

September 2017 Development Paper

MariEMS Learning Material - E-Navigation and Weather Routing

This is the 14th compilation by Professor Dr Reza Ziarati on the work of the EU funded Erasmus + MariEMS' partners and material researched by Chief Engineer Mohammed Haque. The material is composed from Chapter 14 of the learning material.

14. E-Navigation and Weather Routing

14.1 What is E-Navigation

It has long been recognized that there was a clear need to provide the master of ships and those responsible for the safety of the vessels ashore with modern proven tools to make marine navigation and communication more reliable and hence reduce errors, especially those with the potential for loss of life, injury, environmental damage and undue commercial costs. It was also noted from information disclosed over time that navigational errors and failures had been significant in overall incidents that required a full investigation. This inspired the development of new technologies such as Automatic Identification System (AIS), Electronic Chart and Information System (ECDIS) Integrated Bridge and Navigation Systems, Automatic Radar Plotting Aids (ARPA), Long Range Identification and Tracking (LRIT) systems, Vessel Traffic Services (VTS) and the Global Maritime Distress Safety System (GMDSS). The aim was to develop a strategic vision for the utilization of existing and new navigational tools, in particular electronic tools, in a holistic and systematic manner. The proposed solution was named e-navigation. As a result of proposals made to IMO MSC (Marine Safety Committee) on the subject, a Strategy Implementation Plan (SIP) was developed in the past and five solutions were agreed to provide a basis for this purpose that are;

- **S1:** Improved, harmonization and user friendly bridge design;
- **S2:** Means for standardised and automatic reporting;
- **S3:** Improved reliability, resilience and integrity of bridge equipment and navigational information;
- **S4:** Integration and presentation of available information in graphical displays received via communication equipment; and
- **S5:** Improved communication of VTS service portfolio.

The solutions S2, S4 and S5 are designed to improve communication between ship and shore for safe ship management purposes. These same initiatives may have the highest potential to reduce GHG emissions from ships as any reduction in the waiting time to enter port or a delay in the passage of a river or estuary can have a positive impact on reducing fuel consumption of a voyage and thus its GHG emissions. IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) defines the e-navigation as "e-navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment". The implementation of e-navigation involves the development of onboard navigation systems that integrate all relevant ships sensors and supporting information. ECDIS is the main item of the broader e-navigation initiative that has evolved as a result

of IMO activities. There are currently over 40 different approved ECDIS systems installed on ships and most if not all have different user interfaces using different methods of implementing requirements and alarms. The IMO considers the implementation of e-navigation in the world's fleet as a long term objective rather than a short term fix. It should also be noted that the on-board e-navigation system will have a shore based e-navigation to support it that will require other challenges. It is hoped that e-navigation will be an enabling technology that would facilitate more efficient ship scheduling and routing, thus leading to more energy efficient shipping and a reduction in the amount of GHG emissions it produces. The IMO and IALA have provided the following e-navigation model (see Figure 14.1) to describe the overall concepts and outline the basic elements of the system.

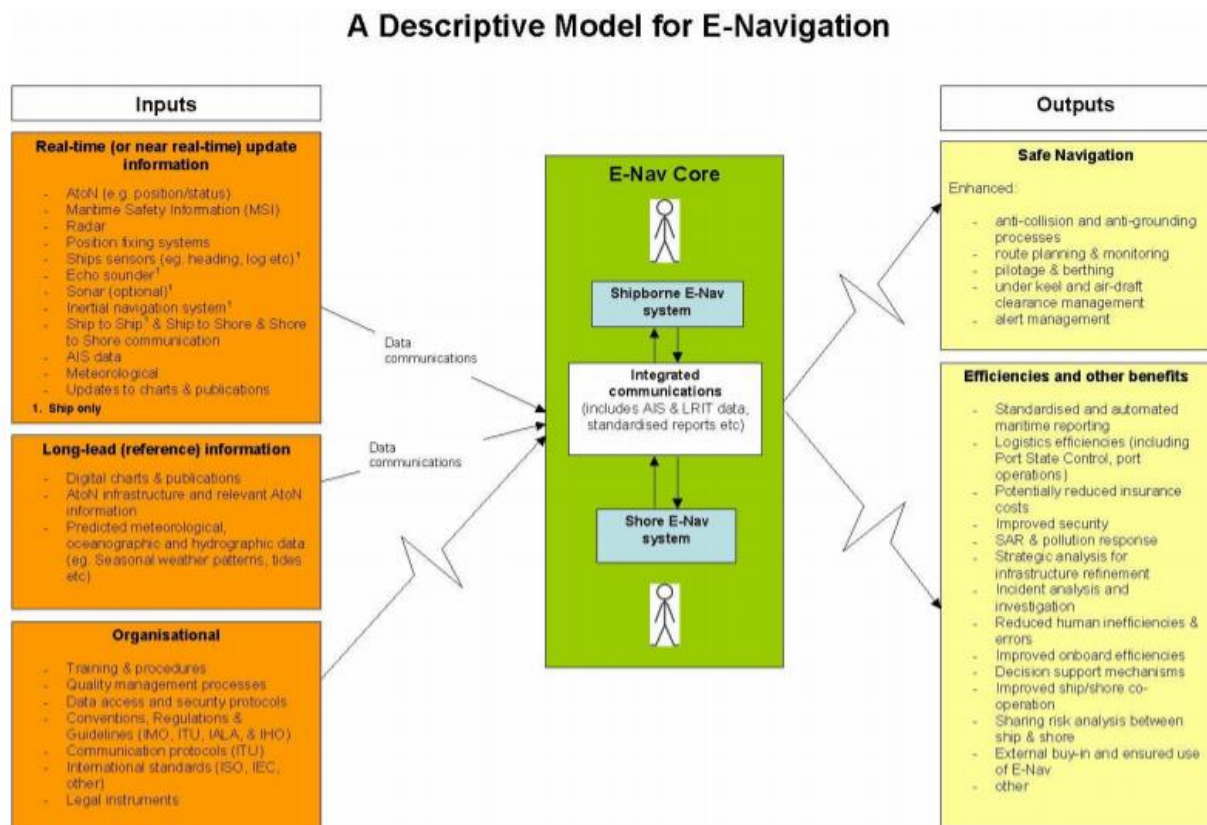


Figure 14.1: The IMO model of the principle outline and basic elements of the e-Navigation concept

It can be seen that this model implements many other shipboard and shore side management elements and not just navigation with the aim of ensuring the highest standard in environmental protection and safety. The system intends to combine measures like passage planning with dynamic real time monitoring to ensure that the pre-planned under-keel clearance is maintained during the whole passage. There could be on-line monitoring of ships' routes that could be analysed in relation to GHG emissions to look for ways to reduce fuel consumption and cost. The system would have built-in decision support system to assist both the masters and officers on navigational watch. The system would be berth to berth management including route monitoring, pilotage and berthing.

14.2 E-Navigation Tools and GHG Emissions

It is clear that any reduction in collision and grounding will lead to the reduction of ship generated pollution. The IMO and IALA are also looking at the possibility of using e-navigation to reduce carbon, sulphur and nitrogen emissions from ships. This would be done through more efficient

vessel route handling at sea and also while on pilotage and berthing. It has also been proposed to use e-navigation data to audit the measurement of emissions data if and when they need to be reported. The main and fundamental change with the introduction of e-navigation will be the closer relation between the “officer of the watch” on the bridge and the assistance provided from shore based stations in carrying out the safe navigation of the ship. There are of course still many legal obstacles to this particularly with regard to who will be responsible for the navigation of the ship if directed by shore side, particularly in a collision avoidance situation in open sea. The developments of centralized shore-based traffic organizations that have the authority to modifying voyage plans and make dynamic route changes from ashore for the purpose of safety and efficiency of the overall traffic in a monitored coastal area, are the subject of several research projects. These are currently under discussion but still some way off from introduction. It is still difficult to predict what the technological developments will be in the future to allow the development of e-navigation so the potential impacts on efforts to reduce GHG emissions are still difficult to estimate. However, the ship navigational information (GPS data) has successfully been used to estimate shipping fuel consumption and GHG emissions for example under Third IMO GHG Study 2014. There is currently equipment or systems either in use or at an advance state of development that will form part of a shipboard e-navigation system that may be used to reduce GHG emissions. Examples are:

- **Voyage performance analysis:** This system can measure ship speed, shaft propulsion power and external environmental situation such as wind and waves that could be used for monitoring voyage performance and to identify performance deviations. These performance deviations that may be positive as well as negative could be used to improve the ships environmental performance. Such a system could rely on data collected as part of e-navigation system.
- **ECDIS (Electronic Chart Display and Information System):** The electronic chart and information system has the potential for improving navigational practices and reduce GHG emissions. In this respect, weather routing may become a more effective tool than is today.
- **Autopilot precision and effectiveness:** A new generation of autopilots is under development that can automatically adapt the steering actions to prevailing weather conditions and sea state. These systems include dedicated functions such as 'precision' and 'economy' modes depending on the requirement of the ship. If the autopilot is operating in economy mode it would reduce rudder movements, thus reducing the drag of the rudder that will save fuel. If the ship is in restricted waters where very accurate course and position is required, the autopilot will be put in precision mode providing for the better accuracy and ensuring safe navigation.
- **Manoeuvring assistance tools:** With the introduction of modern information and communication technologies, more and more assistance tools have been introduced additionally to standard mandatory navigational bridge equipment. Among those integrated systems there are tools for planning and monitoring purposes on the macro and micro level. Macro planning deals with waypoint planning for the sea trail of any voyage from point A to B. Micro planning is dedicated to the planning of detailed steering sequences for complex manoeuvres in harbour areas, even including berthing operations. Once the planning process is completed and approved, the bridge team can follow the steering sequence using any dedicated display to check the plan is being kept. The use of sophisticated planning and monitoring tools optimizes the number of elementary manoeuvres in order to meet the requirements for the safety of navigation while also meeting the requirements for the

minimum use of the steering equipment and saving fuel and time and simultaneously reduce GHG emissions when operating in coastal and harbour areas.

- **Integrated navigational systems:** This can achieve fuel savings by keeping cross track error to a minimum while in passage. This technology has been brought about by extremely accurate GPS position information, which can calculate the ships position down to a few meters with the capability of giving accurate heading information. With this system, better course control is achieved by requiring less frequent and smaller corrections to minimize rudder resistance. Generally a ship is most efficient with regard to rudder position, when the rudder is mid-ships and not carrying any helm in either direction due to wind or sea conditions. The superstructure and hull form designs above the water can affect the amount of helm the ship needs to carry for a particular wind direction. Advances in the shape of the above water profile of the hull and superstructure to reduce the effects of wind resistance could have a positive effect in this area.
- **Computerised manoeuvring assistance tools:** This takes into account the prevailing environmental conditions such as wind and current, ship condition, current course, speed, draught and the trim of the vessel. The systems can adapt the manoeuvring characteristics to the external environmental condition to ensure efficient use of energy and resources and minimise emissions of GHG. The intended passage is split into a number of pre-planning manoeuvres called elementary manoeuvres. Elementary manoeuvres are defined as each single manoeuvre or command of rudder, engine and thrusters or other steering equipment. Once the planning process is completed and approved, the bridge team can follow the steering sequence using any dedicated display to check the plan is being followed. The use of these sophisticated planning and monitoring tools optimises the number of manoeuvres for safe navigation while maintaining minimum use of the steering equipment to saving fuel and time reducing GHG emissions when operating in coastal and harbour areas.

As can be seen, e-navigation provides significant new opportunities for optimizing navigation actions in favour of safety and environmental protection.

14.3 ECDIS (Electronic Chart Display and Information System)

The international convention for safety of life at sea SOLAS will require in the near future that the paper charts to be replaced by approved electronic charts that must be used in conjunction with an approved ECDIS. Paper charts will only be able to be used as a backup or on small ships of less than 500 GT. These electronic charts are currently in two formats the main one being “vector charts” which can be scaled up or down and not lose any definition, as the information on them is purely digital. The other type which should only be used where there is no “vector chart” available is the “raster chart” which is a copy of the paper chart and cannot be scaled up in too much without losing definition. The ECDIS takes the information from the approved electronic chart and reproduce an image on a display system. The ECDIS can however do much more as it also has, as a minimum, the speed, water depth and position input from sensors so these other ship’s information are accessible by it and can be seen at all times. Many ECDISs also have the capability of showing radar, ARPA and AIS data so other ships can also be seen on the ships ECDIS display unit but this is not mandatory. Figure 14.3 shows a concept of how ECDIS is linked to other ship-board systems. The ECDIS should however not be used for collision avoidance as an ECDIS is not approved as a radar so such information can only be used as an aid to navigation. The ECDIS is used to include the ships passage plan on and it has the ability to analyse the ships route and provide alerts for better ship course control. The ECDIS will also alert the “officer of the watch” of deviations from any pre-programs

safety zones set by the officer or master. All the above capabilities are relevant to some important energy efficiency measures such as weather routing and route planning, course control and so on. With ECDIS, the latest navigational information is introduced automatically, saving companies a significant amount of time that would otherwise be spent researching and gathering. In terms of communication, electronic data has far more advantages than paper-based information. It is easy for updates to be transmitted electronically to several recipients, which is vital for shipping companies.

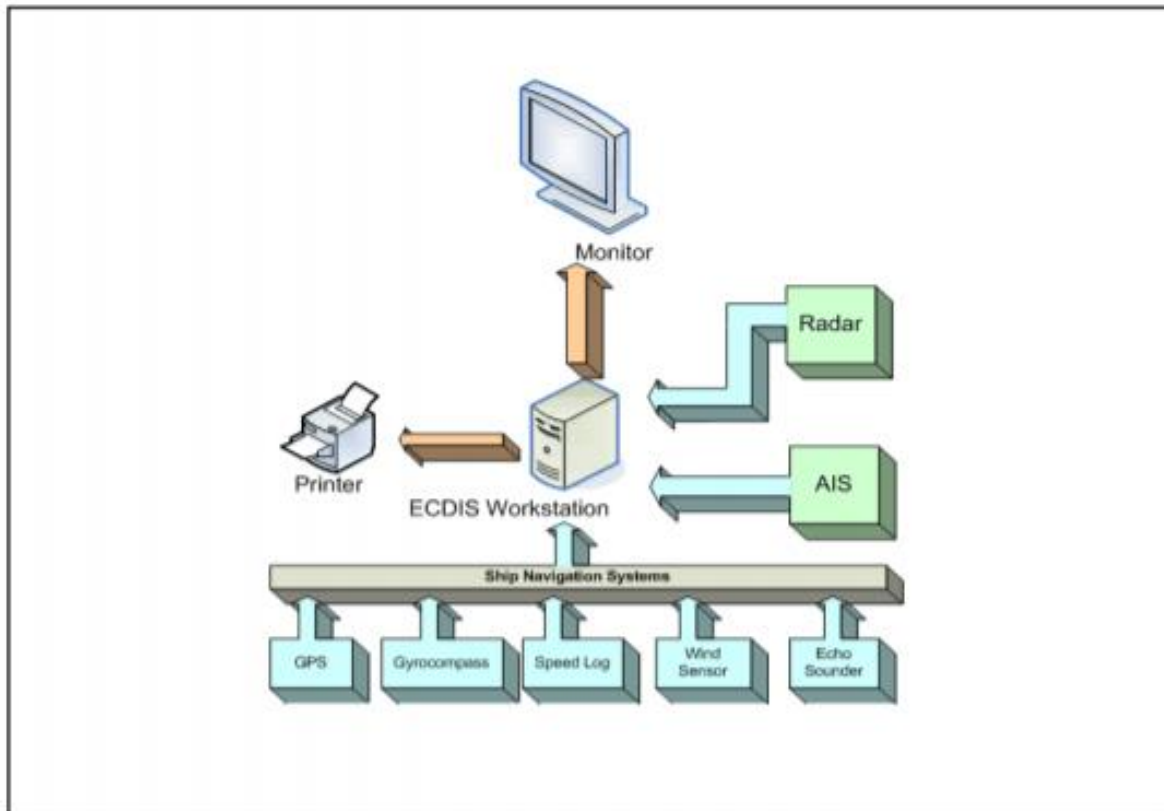


Figure 14.3: Concept of ECDIS and its' integration with other system [Fredrik Larsson]

14.4 ECDIS Use for GHG Reduction

The ECDIS main advantage over the traditional paper plot method of getting from A to B is that it is capable of accurately plotting and monitoring the ships position in real time to ensure that the ship follows the optimum course to the destination. In the old systems, the ships position was normally plotted between every 15 minutes to an hour in coastal situations and every watch when in open oceans. Course adjustments were then made, where necessary, to make the next alter course position. An ECDIS fitted to the ship has the ability to be linked to an advanced automatic pilotage system called a track pilot that can improve the vessels ability to keep on track and alter course at just the right time to minimise the distance travelled this will ensure that the ship take the minimum distance between the departure and destination port, thus reducing GHG emissions. There are however at present dangers to altering the course of a ship without the knowledge of the "officer of the watch", particularly in restricted waters with lots of ships around. These systems as yet fully cannot take into account other ships and the requirements of the International Regulations for the Prevention of Collision at Sea commonly known as the 'Rules of the Road' but when the principles of e-navigation are fully implemented the possibility is there. An ECDIS can give a quick method of calculating estimated time of arrivals (ETAs) at the port of arrival taking into account the current position of the ship, the distance to go and the tidal rates and directions without doing a

complicated calculation. This information gives the officer of the watch the information to accurately adjust the speed of the vessel so that it arrives at the pilot station or start of the pilotage passage at exactly the right time when on coastal passages or approaching the port taking into account the height of tide for entry or any other environmental factors. This tool can also be used when slow streaming on ocean passages to adjust the speed for better fuel efficiency and more convenient time of arrival but as mentioned in previous section on shipping law any reduction of speed to reduce fuel consumption when on charter should be verified. The ECDIS has the potential to improve voyage planning and fuel efficiency of a vessel on an ocean passage when the ship is operating at her full service speed. For example, as the ECDIS can continually monitor the ships position to ensure that it is on the intended track. The ECDIS can follow a Great Circle curved track that requires the ship to constantly alter the ship's course, as the ship will be following a circular path. The Great Circle path which is the shortest distance between two points on the earth's surface will always be curved unless the ship is travelling due North, South, East or West when the ship is following the same latitude or longitude.

14.5 Passage Planning

The passage plan is the most important part of the voyage plan. Careful planning and execution of the passage plan can achieve an optimum route and improved efficiency. The ECDIS can be an important part of any passage planning and implementation. The stages of a passage plan are as follows [*IMO Resolution 893(21)*]:

1. **Appraisal:** An overall assessment of the intended voyage will be made by the master, in consultation with the navigating officer and other deck officers who will be involved, after all relevant information has been gathered. This appraisal will provide the master and his bridge team with a clear and precise indication of all areas of danger and safe navigation taking into account the calculated draught of the vessel and planned under-keel clearance.
2. **Planning:** Once a full appraisal has been carried out the navigating officer carries out the planning process. The detailed plan would cover the whole voyage, from berth to berth, and includes all waters where a pilot will be on board. The plan would be completed and include all the relevant factors listed in the IMO guidelines. The appropriate charts should be marked clearly showing all areas of danger and the intended track plus all other safety related information. The main details of the voyage plan should also be recorded in a bridge logbook used specially for this purpose to allow reference to details of the plan at the conning position without the need to consult the chart. Supporting information relative to the voyage, such as times of high and low water, etc. will also be recorded in the logbook.
3. **Execution:** The execution of the finalised voyage plan would be carried out taking into account the factors listed in the IMO guidelines. The master would take into account any special circumstances which may arise, such as changes in weather, which may require the plan to be reviewed or altered.
4. **Monitoring:** This is where the passage plan is monitored to affirm that the vessel follows the intended route. Monitoring of the vessel's progress along the pre-planned track is a continuous process. The officer of the watch, whenever in any doubt as to the position of the vessel should immediately consult the master to ensure safety of the vessel. Information on passage planning is contained in the IMO resolution 893(21) 'Guidelines for voyage planning' that describes in detail what needs to be done under the above 4 stages and the ISF / ICS (International Shipping Federation / International Chamber of Shipping) publication

“Bridge Procedures Guide”. It should be noted that the above IMO guidelines address the voyage planning from the safety of navigation purposes rather than energy saving. For energy saving purposes, the route planning needs to take extra dimensions such as avoiding shallow waters, avoiding sea currents, etc. thus will be combined with overall voyage planning using weather routing and so on. Thus, a fuel-efficient operation should be part of the ‘passage planning’ and taken into consideration at the appraisal stage above.

14.6 Operation in Congested Routes

When operating in areas of high traffic density, it may be necessary to deviate substantially from the intended track by an alteration of course to comply with the collision regulations. There may also be a need to slacken speed, stop or reverse the means of propulsion. In cases such as this, any considerations to reduce CO₂ emissions are outweighed by an international obligation to comply with the international regulations for the prevention of collision at sea. It is very difficult to include such requirements in any GHG reduction plan. Ships are required to proceed at a safe speed in restricted visibility waters. This will require the master to reduce the speed of the vessel and if necessary stop the vessel until all danger of a collision is over. The international regulations for prevention of collision at sea require all ships to comply with its regulations. It may be necessary to ignore energy saving measures when operating in such areas and again navigational safety and good seamanship must always take priority. Ships may operate in an area of restricted visibility for several days which may require them to reduce speed significantly or even wait with subsequent need for over steaming that overall will result is a significant increase in fuel consumption but yet again navigational safety must take priority. The main questions answered is weather with e-navigation systems and ECDIS and weather routing information, such areas of operations that lead to significant increase in fuel consumption could be avoided? These are certainly issues that may be tackled once the relevant data are mature and e-navigation is fully in place.

14.7 Shallow Water and Narrow Channels

In shallow water both frictional and wave making resistances increase. The reasons are:

- Flow velocities under the hull increase as well as the wetted surfaces increase. Both of these increase the ship’s frictional resistance in shallow waters.
- The waves created under shallow water take more energy from the ship than those in deep water for the same speed. This increases the wave making resistance.

Because of the above, shallow water can have a significant impact on ship resistances. Table 14.7 shows the fuel consumption increase (%) for different water depths D in meter and speeds X in knots.

X	D	Increase (%)
10	8	5
10	10	3
10	100	0
17	8	20
17	15	10
17	100	0
20	8	30
20	15	20
20	100	0

Table 14.7: Increase in fuel consumption (%) as a function of speed and water depth [Mariners Handbook]

In shallow water, the deep draft vessels can experience “squat” (*The squat effect is the hydrodynamic phenomenon by which a vessel moving quickly through shallow water creates an area of lowered pressure that causes the ship to be closer to the seabed than would otherwise be expected. This phenomenon is caused when water that should normally flow under the hull encounters resistance due to the close proximity of the hull to the seabed. This causes the water to move faster, creating a low-pressure area with lowered water level surface. This squat effect results from a combination of vertical sinkage and a change of trim that may cause the vessel to dip towards the stern or towards the bow*) which, depending on the hull form of the vessel will generally increase ship draft and increase the trim either by the head or the stern. This can result in the ship virtually dragging itself along the bottom. Signs of squat are erratic steering, large amount of helm required and a trail of muddy water from the stern. Squat can seriously increase fuel consumption. The solution to the problem is simply slow down where possible. It has to be realised that a ship in a narrow channel making for a tidal port with a draft restriction, may have to increase speed to make the tide even if it results in a significant increase in the use of fuel. So, there are exceptions to the above general rules. However, in the future with the increased planned accuracy of satellite navigational systems, improved tidal information and the use of ECDIS the ships will have the capability of resolving the above issues in a better way. If a ship is operating on a trade where tide heights and depth of water in the channel or on berth is a major consideration, the operator may need to look for other ways to reduce the ships energy use as some of these limitations cannot be overcome. The use of ECDIS capability plus weather routing services can provide savings via avoiding inappropriate operations in shallow water, restricted areas and narrow channels.

14.8 Weather Routing

14.8.1 History

Weather routing has been around for a long time and was originally developed by the shipmasters in the time of sailing ships that often develop their own weather charts. The ship would also take their own weather observations of temperature, pressure, wind direction, wind force, direction of swell and cloud type and cover; all of which were recorded in the ship’s log book as is still done today.

In the 19th and early 20th century this information was collected nationally by such organisations as the predecessors of the United Kingdom Hydrographic Office. From this information, publications such as 'Ocean Passages of the World', Mariners Handbook (particularly for ice navigation) and weather routing charts were developed and have become mandatory publications on ships of many Flag states. At the turn of the 20th century, the development of radio enabled ships to transmit weather data over long distances using 'Morse Code' giving ships advance warning of storms and hurricanes. Long wave low frequency radio communication was also used to transmit to the shore up-to-date weather data. Morse code was still used for ship radio communication right up to 1999 when the GMDSS (Global Maritime Distress and Safety System) was fully implemented and the use of long wave and similar low frequency radio frequencies that could only be sent by experienced radio officers was no longer required. All radio communication could then be sent in plain language via satellites with little training. These data enabled shore side forecasters to develop and send up-to date weather forecasts and charts to all ships in a particular sea area. It was not until the late 60s and early 70s that weather routing as we know it today was developed. This major change was happened because of the increased accuracy of weather information that could be provided by the various met offices using satellite technology viewing from space in real time on various aspects of weather developments.

14.8.2 Fuel consumption and weather

The fuel consumption for a ship not only depends on speed, but also on water depth and weather conditions. The impact of shallow water operation on fuel consumption was discussed in the previous section. The weather condition includes wind and wave. To demonstrate the typical impact of wind on a ship's fuel consumption, Table 14.8.2 provides a typical and approximate relation between increased wind strength, direction, and increased fuel consumption for each unit of Beaufort unit. Accordingly, a one Beaufort increase in sea state would result in 4% increase in fuel consumption due to the head wind.

Wd	Type	Increase (%)
315-360, 0-45	Head wind	4
45-135, 225-315	Side wind	2
135-225	Tail wind	1

Table 14.8.2: Increase in fuel consumption due to wind from different directions [Mariners Handbook]

Waves may have a significant impact on route selection. In order to take waves into account one has first to know their height and direction along the contemplated route as a function of location. Such knowledge may allow selection of the route and of power setting that minimize the transit time. However, the waves' height and direction may change over time and may not be known in advance.

In most oceans, there are regular currents that ships may be able to exploit for faster passage. Ocean currents are not constant but change over time. Thus getting reliable timely information regarding the ocean current at the location of a vessel poses a major obstacle. Satellite may provide timely reliable estimates of dynamic current patterns that are necessary for routing a vessel through such currents. The major question is whether there is a sufficient market to justify development of a system for collection of the necessary data.

Based on the above, the ship speed and route is best not only to be decided by commercial and contractual considerations but also using data on sea condition, sea currents, water depth and wind characteristics. The optimal speed distribution along the route can be calculated in advance, if a weather forecast is available. These techniques are used by weather routing service providers as part of their ship modelling and analysis. The advantages of including weather routing in a ship's passage plan is that a ship on an ocean passage can significantly reduce its fuel used by reducing the time taken for a particular voyage, even if the route taken is longer. Weather routing is mainly applicable to ocean going vessels that have some flexibility in which route they take. The abatement potential is quoted at between 1 and 4% but some providers do quote much higher for individual ships on particular routes of up to 8%. A significant proportion of the world's fleet already use weather routing and often included in the charter party so the possible abatement potential worldwide is believed to be less than the above. Some weather routing services also provide advance and accurate current and tidal predictions which can also be used on coastal routes. There are many weather routing providers throughout the world so there is plenty to choose from. Owners may wish to look at providers that specialise in the type of trade and area they operation in.

14.8.3 Use of weather routing:

If a ship is operating in a sea area which has a high occurrence of bad weather, the owner may consider using weather routing services to reduce fuel cost and ship and cargo damage. For example, ships that are fine-lined and are fast often suffer from panting and pounding at the forward section of the ship when the wind and sea is ahead. Panting and pounding can result in significant damage below the waterline forward on the hull plating and it may be necessary to reduce the ship's speed to save both fuel and expensive dry-dock bills repairing or renewing hull plating. These fast ships are often container ships or reefers or LNG ships and are on a set schedule and slowing down because of bad weather can mean that fleet management will suffer. Weather routing service can direct the ship away from sea areas where such weather conditions exist with the likelihood of damage and increased fuel costs. Heavy rolling with a beam sea can result in significant damage to both the ship (racking stresses) and the cargo, particularly if it is carried on deck so it may be necessary to alter course lengthening the distance. The ship may not be going exactly the right way, but at least it will be safer and may be using the minimum level of fuel for the distance travelled. Weather routing service can use long-range weather forecasts to route the ship away from these heavy beam sea conditions, optimising the distance and time travelled. In the case of extreme heavy weather conditions such as Tropical Revolving Storms (TRS) or hurricanes, it may be necessary to make substantial changes to the intended track resulting in a much larger distance travelled. Weather routing services with their up-to-date and accurate information of the direction of the storm can direct the ship on the safest and shortest route to avoid dangerous sea conditions. In some cases the weather routing service may advise delaying the ship's departure until the weather improves by either staying in port or finding a safe anchorage until a storm passes; saving fuel and avoiding damage to the ship and cargo.

14.8.4 Weather routing services

Weather routing services can help to optimise the route a ship takes given the prevailing weather conditions. It was primarily used for avoiding rough seas and for ship safety purposes. Weather routing can be effectively used for a reduction in travel time and a reduction of fuel consumption. Weather routing depends on the accuracy of the data provided by the various met offices around the world. The types of weather routing services offered are;

- Own ship using current and wind charts.

- Weather routing software onboard that is kept up to date by weather routing services ashore with the route being planned by the master of the ship.
- Shore based weather routing where the shore based weather routing service provider advises the master on a regular basis of what route to take.

If the owner or in some case charterer of the ship decides to use external vessel weather routing service providers, they will have to decide which category of route the ship should follow. The owner will be aided to choose one of the following routes, as examples:

- Fastest route.
- Fastest route least fuel.
- Fastest route least damage
- Fastest route least fuel and least damage

The route that the owner requests from the weather routing provider will depend on a number of factors including the type of cargo, the type of ship, the area of operation, the conditions of the charter party. If for example the ship is carrying an expensive cargo that is very susceptible to damage from heavy rolling and pitching, the owner may decide to ask for the least damage route and accept that the ship may take longer and use possibly more fuel to reach its destination. If there is no time constraint because the port of discharge or loading is blocked with traffic the owner or charterer may choose the least fuel route. If there are no such constraints and it is of utmost importance that the ship arrives at the port in time the owner or charterer may decide to ask for the fastest route.

It should of course be recognised that the navigation of the ship is ultimately the master's decision and he can at any time ignore the advice given by the weather routing services if he believes that following that particular advice would threaten the ship, its cargo or crew. For example, if the ship enters thick fog area, the International Regulations for the Prevention of Collision require the master to slow down and if the ship gets a distress message, the ship is obligated to go to help the ships under distress.

14.8.5 Data used for weather routing

Weather routing service providers play more and more a stronger role in voyage planning and choice of route. They rely on information about ship, sea and weather to provide their service. They would normally do this via building a computer-based ship model in their system. If possible, the weather routing service provider will visit the ship and collect the ship data from the master. They would look in particular for characteristics of the vessel so that it can be built into their model for best route planning. If the ship visit is not an option, the service providers will either request the data from the ship owner or use data from a sister ship. The weather routing service providers will require ship specific information such as:

- Ship type
- Ship dimensions
- Ship summer load line and ballast passage draft
- Ship draft for the planned voyage

- Carriage of deck cargo
- Service speed
- Max speed

Additionally, weather routing service providers will take into consideration the following data when putting together a plan for ship on a particular voyage;

- Historic data on currents, wind, pressure, temperature, water temperature, paths of depressions, Tropical Revealing Storms (TRSs) and wave heights.
- The latest information on wind, waves, wave heights, temperature, pressure, cloud cover and type provided by national and private weather meteorological data suppliers. This information is gained from ships at sea, satellites, and shore observations.

The weather routing services provider use advanced computer-modelling tools to predict the weather pattern and how this will affect the ship at a particular course and speed. From this information, the model can then produce a voyage route or routes that will reduce the fuel consumption or voyage time for these conditions taking into account the safe navigation aspects. It should however be kept in mind that these predictions still rely on the accuracy of the data for both the ship and assumption that “the weather pattern will do as it did in the past”. These models are getting better but the weather is such a complicated system that mistakes in forecasting are always possible; but much less than before.

14.9 References and further reading

The following list provides references for this section and additional publications that may be used for more in-depth study of topics covered in this section:

1. “IMO train the trainer course material”, developed by WMU, 2013
<http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Air%20pollution/M3%20from%20management%20to%20operation%20final.pdf>
Viewed Nov 2016.
2. IMO resolution 893(21) ‘Guidelines for voyage planning’,
<https://mcanet.mcga.gov.uk/public/c4/regulations/safetyofnavigation/annexes/Annex25.htm>. Viewed Nov 2016.
3. Larsson F, “Marine Issues”, Intertanko presentation to Northern European Panel – HAMBURG 2009. Viewed Nov 2016.