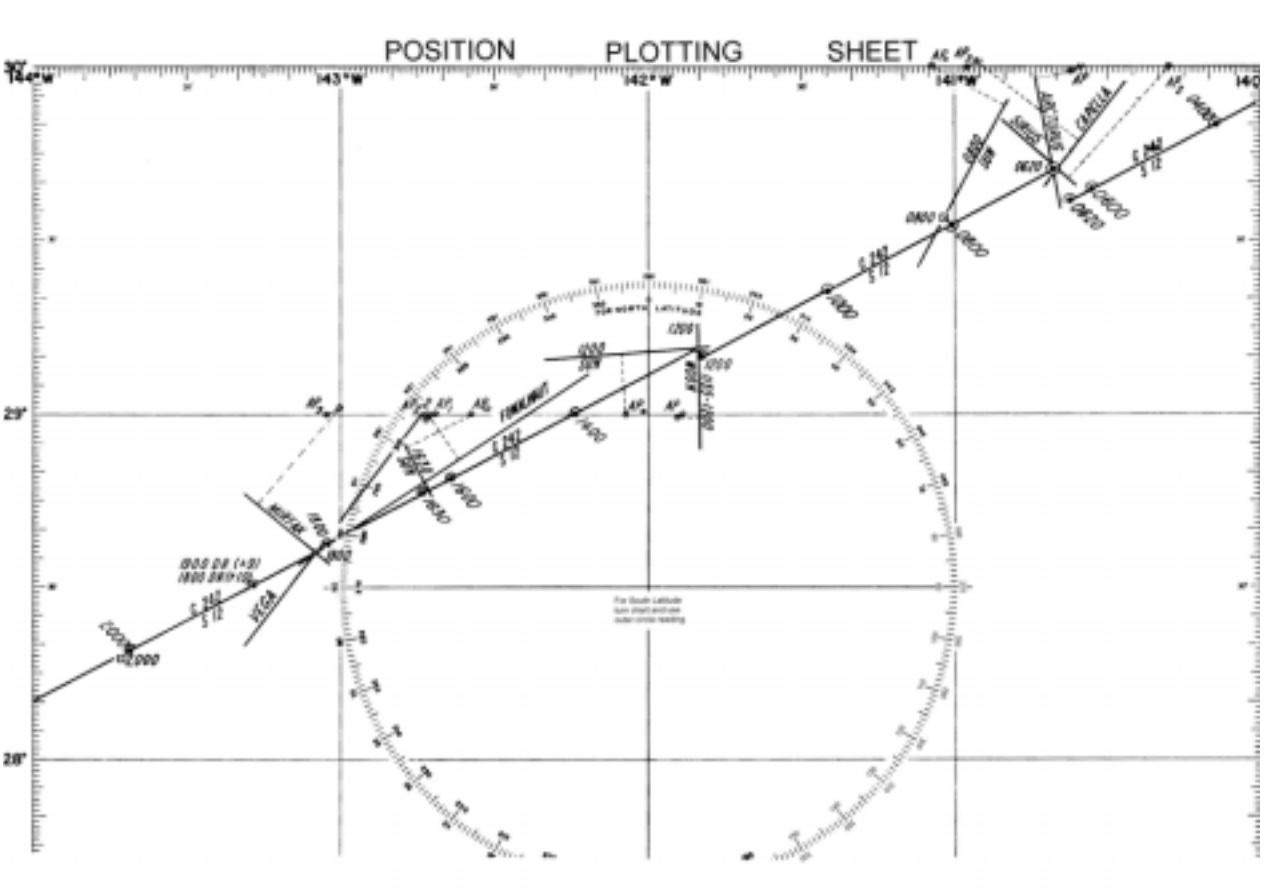

Figure 2512. Typical celestial plot at sea.

SPECIAL CONSIDERATIONS FOR SMALL CRAFT

2513. Navigation Of Small Craft

In principle, the navigation of small craft is the same as that of larger vessels. However, because of a small craft's shallower draft, greater maneuverability, and possible limitations of equipment and expertise, there are important differences. Small craft often spend most of their time within sight of land, and their navigation is largely a matter of piloting. They generally are close enough inshore to reach safety in case of storm or fog. Since most of them are primarily pleasure craft, there is a tendency for their navigation to be a less professional process than in commercial or military craft.

Regardless of the nature of the craft, it should carry the minimum safety equipment required by the U.S. Coast Guard. In addition to this Coast Guard mandated safety equipment, a small craft should also carry a compass, charts, plotting devices, speed log, tide tables, Coast Pilot or Sailing Directions, and binoculars.

All craft venturing offshore should carry a properly registered EPIRB and VHF radio. Loran C, Omega, and GPS receivers are available; boats that transit out of sight of land should have at least one of these.

If the craft is to proceed out of sight of land for more than short intervals, celestial navigation equipment should be aboard. This equipment should include a sextant, an accurate timepiece, a means of receiving time signals, an almanac, and sight reduction tables. Celestial navigation calculators or computer programs are also useful.

A small craft navigator of limited experience may underestimate the importance of professional navigation. However, his vessel's safety depends on his skill. He must plan his track and know his position at all times. Small craft navigation also requires a complete, accurate, and neat plot. Where this is impractical because of heavy weather or limited plotting space, use a careful log and dead reckoning plot.

CONCLUSION

2514. The Importance Of The Navigation Process

Navigating a vessel is a dynamic process. Schedules change; missions change. Planning a voyage is a process that begins well before the ship gets underway. Executing that plan does not end until the ship ties up at the pier at its final destination.

Develop a navigation process encompassing the principles discussed in this chapter. Carefully planning a route, preparing required charts, and closely monitoring the ship's position enroute are fundamental concepts of safe navigation. A mariner should never feel comfortable unless he is following an approved track plotted on a corrected chart on which he has frequently updated his position.

Developing and implementing such a routine is only half of the battle. Watchstanders must follow approved procedures. U.S. Navy grounding reports and U.S. Coast Guard accident reports attest to the danger courted when a vessel disregards basic navigation safety.