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Shore-based Voyage Planning

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Masters of Maritime Management

The objective of the thesis was to describe the voyage planning process and factors that influence it to see how the process could be adapted for being performed shoreside. The thesis is a qualitative study written from the voyage planning officer's point of view concentrating on the appraisal and planning stages.

Regulatory framework was defined using IMO and British Admiralty publications. Carnival Corporation's SMS policies and Holland America Line's voyage planning routines were used as examples of the process. As there is not much research available on voyage planning and new developing technologies, interviews and internet sources were used.

The amount of work put into a voyage plan varies greatly depending on a ship type and trade area, but generally it is a time-consuming process, partly because the information needs to be gathered from multiple sources and is not always easily available. The concept of e-navigation is aimed to improve connectivity between different systems and stakeholders allowing new types of services and information dissemination across the industry enabling the navigators to receive relevant information in time and often automatically with no need to request the information separately. Also automated ship-to-ship information exchange will become possible.

AI-aided planning software and government provided passage plans can be of assistance in the voyage planning officer's work, but their scope is still quite limited. In the future when the technology develops, and especially if all information can be accessed from a single window, time spent on appraisal and planning stages will decrease considerably and most of the process could be done shoreside leaving the officers on board more time for other tasks.

Autonomous vessels and augmented reality are the future, and as the technology develops shore-based voyage planning will become more common.

Key words
Voyage planning, e-navigation, autonomous ships

CONTENTS

ABBREVIATIONS

ADRS	Admiralty Digital Radio Signals
AENP	Admiralty e-NP
AIO	Admiralty Information Overlay
AMSA	Australian Maritime Safety Authority
APR	Automated Position Report
ARCS	Admiralty Raster Chart Service
ATT	Admiralty Total Tide
AVCS	Admiralty Vector Chart Service
AWWTS	Advanced Wastewater Treatment System
BA	British Admiralty
BAM	Bridge Alert Management
BIIT	Built-in Integrity Test
BWTS	Ballast Water Treatment System
CSMART	Center for Simulator Maritime Training
CSV	Commence Sea Voyage
ECR	Engine Control Room
ENC	Electronic Navigational Chart
ENSI	Enhanced Navigational Support Information
EOOW	Engineering Officer of the Watch
ESV	End of Sea Voyage
EO	Environmental Officer
FOC	Fleet Operations Center
GOFREP	Gulf of Finland Reporting System
HAG	Holland America Group
HESS-MS	Health, Environment, Safety and Security Management System

INS	Integrated Navigation System
LOP	Line of Position
MASS	Maritime Autonomous Surface Ships
MIN	Marine Information Network
MSC	Maritime Safety Committee
MSP	Maritime Service Portfolio
NAS	Navigational Assistance Service
NCA	Norwegian Coastal Administration
NOAA	National Oceanic and Atmospheric Administration
NtM	Notices to Mariners
PAIR	Pre-Arrival Information Report
PAYS	Pay As You Sail
PBG	Pilot Boarding Ground
PI	Parallel Index
PNT	Position, Navigation and Timing
PPO	Port Paper Officer
PPU	Portable Pilot Unit
PSSA	Particularly Sensitive Sea Area
OOW	Officer of the Watch
OWS	Oily Water Separator
PWOM	Polar Water Operation Manual
QCPP	Queensland Coastal Passage Plan
RCDS	Raster Chart Display System
RCO	Risk Control Option
RNC	Raster Navigational Chart
ROC	Remote Operations Center
RTF	Real-Time Ferries

S/C	Staff Captain
SCC	Shore Control Center
SD	Sailing Directions
SMS	Safety Management System
SOG	Speed Over Ground
SOP	Standard Operating Procedure
STM	Speed to Make / Sea Traffic Management
T&P	Temporary and Preliminary Notices to Mariners
TOS	Traffic Organization Service
UCO	User Chart Object
UKC	Under Keel Clearance
VAIS	Vessel Arrival Information Sheet
VOM	Voyage Overview Meeting
VP	Voyage Plan
VPO	Voyage Planning Officer
VTSO	Vessel Traffic Service Operator
WOL	Wheel over Line
WOP	Wheel over Point
WP	Waypoint
WTD	Watertight door
XTD	Cross Track Distance
ZOC	Zone of Confidence

1 INTRODUCTION

1.1 Background

A well-made and comprehensive voyage plan is an imperative part of sailing a vessel from point A to point B. Every vessel excluding fishing vessels and pure recreational craft must have a proper voyage plan before departing from port. IMO regulates voyage planning to some extent in various codes, conventions and guidelines, that partly overlap, but it is left to the voyage planning officers to decide how to implement the regulations. Shipping companies' safety management systems give some guidance, depending on the company's size, traffic area and type of ships. Cruise ships generally try to follow rules rigorously and their SMS can be quite detailed in some respects, with voyage planning standards above those of cargo ships. In this paper the Carnival Corporation standards are used to illustrate how to achieve a high-quality voyage plan that fulfills the requirements.

Demands of voyage planning vary from ship to ship and from area to area. A ferry plying between the same two ports has no need to create new voyage plan regularly unless there are major changes e.g. in routeing; usually small amendments due to e.g. weather are sufficient. A small cargo ship in coastal trade needs to take into account ballast operations, but otherwise there are not many environmental discharge considerations. Cargo ships in worldwide trade have to consider weather routing[1] during the ocean passages, but they generally follow the regular shipping routes. On a cruise ship the voyage plans has to take into account factors that are not an issue on other types of ships. Today most of voyage planning is still done onboard by the navigation officer, on cruise ships in particular workload related to planning is quite high and some of it could be shared by shoreside resources.

In future when unmanned and autonomous vessels will become more common the voyage planning must be done shoreside by necessity. The topic of autonomous

[1] Weather routing: Optimizing the planned route based on weather data.

shipping goes beyond IMO's strategy of e-navigation, which is aiming for standardized integration of marine information[2], but the research will benefit greatly from the e-navigation concept.

European Maritime Safety Agency EMSA publishes Annual Overview of Marine Casualties and Incidents. According to the report published in 2019 there were 3174 occurrences reported in 2018[3]. Over half of the accident events (54.2%) with a ship[4] were related to issues of a navigational nature, such as contacts, grounding and collisions[5]. EMSA divides root causes to "accident events" and "contributing factors". During the period of 2011-2018 human action represented 65,8% of accident events, and 65% of events within human action category were related to shipboard operations[6]. Generally the mid-water phase of the voyage appears to be the most unsafe, but there is no statistics showing the phase per accident type, so at which stage accidents of navigational nature occurred is not known. However, 78% of the casualties were reported to have happened in internal waters.

There are no detailed statistics available as to how many accidents can directly be attributed to voyage planning[7], but it is safe to assume that inadequate voyage planning has caused or contributed to at least some of the grounding/stranding accidents. According to EMSA's Annual Overview "inadequate work methods" were the second most common contributing factor in all human action related accidents on cargo ships[8] with "lack of knowledge" and "lack of skill" contributing to over half of the accidents. On passenger vessels (including also small ferries on short domestic routes) "inadequate work methods" was by far the most common factor, with "lack of knowledge" and "lack of skill" contributing to roughly one third of the accidents[9].

2 IMO MSC 85/26/Add.1, Annex 20, 1.1
3 European Maritime Safety Agency Annual Overview of Marine Casualties and Incidents 2019, p. 8
4 Meaning that the nature of the accident was not a pure personal injury.
5 European Maritime Safety Agency Annual Overview of Marine Casualties and Incidents 2019, p. 8
6 European Maritime Safety Agency Annual Overview of Marine Casualties and Incidents 2019, p. 8
7 Haimila, Risto
8 European Maritime Safety Agency Annual Overview of Marine Casualties and Incidents 2019, p. 65
9 European Maritime Safety Agency Annual Overview of Marine Casualties and Incidents 2019, p. 104

Some accidents are caused by errors in the appraisal or planning stages where the voyage planning officer has missed some crucial piece of information. Sometimes it has been a question of incorrect ECDIS settings[10] which has led the officer to believe that the planned track is in safe waters, sometimes a change to regulations in the area of a previously acceptable track has not been identified. In some cases the problem could have been avoided by simply running the electronic route check function in the ECDIS, which would have highlighted the areas of concern.

Voyage planning-related accidents that happen during the execution and monitoring phases are likely caused by human error as opposed to technical problems. For instance, groundings can occur not only due to a faulty voyage plan or incorrect safety contour settings, but also because the OOW decided not to follow the existing plan taking a short cut instead without a proper check. Even if the vessel is sailing along the approved track inadequate monitoring by OOW can cause it to miss a turn at a waypoint putting the vessel in danger. Technical malfunction, such as black out or a steering gear failure, may cause groundings that cannot be prevented by proper voyage planning, even if all contingencies have been looked at.

1.2 Aim of the study

The objective was to describe the voyage planning process and factors that influence it to see how the process could be adapted in order to do part or all of the work shoreside. As some planning is already being done by shore-based personnel or artificial intelligence-aided software it was looked into how this type of voyage planning could be increased, and how likely it is to happen in the future. Development of autonomous vessels is well underway, and their voyage planning will be done shoreside by necessity. Although most of the MASS[11] development at this point

[10] In 2013 the chemical tanker Ovit grounded on the Varne Bank due to shortcomings in the voyage planning process. The track, which crossed over the bank, had been made by an inexperienced junior officer and was not checked by another person.

[11] Maritime Autonomous Surface Ships

concentrates on technical solutions some human involvement will be necessary for the operations in the future, how much will depend on the level of automation.

This thesis is a qualitative study written from the voyage planning officer's point of view, i.e. looking into what is required in practice to achieve a good professional voyage plan. This paper concentrates more on the appraisal and planning phases, as execution and monitoring, especially on MASS, can be more a question of available technology and equipment than human activity.

IMO and British Admiralty's documents and publications were used to define the regulatory framework governing the voyage planning process. Carnival Corporation's safety management system policies illustrate the demands a shipping company sets for a high-quality plan, and Holland America Line's (a Carnival Corporation operating line) voyage planning routines were used as an example of how a thorough passage plan is achieved in practice.

There is not research available on the voyage planning process itself, nor any statistics on how much time the voyage planning officers (VPOs) generally spend on different parts of appraisal and planning stages or how the demands for a voyage plan differ between ship types and trading areas. However, it is a fact that the demands vary greatly, and it can be assumed that VPOs on cruise ships with variable itineraries, plenty port calls and specific information requirements spend more time with the appraisal and planning stages compared to cargo vessels.

Although the practical planning process is not much studied, there are several research projects ongoing associated with e-navigation, and results from some of them were available. Autonomous ships and AI-aided planning are being developed by several actors worldwide, but the amount of published material is often in form of short presentations or papers, and a lot of it is related to pure technological matters not directly interesting from the voyage planning officer's point of view.

The intention was to visit companies that provide and develop products like software for AI-aided planning or autonomous vessels to see how the products work in real-life and what kind of advantages they have over conventional equipment, or problems they might cause for voyage planning officers. Unfortunately the coronavirus pandemic during spring 2020 did not allow this so instead the information was gathered mainly from internet sources and interviews. This naturally limits the type of information obtainable as it is hard to describe a complex product without actually seeing it and having an opportunity to get hands-on experience.

2 REGULATORY FRAMEWORK

IMO regulations are the main source for principles concerning voyage planning. SOLAS, STCW and Polar Code give very general guidelines for voyage planning, but do not go into any details on how to achieve a good plan. IMO Guidelines for Voyage Planning is more detailed outlining minimum requirements, but no examples or practical guidance on how to do it are included. British Admiralty's publications NP231 and NP232 go more in depth and are generally used as examples of good voyage planning although they do not have a regulatory status. Safety management systems govern voyage planning in individual companies, and it is up to the company to decide how detailed instructions they want to include in addition to minimum requirements set by the regulations. The flag states are responsible for controlling their ships' adherence to carriage requirements. In Finland the only mention of voyage planning in the maritime law[12] is a direct translation of SOLAS Regulation 34, excluding the reference to IMO Guidelines for Voyage Planning.

In the future with the development of autonomous vessels some of the regulations will need to be amended to suit the new reality. Although the main objectives of a voyage plan will remain the same, the way safety and efficiency are reached will be somewhat different which will be reflected in the voyage plan and should therefore be also reflected in the regulations.

2.1 SOLAS

Voyage planning is mentioned shortly in SOLAS Chapter V *Safety of Navigation*. Regulation 2 defines the nautical chart. Regulation 19 *Carriage Requirements for Shipborne Navigational Systems and Equipment* requires all ships to have "nautical charts and publications to plan and display the ship's route and to plot and monitor positions throughout the voyage"[13].

12 Maritime Law 6 chapter 3 a §
13 SOLAS Regulation 19.2.1.4

Voyage planning as such is not mentioned in Regulation 27 *Nautical Charts and Nautical Publications*, but the regulation talks about carriage requirements for sources of information essential for voyage planning: "Nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage, shall be adequate and up to date"[14].

Regulation 34 *Safe Navigation and Avoidance of Dangerous Situations* requires that "the master shall ensure that the intended voyage has been planned using the appropriate charts and publications taking into account the guidelines and recommendations developed by IMO". Here a direct reference is made to IMO Resolution A.893(21) *Guidelines for Voyage Planning* as the guidelines to be followed.

Further it is said that "*the voyage plan shall identify a route which takes into account any routeing systems, ensures sufficient sea room throughout the voyage, anticipates all known navigational hazards and adverse weather conditions, and takes into account environmental protection measures*"[15].

2.2 STCW

In STCW voyage planning is mentioned in Part A Chapter II and Chapter VIII. In Part B the *Guidance regarding the use of simulators* sets the requirements for ECDIS training, in addition to recommendations on what deck officers should know in effect to cover all aspects of voyage planning.

Part A, Chapter II – Standards regarding the Master and Deck Department
Table A-II/1 Navigation at the Operational Level
All deck officers should be able to plan and conduct a passage and determine position. Thorough knowledge of and ability to use nautical charts and publications is required,

14 SOLAS Regulation 27
15 SOLAS Regulation 34

together with ability to determine the ship's position using electronic navigational aids and use of ECDIS to maintain the safety of navigation. Further they should be able to maintain a safe navigational watch, including knowledge of routeing systems, reporting and the use of information from navigational equipment.

Table A-II/2 Navigation at the Management Level

Officers at the management level must be able to plan a voyage and conduct navigation for all conditions by acceptable methods of plotting ocean tracks, taking into account for example restricted waters, meteorological conditions, including ice and restricted visibility, TSS, VTS and areas of extensive tidal effects. They must be able to determine the ship's position and the accuracy of the fix.

Criteria for evaluating competence mentions for example that the planned route needs to be supported by facts and statistical data obtained from relevant sources and publications. All potential navigational hazards need to be accurately identified.

Part A, Chapter VIII – Watchkeeping

Section A-VIII/2 Watchkeeping arrangements and principles to be observed

As per Part 2 – *Voyage planning* the master shall ensure prior to each voyage that the intended route is planned using adequate and appropriate charts and publications. All relevant information must be taken into consideration and be up to date. The route shall be clearly displayed and be available at all times to the OOW. If a deviation from planned route is necessary, the amended route shall be planned prior to deviating.

In Part 4 – *Watchkeeping at sea* several references are made to the requirement to properly monitor the ship's progress.

Part B of STCW *Recommended Guidance* gives more detailed recommendations additional to mandatory standards in Part A for knowledge and skills that deck officers should attain, covering the aspects relevant to all stages of voyage planning.

2.3 IMO Guidelines for Voyage Planning

The most important regulation governing voyage planning is IMO Resolution A.893(21) – *Guidelines for Voyage Planning*. IMO Guidelines is more detailed than STCW and SOLAS, and it lists items that need to be taken into account, but it does not give any examples on how to achieve the required result.

According to the IMO Guidelines the objectives for a voyage plan is "*the development of a plan for voyage or passage, as well as the close and continuous monitoring of the vessel's progress and position during the execution of such a plan*" to ensure "safety of life at sea, safety and efficiency of navigation and protection of the marine environment"[16].

The Guidelines divides voyage planning into four stages:

2.3.1 Appraisal Stage

Appraisal means gathering all information relevant to the contemplated voyage. Information that should be considered includes e.g.:

- The condition and state of the vessel;
- Up-to-date certificates and documents;
- Appropriate scale, accurate and up-to-date charts as well as any relevant notices to mariners and navigational warnings, including accurate and up-to-date publications;
- Meteorological information including availability of services for weather routeing;
- Ships' routeing and reporting systems, vessel traffic services, and marine environmental protection measures;
- Volume of traffic likely to be encountered throughout the voyage;

[16] IMO Resolution A.893(21) – Guidelines for Voyage Planning 1.1

- If a pilot is to be used, information relating to pilotage and embarkation and disembarkation;
- Available port information, including information concerning the availability of shore-based emergency response.

2.3.2 Planning Stage

Planning stage means detailed planning of the whole voyage from berth to berth, including pilotage areas based on the fullest possible appraisal. The detailed voyage plan should include for example the following factors:

- Plotting of the intended route on appropriate scale charts. All areas of danger, existing ships' routeing and reporting systems, vessel traffic services, and any areas where marine environmental protection considerations apply should be indicated;
- The main elements to ensure safety of life at sea including safe speed, proximity of navigational hazards, the maneuvering characteristics of the vessel and its draft in relation to the available water depth;
- Necessary speed alterations, e.g. due to tidal restrictions, or allowance for the increase of draught due to squat and heel effect when turning;
- Minimum UKC;
- Course alteration points, taking into account turning circle at the planned speed and any expected effect of tidal streams and currents;
- The method and frequency of position fixing, including primary and secondary options, and the indication of areas where accuracy of position fixing is critical;
- Use of ships' routeing and reporting systems and vessel traffic services;
- Considerations relating to the protection of the marine environment;
- Contingency plans, alternative action to place the vessel in deep water or proceed to a port of refuge or safe anchorage in the event of any emergency necessitating abandonment of the plan, taking into account existing shore-based emergency response arrangements and equipment and the nature of the cargo and of the emergency itself.

The details of the voyage plan should be clearly marked and recorded on charts and in a voyage plan notebook. Each voyage plan as well as the details of the plan, should be approved by the ship's master prior to the commencement of the voyage.

2.3.3 Execution Stage

After finalizing the voyage plan the voyage should be executed in accordance with the plan. Factors which should be taken into account when executing the plan, or deciding to deviate from it, include:

- The reliability and condition of the vessel's navigational equipment;
- Estimated times of arrival at critical points;
- Meteorological conditions, (particularly in areas known to be affected by frequent periods of low visibility) as well as weather routeing information;
- Daytime versus night-time passing of danger points, and any effect this may have on position fixing accuracy;
- Traffic conditions, especially at navigational focal points.

It is important for the master to consider whether any particular circumstance, such as the forecast of restricted visibility in an area where position fixing by visual means at a critical point is an essential feature of the voyage or passage plan, introduces an unacceptable hazard to the safe conduct of the passage; and thus whether that section of the passage should be attempted under the conditions prevailing or likely to prevail. The master should also consider at which specific points of the voyage or passage there may be a need to utilize additional deck or engine room personnel.

2.3.4 Monitoring Stage

Monitoring of the progress of the vessel in the implementation of the plan. The plan should be available at all times on the bridge to allow officers of the navigational watch immediate access and reference to the details of the plan. The progress of the vessel in accordance with the voyage and passage plan should be closely and continuously monitored. Any changes made to the plan should be made consistent with these guidelines and clearly marked and recorded.

In addition to Resolution A.893(21) IMO has published supplementary guidelines for passenger vessels: Resolution A.999(25) – *Guidelines for Voyage Planning for Passenger Ships Operating in Remote Areas*. It was developed "in order to prevent incidents of groundings and collisions, and thereby enhance safety of life at sea".[17] It includes additional factors that ships operating in remote areas should include in their voyage planning, although all of these are things that should be considered in any area on any ship, not only passenger ships sailing in remote areas.

According to Resolution A999(25) the following factors are to be included in appraisal stage[18]:

- The source, date and quality of the hydrographic data on which the charts to be used are based;
- Limitations on available maritime safety information (MSI) data and Search and Rescue resources;
- Availability or lack of aids to navigation;
- Places of refuge.

If the ship is operating in Arctic or Antarctic waters the voyage plan should consider also the following factors:

- Knowledge of ice and ice formations, in order to be able to navigate in ice, and how environmental conditions relating to current, wind, calm weather, fog and different seasons affect the ice and navigation in ice;
- Current information on the extent and type of ice and icebergs in the vicinity of the intended route, and statistical information on ice from former years;
- Operational limitations in ice-covered waters;
- Availability and use of ice navigators.

17 IMO Resolution A.999(25) – Guidelines for Voyage Planning for Passenger Ships Operating in Remote Areas
18 IMO Resolution A.999(25) – 2.1

During the planning phase the following factors should be considered:

- Safe areas and no-go areas;
- Surveyed marine corridors, if available;
- Contingency plans for emergencies in the event of limited support being available for assistance in areas remote from SAR facilities.

In Arctic or Antarctic waters the voyage plan needs to address conditions when it is not safe to enter areas containing ice or icebergs because of darkness, swell or fog, safe distance to icebergs, and presence of ice and icebergs, and safe speed in such areas.

When executing the plan the vessel should "report changes to a previously advised plan to the relevant authorities"[19]. When operating in Arctic or Antarctic waters the ship should consider existing ice conditions and measures to be taken before entering ice waters, e.g., an abandon ship drill and preparation of special equipment.

2.4 Polar Code

Like all the other IMO Codes the Polar Code does not include any detailed instructions for voyage planning. Chapter 11 gives general guidelines for voyage planning in polar waters with emphasis on the special nature of the polar areas. Most of the requirements are basically same as in the Resolution A.999(25) – *Guidelines for Voyage Planning for Passenger Ships Operating in Remote Areas*, which is also referred to in Polar Code Chapter 11. In addition to requirements in other IMO documents the Polar Code specifically mentions avoidance of marine mammals and designated protected areas[20]:

- current information and measures to be taken when marine mammals are encountered relating to known areas with densities of marine mammals, including seasonal migration areas

[19] IMO Resolution A999(25) – 4.1
[20] IMO Polar Code Chapter 11, .6-.8

- current information on relevant ships' routing systems, speed recommendations and vessel traffic services relating to known areas with densities of marine mammals, including seasonal migration areas
- national and international designated protected areas along the route

Hazards specific to polar areas include the effects of ice and low temperatures (such as stability, emergency preparedness and equipment performance), remoteness (in terms of lacking SAR facilities, and possible lack of adequate hydrographic data and navigational aids), rapidly changing and severe weather conditions, and environment that is sensitive to harmful substances and other environmental impacts. These hazards, among other things, must be considered when making the ship-specific Polar Water Operational Manual (PWOM). Operational assessment of the ship and its equipment is carried out taking into consideration the operating area and the time of the year, and risk assessment is done. The master is required to take into account procedures required by the PWOM.

2.5 MSC.1/Circ.1184 Enhanced Contingency Planning Guidance for Passenger Ships Operating in Areas Remote from SAR Facilities

As contingency planning is part of making a voyage plan the MSC Circular 1184 is relevant to those passenger ships operating in remote areas. It is a short document that defines criteria for determining what can be considered an area remote from SAR facilities and reminds of the need to assess and plan for risks of remote area operation. The circular gives recommended enhancements that should be considered when planning for a remote area, including:

- voyage pairing, i.e., mutual exchange of information, so that, if two or more passenger ships are operating in the same general area at the same time, each can be used as a SAR facility in case of accident to another
- the carriage of enhanced life-saving appliances
- the provision of additional life-saving resources

2.6 ISM

The ISM Code does not expressively mention voyage planning, but it refers to same objectives mentioned also in IMO Resolution .893(21) – *Guidelines for Voyage Planning.* According to ISM the company should clearly define and document the master's responsibility with regard to for example implementing the safety and environmental protection policy of the company and verifying that specified requirements are observed. Concerning with shipboard operations the Company should establish procedures and instructions, including appropriate checklists, for "key shipboard operations concerning the safety of the personnel, ship and protection of the environment"[21]. The various tasks should be defined and assigned to qualified personnel.

2.7 Other sources

In addition to IMO codes and guidelines there are other documents governing the voyage planning process. Deck officers must comply with the company Safety Management System (SMS), whereas British Admiralty publications do not have a regulatory status and are for guidance only. However, the BA publications go more into detail than any of the other documents and being of high quality their advice is usually followed.

2.7.1 NP231 Guide to the Practical Use of ENCs

Chapter 6 of NP231 discusses voyage planning with ECDIS. During appraisal the voyage planning officer should consider for example ENC coverage (including appropriate scale and up to date ENCs and ENC accuracy), AIO, Readme text file, weekly NtMs and T&Ps.

[21] ISM Code Part A-07 Shipboard Operations

When planning the voyage NP231 advices to check ENC display settings and scale. Safety settings needs to be determined, the recommendation is to always set safety contour and depth, cross-track distance (XTD) and look-ahead sector; deep and shallow water contours should be set. Routes must be checked both electronically and visually as the electronic check does not provide an automatic alarm for everything. Correct contour settings, XTD and radius should be also checked visually.

For execution and monitoring NP231 recommends using proper alarms and indications, look-ahead settings and appropriate display settings (text is recommended to be kept at minimum, displaying only the immediately relevant information). Monitoring the overlay is a useful tool, if radar and chart display shows good alignment all systems are performing correctly, but visual position checks (LOP) should also be used.

2.7.2 NP232 Guide to ECDIS Implementation, Policy and Procedures

Another BA publication, NP232, goes more into detail than NP231. It gives examples and recommendations on how to solve issues arising during the voyage planning process.

Appraisal stage is defined as the responsible officer identifying all the essential information so that any gaps can be filled, and risks can be assessed and mitigated. All necessary information sources should be taken into account and the goal is to identify all dangers to navigation, determine the full extent of safe water, locate routeing, reporting schemes and VTS, note any environmental areas, and identify sources of information that require updating. The basic structure of appraisal procedure is to gather all information available that will influence the plan, assess the information, identify associated risks and any shortfalls to be resolved, and put in place a procedure to obtain updates to data already held. As part of the appraisal process appropriate ENCs are selected, ordered and updated; T&P, AIO, navigational warnings, Readme and Section VIII updates to admiralty digital products and services are checked. The responsible officer must understand the limits of ENC accuracy and know how to use associated software such as digital chart catalogue, updating and folio management service, weather prediction programs, and voyage optimization tools.

Planning should be done berth to berth, taking into consideration vessel's characteristics (UKC, air draft, turn radius). ZOC is to be verified and scale minimum set off for planning, pick report is to be utilized. If the officers onboard have previous knowledge of the area it should be used, any other local knowledge should be gathered from available sources (such as SD, pilot or port assessment). Safety parameters are decided. NP232 introduces two methods for crossing the safety contour: safety contour is left as it is and own safety line is used around safety depth, or alternatively the safety contour is set lower than safety depth, which brings up the issue of isolated dangers not being highlighted. Chart alarms should be chosen to give time to investigate; NP323 recommends 1-2 min in channels, 12-15 min in coastal waters and 30 min on ocean. Details can be added to ECDIS as UCOs. When the plan is ready it needs to be reviewed by running a second person check, finalizing the output and making changes if required. For monitoring NP232 recommends constantly checking that all equipment operates correctly and performing cross checks.

2.7.3 Carnival Corporation Safety Management System

Carnival Corporation's safety management system (HESS-MS) includes several policies that govern the voyage planning process on the corporation vessels. All deck officers must be familiar with the policies, and these policies are also taught at CSMART, the Carnival Corporation's simulator training center in Almere, Netherlands. The most important is the marine policy *Voyage Planning*, which summarizes the IMO Guidelines and NP232 setting the minimum standards for a voyage plan. *Voyage Plannin*g defines the voyage planning process as the process of gathering information relevant to the voyage, including ascertaining risks and assessing its critical areas. The voyage must be developed and documented in at least three sections: departure, sea passage, and arrival. The Voyage Planning Officer (VPO) is required to develop a navigational strategy to ensure safe and efficient navigation from berth to berth, incorporate environmental restrictions and support decision-making process.

The voyage planning policy includes a planning checklist, a safety depth calculation form and a template for environmental schedule. All the checklists and templates in the policy must be used by all Carnival Corporation ships and the ships are not allowed to make their own modifications. As Carnival Corporation ships are engaged in a variety of itineraries worldwide ranging from 7-day cruises from the same port all year round to 3-month expedition cruises sailing round the globe it is obvious that the same templates do not fit everybody. This creates extra work for the officers involved in voyage planning as they need to work around the problems and try to create something that works for their ship, but still complies with the SMS. The reason behind the corporation's reluctance to allow ship-based templates for environmental schedules is to reduce the amount of non-compliant discharges.

In addition to *Voyage Planning* there are references to voyage planning in at least fifteen other policies varying from sailing in whale waters (*Marine Mammal Avoidance*) to managing the waste streams on board (*Intact Stability Management*). Most of the regulations are quite self-evident and should be considered in any case during the voyage planning process as part of good seamanship like the requirement to have up-to-date charts (*Chart and Publications Management*) or to actively monitor warnings received and take action if needed (*Company Navigational and Watchkeeping Orders*). However, some of the policies do point out things that are not encountered regularly such as parametric/synchronous rolling[22] to be taken into account during the execution phase (*Heavy Weather*), or give detailed parameters to be used such as anticipated potentially hazardous conditions (*Watertight Door Management*)[23] and position fixing frequency when using paper charts (*Company Navigational and Watchkeeping Orders*).

[22] Parametric rolling: Phenomenon occurs when seas are coming from bow/stern and variations in stability moment causes large roll angles. Synchronous rolling: Phenomenon occurs with seas from abeam causing the vessel's natural rolling period to equal the period of the waves resulting in heavy rolling with the possibility of capsizing.

[23] The list of conditions that can be defined as potentially hazardous includes for example UKC being less than twice the draft, which affects the WTD schedule for example in the Southern Baltic and needs to be addressed during the planning stage.

HESS-MS includes also several policies governing discharges and actions expected from deck and technical officers regarding the environment. *Worldwide Cruising Environmental Standards* sets the minimum limits for all discharges. The environmental matrix attached to the policy lists all the countries and areas the corporation vessels are sailing in indicating which discharges are allowed under which conditions, the matrix is used daily on board in all stages of voyage planning. It also includes marine sanctuaries and other special areas which have stricter limitations than the surrounding waters.

Although many of the policies refer to the planning stage of voyage planning, several are applicable to execution and monitoring phases as well and all deck officers are required to be familiar with these policies such as *Deck Officer Environmental Responsibilities* and *Ballast Water Management*.

3 VOYAGE PLANNING ON CARNIVAL CORPORATION SHIPS

In this paper the Carnival Corporation standards are used as an example of the voyage planning process. Carnival Corporation is the world's largest travel leisure company with over 100 ships, all of which follow the same general voyage planning policies described here. There are some small differences between operating lines and here reference is made to Holland America Group's (HAG) routines (including Holland America Line, Seabourn, Princess and P&O Australia). Although all planning is done using the same guidelines and policies the Carnival Corporation recognizes that individual ships' needs may differ due to e.g. sailing area, and they allow some leeway for the voyage planning officers by saying that each voyage planning officer shall develop their own navigational strategy[24]. This leads to some differences between ships even within the same operating line in how the planning process proceeds and how the information is presented. Therefore the process described in this paper represents only author's own experience from five HAG vessels and may not be identical to the way the planning is done on some of the other company vessels.

The process of voyage planning is extensive and very time consuming, and especially on ships with varied itinerary the Navigation Officer, who is also the voyage planning officer (VPO), is not doing full time watchkeeping if possible, to enable them to have enough time for the planning. The Navigation Officer is a 2nd Officer (a senior watchkeeper with the minimum of Chief Officer's license) who has one or two 3rd Officers and sometimes a cadet as assistant(s). The VPO usually does all the pre-planning from appraisal to making the track, with the assistant navigation helping with tidal information, voyage and port notes, and schedules in addition to other duties that belong to the team navigation. Tasks related to voyage planning can be divided in different ways depending on e.g. itinerary, workload, the number of people in the team and their level of experience. The Navigation Officer is the leader of the team navigation and it is left to their discretion how to allocate the tasks.

[24] HESS-MS Voyage Planning

3.1 Sources for appraisal

As per voyage planning policy the VPO "must conduct a full appraisal of the intended voyage before beginning the planning phase". *Appraisal and planning checklist* (see Appendix 1) must be used to ensure that all aspects are covered. "*Appraisal should provide clear indication of all areas of danger, areas where it will be possible to navigate safely, any routing, reporting and VTS systems, any areas where marine environmental protection consideration apply*"[25].

Planning is a long process, the tracks are made generally between three months and one year before sailing, with additional information such as berth information added closer to the actual cruise. Although voyage planning is described as a straight forward linear process (appraisal-planning-execution-monitoring), in real life it is more of a circular process, with some appraisal going on during the planning stage as the plan gets revised, and some planning done during the execution phase if a need arises to modify the plan.

If the ship has been sailing in the same area for some time already and a new port is added to the itinerary, the task is not very demanding, but repositioning to a whole new area puts more strain on the planning. Sometimes a ship visits a port where no other company ship has been before, and that generally requires quite some extra work in the appraisal stage to enable the VPO to ensure that it is possible and safe to visit the port with a cruise ship.

3.1.1 Official sources

The first source used in appraisal is usually ECDIS. Carnival Corporation sets minimum standards for ECDIS settings for appraisal and planning stages (the terms may vary between ECDIS manufacturers)[26]:

25 IMO Resolution A.893(21) – Guidelines for Voyage Planning 2.2
26 HESS-MS Voyage Planning

- Appropriate scale
- Visibility group set to “ALL”
- Appropriate safety depth/contour for each leg
- Shallow water danger “ON”
- AIO[27] “ON”
- Update review
- Date dependents objects within execution date
- Accuracy symbols on when appraising chart accuracy
- Ignore scale minimum “ON”[28]
- Scale dependent objects “ON”
- Track limit for each leg

Looking at the area gives a general idea what can be expected; if it is confined waters with many restrictions, or a relatively simple open sea passage from pilot to pilot. Admiralty Information Overlay (AIO) is a useful tool, but it is being used less and less as most countries include T&Ps[29] in the ENC updates and do not publish AIOs anymore, this is why it is important to check “Update Review”. Safety notices such as Readme file or Section VIII must be checked, since they contain information for example about cancelled ENCs or errors in cells that might be relevant. Navigational warnings and local Notices to Mariners are important, but they are usually reviewed during the planning stage and again closer to the actual sailing date.

Most ships today use the British Admiralty’s digital publications ADP and E-NPs, and these provide a large part of the information needed for a voyage plan, but local publications are needed. In Australia the Seafarers Handbook for Australian Waters provides information not available in BA sources and in the USA local pilot books are often used in addition to BA Sailing Directions. Mariner’s Handbook NP100 provides

[27] Admiralty Information Overlay shows Temporary and Preliminary Notices to Mariners as an overlay on the ENC.
[28] Ignore Scale Minimum must be “OFF” when checking the chart coverage. If SCAMIN is left “ON” the over scale alarm is not activated and the jail bars do not appear, and the VPO will have no indications that the ENC compilation scale is not suitable for navigation.
[29] Temporary and Preliminary Notices to Mariners indicate non-permanent changes to charts and ENCs.

general information on e.g. ice and weather. Routeing charts and NP136 Ocean Passages for the World can provide some information for ocean crossings.

BA publications are generally of high quality, but when sailing in more exotic parts of the world the VPO needs to bear in mind that the BA publications can often be not only inadequate but also downright faulty, and the information needs to be double checked from another source whenever possible. There can be errors in the BA publications even when sailing in European waters, although this is not very common.

Security related information in general comes from the BA Maritime Security Charts (Q Series) and for reporting from ADRS. The company provides the ship with security information about the ports and this is communicated to the VPO via Security Officer when applicable. If any planned ports of call have serious concerns about security, the company most likely will cancel the call, or if the ship visits the port then usually shore leave is not allowed and only organized shore excursion tours will take place. Often cancelling is a result to a last-minute change due to a terrorist attack or a coup, which does not give the VPO much time for planning. Sometimes the company will inform the ship about alternative port or the call is just cancelled, and the ship will proceed to the next port of call, but sometimes the Master and VPO must try to search for a substitute.

3.1.2 Internal sources

Past experience is one of the easiest tools for the VPO to use. Officers transfer from ship to ship occasionally and unless the ship is sailing in a less frequented area, there is often somebody on board who has previous experience of the area. When a ship is scheduled to go to a place where it has never sailed before, the VPO usually checks which ships have been there and asks for tracks and other information directly from the other Navigation Officers.

Holland America Group has an internal Marine Information Network (MIN) which is a useful tool including many things relevant to voyage planning. If a new port is added to company itinerary somebody from the office will visit the port to conduct a port assessment prior to the first call. When the first ship calls the port, the VPO will fill in a port visit report and send it to the office. These assessments and reports are made available to all HAG ships via MIN. Any ship can send in reports and pictures of a port any time and are encouraged to do it if they find that any information has changed. These reports are quite useful to VPOs planning for the same area as they are made by cruise ship officers and can give relevant information not available anywhere in other sources[30]. When a ship visits a tender port for the first time the company asks them to provide a tender ride video, which can be used in tender briefings on other ships.

Although port information is the most important part of MIN, there are also passage notes for some areas highlighting the special features. The Carnival Corporation's simulator training center CSMART has conducted port studies for some of the more frequently visited ports or ports that are considered difficult, and these studies can be also found in MIN. The voyage planning policy requires the VPO to check these port studies if planning for any of these ports[31]. The ships' itineraries are published in MIN and the schedules also list if the port is a tender port or if the ship is docking. This is not always correct, and if other sources indicate differently the VPO needs to check which one is applicable as other departments, such as Shore Excursions, rely on information from the VPO when planning their operations.

The most important sources for environmental regulations are MARPOL and *Worldwide Cruising Environmental Standards*, known as "the environmental matrix", which is updated monthly and lists discharge and emission regulations per country, including notes on marine sanctuaries and other special areas, sometimes providing coordinates for these areas. More and more countries claim an archipelagic baseline, which is often not marked in ECDIS, but the environmental matrix lists only undisputed baselines. Many ships opt to follow also disputed baselines to avoid any possible repercussions with the authorities of the country, and coordinates for these

30 One report on Petropavlovsk, Russia, warned that immigration on arrival took so long that it had not finished by the time the ship was scheduled to sail so nobody was able to go ashore. When arrival clearance was finally finished (a couple of hours after scheduled departure in late afternoon), the departure clearance was started and the whole process took so long into the night that the vessel had to cancel also the next port of call because of the delay.

31 HESS-MS Voyage Planning

baselines need to be obtained from either the UNCLOS website or the US Navy Maritime Claims Reference Manual, which includes also charts if available. Even if the country claims only a normal baseline from the low water mark it is not always simple to determine where their territorial waters end as the width of territorial waters can vary, 12NM being the most common. If the neighboring country is close (less than 12NM) the VPO must try to find out the exact coordinates of the border as ECDIS does not usually provide that. A website called Marine Regions is normally used for checking the territorial waters and EEZ. Although Marine Regions does not provide a list of coordinates for the boundaries, it gives a good visual overview that often enables the VPO to determine the limits.

HESS-MS gives guidance for marine mammal avoidance and policy *Marine Mammal Avoidance* lists areas where a speed limit or other local regulations concerning whales exist, including links to websites for detailed regulations. A speed limit of 10kn is the standard around the world in areas where a heavy concentration of whales can be expected. In some places the speed limit is a recommendation, like Hauraki Gulf, in others, such as Gulf of St. Lawrence, it is strictly enforced with a substantial fine (in some cases up to tens of thousands of dollars) if the ship's speed exceeds the limit with as much as a tenth of a knot[32]. The HESS-MS policy does not list all whale areas, and the VPO needs to check other sources to make sure that the regulations are followed. For example the Gulf of Panama has a seasonal speed limit, which is not mentioned in any BA publications or *Marine Mammal Avoidance* but can be found by interrogating the ECDIS.

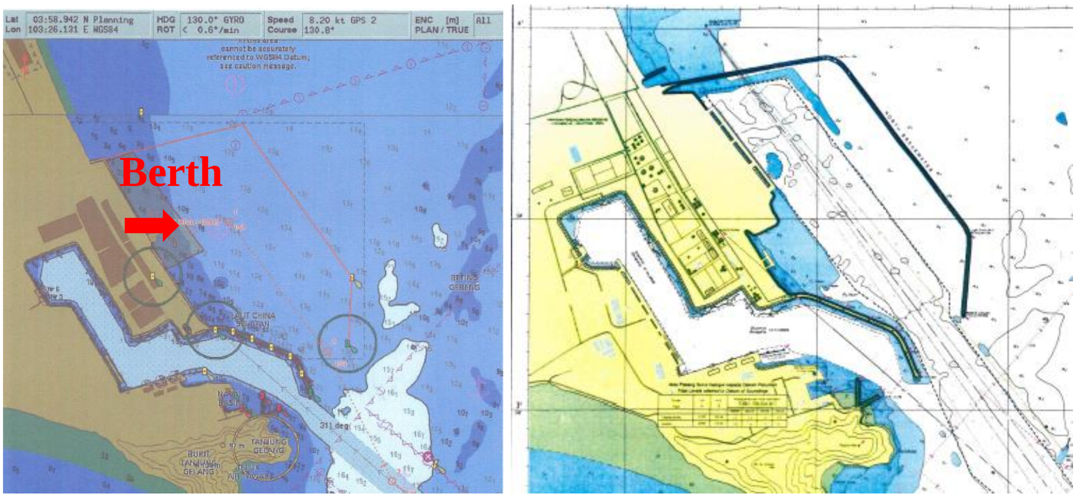
3.1.3 External sources

For many ports in regularly visited areas the official sources listed here are sufficient for a proper appraisal, but often the VPO needs to dig deeper to make sure that all aspects are covered. FindaPort program (previously known as Guide to Port Entry) includes some information not found in Sailing Directions and can give indication e.g.

32 Transport Canada www.tc.gc.ca/en/services/marine/navigation-marine-conditions/protecting-north-atlantic-right-whales-collisions-ships-gulf-st-lawrence.html (Referred 13.5.2020)

for the expected berth. If the ship has not visited the port before, the VPO usually sends the agent a port questionnaire with questions on e.g. dock, gangway and tugs. Often the agent is able to provide details about the port not available in other sources, such as compulsory tugs, dock height, location of the tender pier or even local tide tables, which can sometimes differ from the ATT. Some local regulations, reporting requirements and speed limits may not be mentioned in ADRS or SDs and the VPO must rely on the agent to provide this information or search for the information on the internet. For example in Singapore Cruise Bay the ships with an air draft exceeding 45m must stop before entering the channel to undergo a manual air draft check, since they have to pass under a cable to reach the dock, but there is no mention of this in any BA publication. Port visit reports in MIN often bring up regulations like this giving the VPO an indication to check with the agent.

When calling a port that is still under construction or newly finished the official sources often do not have much, if any, information at all, and in some cases the port does not even exist according to BA publications. It has happened that according to official ENC there is open water where in fact a fully operational port exists. If it is a question of a last-minute change to the itinerary there is no time to search for local paper charts, and then the only alternative is to use unofficial charts (such as iSailor application) or rely on the pilot and information received from the agent.



Official ENC (UCOs added by VPO) Scanned copy of a local chart provided by the pilot

Figure 1. Port of Kuantan, Malaysia (February 2019)

The importance of the internet as a source is constantly increasing. Especially in western countries many VTS, ports and pilot associations have their own websites with e.g. local regulations, dock information and passage plans that the official sources do not mention at all, but which are important for ships to know. The agent may provide this kind of information of their own accord, but they do not always do that and in that case the VPO needs to either ask for the information or find it some other way. Most local regulations are not found in BA publications, and although a few (e.g. US Rules and Panama Canal Regulations) can be obtained as a hard copy from the chart provider, normally downloading them is the only option. This also ensures that the latest version is used, for instance, Panama Canal Authority publishes Notices to Shipping and Advisories to Shipping which cannot be obtained in any other way.

Although most of the sources provided by government agencies and hydrographic offices must be obtained from the chart provider, there are also some official sources available in the internet free of charge. For example, the US National Oceanic and Atmospheric Administration (NOAA) offers US Coast Pilots (equivalent to BA Sailing Directions) for download via their website for no cost. ENCs are also available, as well as RNC, although raster charts are being gradually phased out[33].

Internet is not useful only for port information but can also provide real time weather information e.g. at a pilot station, and also tide and current information not obtainable anywhere else[34]. ADRS provide time zones and local time information, but the data is not presented in a very user-friendly way and finding a correct time zone for the more obscure ports can be challenging. That is why many VPOs use time and date websites which give an easier overview of e.g. daylight-saving times etc. and double check the information from ADRS 2. However, when using the internet as a source the VPO must be critical as to reliability of the information. Most of the information is accurate,

[33] https://www.nauticalcharts.noaa.gov/ (Referred 2.6.2020)

[34] For example ships sailing to Montreal need to pass under a bridge in Quebec City, but the passage cannot be made at high water as the bridge is quite low. The water level in the St. Lawrence River at Quebec City is not influenced only by the tide, but also by e.g. rainstorms or melting snow which can raise the water level, and tidal data is not sufficient alone to determine the time window for the passage. A Canadian website gives dynamic water level information and provides a dynamic vertical clearance calculation with 15 minutes interval, so that ships can plan what time it is possible to pass under the bridge.

especially on official government or port websites, but there is a chance that incorrect or outdated information is included.

Sometimes there can be a lot of information available e.g. on a port website, or the agent sends several documents to the ship, but although English is the international language of shipping it does not mean that non-western countries are willing to accommodate to the fact, and they can happily send information like this, which is quite useless to the VPO unless they happen to be Japanese:


小型船公共係留施設(水深−1.5m以深)

地区名	施設名	水深(m)	延長(m)	バース数	完成年度
屋島	浜北物揚場	-3.0	75	-	S37
朝日	G地区(-4m)物揚場	-4.0	416	-	S61
	朝日町(-3m)物揚場	-3.0	31	-	S35
	F地区取付物揚場	-4.0	50	-	S51
	F地区(-4m)物揚場	-4.0	357	-	S50
	福岡町桟橋	-1.5	90	-	H4
	朝日町桟橋	-1.5	210	-	S62
玉藻	城東町1号物揚場	-1.5	180	-	S3
	城東町2号物揚場	-3.0	128	-	H18
	城東町横桟橋	-3.0	237	-	H19
	城東町(-3m)物揚場	-3.0	103	-	S46
	本町物揚場	-3.0	187	-	S56
	北浜町横桟橋	-3.0	92	-	H18
	北浜フェリー岸壁物揚場	-3.0	51+20	-	S34
	玉藻町第1物揚場	-3.5	304	-	S22
	玉藻地区県営第1浮桟橋	-3.0	100	4	H11
	県営第2浮桟橋	-5.0	110×2	2	H22
	玉藻地区(-4m)物揚場	-4.0	105	-	H11
	玉藻地区(-3m)物揚場	-3.0	75	4	H11

Figure 2. Port information from the agent in Takamatsu, Japan

3.2 The appraisal process

Planning is a long process, the tracks are made generally between three months and one year before sailing, with additional information such as berth information added closer to the actual cruise. Although voyage planning is described as a straight forward linear process (appraisal-planning-execution-monitoring), in real life it is more of a circular process, with some appraisal going on during the planning stage as the plan gets revised, and some planning done during the execution phase if a need arises to modify the plan.

3.2.1 Sailing area and chart coverage

The appraisal stage usually begins with the VPO taking a look at the general area of the intended cruise to see where the ship is supposed to go. The official itineraries are published ca. one and half years before the cruise, but they give only the name of the port and the country/province it is located in. On the company website there is an overview map showing the approximate location of the ports, but it is for advertising purposes only and does not give any detailed information relevant for the VPO. Some of the more obscure ports of call are not mentioned in any BA publication and often Google Maps is the best source to find the exact location of the port.

When the area of the cruise is identified, the next step is to check the chart coverage. Depending on the ECDIS manufacture and the chart provider, new ENC cells may need to be ordered if the ship is repositioning to a new area. Nowadays all ships use PAYS (Pay As You Sail), which gives the possibility to have all the ENCs in the world installed in the ECDIS as the user only pays for the cells they sail through, but in reality ships install only those cells they need for sailing and planning purposes. ECDIS do not generally have the capacity to store all the world's ENCs, and as the HAG's chart provider Marine Press of Canada (MP) has a fairly complicated way for managing and updating the ENC library, it is preferable to keep only the cells required, which means that new cells need to be ordered regularly and old cells cancelled, if the ship has a varied itinerary.

Still today in many parts of the world the ENC coverage is inadequate or non-existing and Raster Navigational Charts (RNCs) are needed. If RNCs are required for a larger area or in large scale, then equivalent paper charts must be ordered as backup as per Carnival Corporation policy[35]. This needs to be done although all RNCs are installed on all ECDIS units, both primary and backup, and even if the flag state had less stringent requirements for back-up. This is due to RCDS mode not having the full functionality of ECDIS and therefore it "can only be used together with an appropriate

[35] HESS-MS Chart and Publication Management

portfolio of up-to-date paper charts"[36]. For an overview-scale RNC paper charts are not necessary as the compilation scale of equivalent ENC is normally sufficient.

In some areas, South America in particular (e.g. Chilean fjords, Easter Island and some ports in Pacific Central America), there is no ENC or RNC coverage at all and paper charts are required. If there are no BA charts available, it can be quite hard to find the necessary charts and often assistance from the chart provider or the local agent is needed. Many hydrographic offices, especially in less developed countries, do not publish their chart catalogues on the internet at all, or if the catalogues are available online, they are not available in English. Receiving paper charts for remote, less visited areas can take several months, so the VPO needs to be sufficiently far ahead with the planning to ensure that all necessary charts are received on board early enough to do proper appraisal and planning[37].

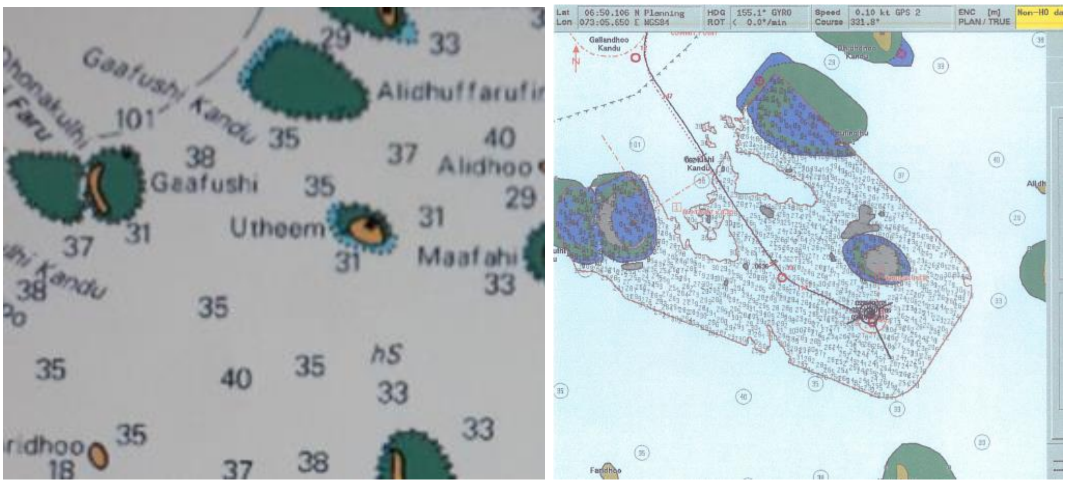
Regulations demand appropriate, official, up-to-date charts and most of the time this is achievable in one way or another, but occasionally when doing expedition cruising more creative solutions are called for. In some remote parts of the world there are no proper modern surveys conducted at all, and therefore there are no charts of appropriate scale available, neither digital or paper, official or unofficial. Sometimes the itinerary planners do not check if a destination is actually reachable by a cruise ship, or if it is feasible to go there, and after the itinerary is published it falls on the ship to find a solution. If the newest chart data is from leadline surveys from 1830s (e.g. parts of the Maldives) the Master has always the option to refuse to sail in the area, but the guests are keen to see these faraway places and the company does its best to make the calls happen.

A custom-made satellite derived bathymetric chart is an option if there is no other chart data available, but as it is very costly (one ENC cell costs a few thousand euros) it is not suitable for large areas. A commercial company can make a survey based on

[36] IMO MSC.1/Circ.1503 ECDIS – Guidance for Good Practice D/26

[37] The best practice is to ask for a screenshot of the chart before ordering it to make sure it fits the intended purpose. It has happened that a VPO has ordered (without checking) what he thought was a harbor chart of Easter Island, but instead received an overview chart of the South Pacific Ocean with Easter Island a barely visible dot.

satellite images and provide a bathymetric chart both in a printable form and as an unofficial ENC cell. The bathymetric chart includes nothing but water depths, there are no land features, aids to navigation or place names. However, the quality of data is very high with much more accurate and dense depth information than on a regular chart.



Official ARCS (the best scale available 1:350000) Unofficial ENC from satellite derived bathymetry

Figure 3. Charts for Utheemu, Maldives

Checking the chart coverage alone is not sufficient, also the quality of chart data must be assessed. The Zone of Confidence (ZOC) or a source diagram needs to be checked, as they give a good indication on the quality of the survey the chart is based on. ZOC is also required for safety depth calculations later on. Even when the compilation scale is acceptable (magnification ratio of x2 or less) the chart may be based on old surveys with unknown or imprecise datum. Such areas are not compatible with satellite navigation and when interrogating the ECDIS a warning comes up alerting the user that positions in the region are estimated to lie within several hundred meters of WGS84 datum. Any datum mismatch and GNSS error areas must be identified before starting the planning phase.

Sometimes the ENC coverage for an area seems fine with acceptable compilation scale and ZOC, but when the ship arrives to the area the charts do not match reality at all. This is the case for example in the Amazon River where the river’s course is constantly changing creating new islands and shallows eroding old ones away. The official ENCs cannot keep up with the changes, and the pilot will bring a set of corrected local paper charts with him when he arrives onboard. These charts are property of the Brazilian government and cannot be obtained beforehand, so the route will be planned on the ENCs the ship has but executed according to the pilots' advice. The bridge team has access to the Brazilian charts during the passage, and they are used for monitoring the ship's position.

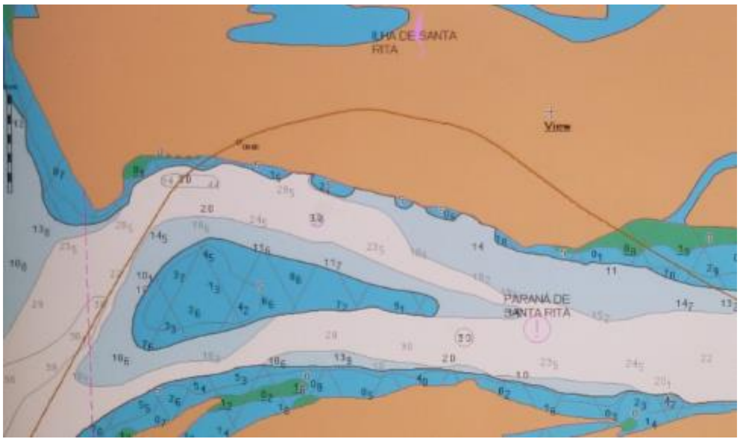


Figure 4. Official ENC for the Amazon River. The brown line is the past track the ship has sailed, seemingly passing over land.

3.2.2 Generation of track

Although the track should be made only after a full appraisal has been conducted, a preliminary track is generated at this stage to see approximately where it is going to pass. This helps to pinpoint for example the applicable reporting schemes, relevant pilot books or the pilot boarding ground if there are several. Sometimes cruise ships are required to use pilot boarding ground for deep draft vessels, and this can make a difference in STM. The official PBG can differ from the actual one, but usually the agent is able to provide the information. It is uncommon that PBG information in BA publications or ENCs is incorrect, but it is not unheard of and comparing different sources of information usually allows the VPO to identify the correct position[38]. Pilot boarding by helicopter is not preferred for safety reasons but can be done if there is no other option.

[38] For example in Male, Maldives, one PBG was discontinued as it would have required a passage through a strait with dangerous currents, and later on a bridge was built across the strait impeding the passage. The incorrect PBG was still shown in BA ENCs two years after the construction started. In Madang, PNG, the PBG was on dry land according to ADRS 6.

At this point there is usually no berth information available yet, and if the port has multiple berths the VPO needs to make an educated guess as where the ship is going to dock in order to be able to prepare a plan from berth to berth without needing to make a lot of changes later. Some ports publish shipping schedules with berth information a few months ahead, for other ports MIN or Findaport can give guidance which berth can be expected. The berth is usually confirmed well in advance before the scheduled call, but there can be last minute changes and the VPO needs to take a look at different alternatives to see where it is possible to dock, or if anchoring must be considered.

The safety depth calculations and UKC are finalized in the planning stage, but some safety depth parameters need to be inserted in the ECDIS to give an overview of navigable waters along the intended track. Normally the deep-water contour settings do not vary greatly on one ship as the calculations are generally based on worst case scenario, and these settings can be used for the preliminary track, which gives the VPO an indication if there are any possible problems with the UKC expected.

3.2.3 Publications and local regulations

Charts do not contain all available information about an area and Sailing Directions, or equivalent pilot books supplement the charts by going into more detail. BA pilot books often give recommended tracks for coastal navigation, but this information must again be double checked since occasionally the SDs give recommended routes through areas that are navigable, but nonetheless prohibited for foreign vessels. E-NPs are not very user friendly and finding the relevant information is time-consuming, but nevertheless it has to be done in order to prepare the voyage plan.

Routeing charts and ADRS can also provide information on recommended routes and possible limitations. Reporting requirements, including security reporting, are checked to see if there are any mandatory schemes that must be followed. ADRS is normally sufficient, but some reporting requirements are not mentioned in official publications, such as Northern Right Whale reporting in Gulf of Maine area, requiring the ships to report all sightings of Northern Right Whales in the area. Information from the agent is used to supplement ADRS, as the information in ADRS can be incorrect particularly for small ports located in remote parts of the world.

Not all relevant information is found in publications and therefore local regulations may need to be obtained some other way, either via the agent or more often by downloading from the internet. Mostly the local regulations deal with the conduct of the vessel, but they may also impose certain technical standards and sometimes ships are required to install for instance extra signaling lights in order to comply. Checking the regulations at the early stage of appraisal gives enough time to order and install the needed equipment, as it is not always part of the standard set up and thus not installed originally in the shipyard. [39]

3.2.4 Environmental conditions

Weather and current information can be obtained from several sources, but SDs give normally a good overview of expected conditions in the area. HAG uses two shore-side meteorological service providers: American WRI and Norwegian StormGeo. WRI has an extensive website with a lot of information including daily weather for all ports of call no matter how remote, BVS is StormGeo's weather program used on the bridge for daily work. It provides detailed information a few days ahead, and it can be used also for route optimization in case of heavy weather, and for calculations to prevent parametric rolling. In the SDs there are notes on currents in straits and around islands, and sometimes this kind of information can also be included in the material received from the agent. For example, the Japanese Coast Guard publishes a document called "Maritime Safety Information", which contains not only local regulations and information about reporting and pilotage, but also information about the weather and sea conditions around Japan.

[39] Cruise ships passing through Panama Canal are required to show a fixed blue light in the mast during dark hours to indicate that they are so called "preferred vessel". In Japan any ship longer than 200m is considered a "Huge Vessel" and when sailing in certain areas, such as Seto Inland Sea or Tokyo Bay, the ship is required to display at day time two cylinders placed vertically on top of each other and at night an all-round green light flashing at regular intervals defined in the regulations.

If the ship is planning to sail in Polar areas, Alaska or Chile, information on the extent and type of ice in the vicinity of the intended route is looked for, but it is not always possible to obtain. Statistical information can give an indication on expected conditions, but the current ice information must be checked closer to the actual cruise. In the North Atlantic Polar areas ships use BarentsWatch-service where ice and weather information, along with safety related information, is gathered in one place. None of the HAG ships has an ice class, and their ice navigation is based on avoiding ice. In Antarctica an ice pilot is normally used, i.e. an experienced master who has worked in Antarctica for a long time and has practical experience of navigating in the area and knowledge of expected conditions.

Tidal information comes mostly from ATT, but if local tide tables are available online or as a separate program (such as AusTides for Australia or Tides&Currents for US) they are often used, since they tend to be more accurate and have more data than ATT. Sometimes the agent can provide a copy of the local tide tables. In British waters and St. Lawrence River local tidal atlases are useful to determine the expected tidal streams during the sea passage or approach, also some ECDIS models can incorporate tidal information. Tidal graphs for the ports of call are checked quite early in the planning process to ensure that there is enough UKC for the planned time of the call and to find out if there is a tidal window that will restrict the entry into the port. Occasionally neither the itinerary planning department nor the port has realized that the port is too shallow for the ship and the earlier the VPO is able to warn them about the conflict, the easier it is to find an alternative port of call or adjust the itinerary.

3.2.5 Protection of marine environment

The environmental schedule is made at a later stage, but an overview of the regulations in the area must be clear already at the appraisal phase. For many discharges Carnival Corporation has more stringent limits than MARPOL, but in some areas, such as Great Barrier Reef, the local regulations are used even if they are less strict that Corporation rules. If a country claims an archipelagic baseline and the ship is expected to be inside for five days, it is clear even without any detailed plan that problems can be expected, and that they need to be addressed as soon as possible in case a change in itinerary or schedule is necessary to ensure compliance with the regulations. The VPO will consult the EO if there is any ambiguities, and if the EO cannot answer the question, they will contact the office. When a preliminary track is made the environmental limits are drawn in ECDIS as User Chart Objects (UCO) to visualize the effect of the environmental limitations. Often the track can be adjusted to stay outside for a longer period without affecting the speed required. If the neighboring countries are close to each other and have different environmental regulations, it must be clearly marked. For example Indonesia allows permeate[40] to be discharged 4NM from shore, but one of its neighbors, Timor-Leste, has not published any regulations and to be on the safe side all overboards are kept closed inside 12NM when in Timor-Leste waters. This means that when the ship crosses the border between Indonesia and Timor-Leste all discharges are stopped although the ship is more than 4NM from shore and outside the MARPOL 3NM limit.

Stability data is not a concern at this stage, but all areas suitable for ballast water exchange (>50NM or >200NM) must be identified. Some countries prohibit even clean ballast discharge without ballast water treatment system (BWTS) within 12NM and the VPO needs to be aware of this especially if their vessel uses ballast water regularly for stability reasons. Closer to the actual cruise, when the voyage plan has been finalized and the environmental schedule is made, the VPO will discuss stability requirements with the Staff Captain, Chief Engineer, EO and the Stability Officer, and the C/E will inform the rest of the team of planned bunkering ports and amounts. If the VPO can see that there may be an issue for wastewater storage, e.g. due to an overnight or archipelagic baseline, they will inform the Stability Officer normally a couple of weeks before the cruise, so that the Stability Officer has time to make a pre-plan. Wastewater issues usually require limits to production and consumption of fresh water and may affect the amount of bunker that can be loaded.

[40] Advanced Wastewater Treatment System (AWWTS) is an on-board grey water and sewage treatment system, which produces purified water called permeate. In most countries the discharge requirements for permeate and grey water are identical, although permeate is practically fresh water. Therefore some countries, like Canada and New Zealand, allow permeate discharge 24/7 even when the ship is alongside.

3.2.6 Contingency plans and speed schedule

Contingency plans are considered for the sea passage during appraisal, for arrivals and departures more detailed contingency plans are made later. Authorities responsible for search and rescue are identified and their contact details are made available to the bridge team. In more remote parts of the world there is a possibility that only assistance available will be other ships sailing in the area, who are not equipped to help a couple of thousand people. In polar code areas the ship must be prepared to be on her own for five days. MSC Circular1184 suggests voyage pairing, but this is not actively used at least on HAL ships.

Although the track is not finalized yet, a preliminary speed schedule is made at this point to make sure that the voyage is achievable without too low or too high speed required, at the same time giving the ship enough time outside the environmental limits for discharges. The company publishes a so called ICN (Itinerary Condition Notification) schedule with official arrival and departure times including miles, required speeds and fuel consumption. This schedule is never accurate and the VPO must compare it with their own calculations quite early on to identify possible challenges. Especially if the ICN schedule shows very low or high STM it is likely that some kind of adjustment of either the route or the time schedule will be necessary. If the ship is planning for an area with varied emission restrictions the Chief Engineer usually needs a preliminary speed schedule several months before, with approximate distances inside and outside of different emission areas and speed limits, to be able to plan consumption for different types of bunkers[41].

[41] For example a Western Alaska cruise from San Francisco will sail both in and out of ECA zone, inside the Californian 24NM limit, passing several marine sanctuaries and whale waters with a speed limit. In practice for part of the cruise HFO with 3.5% sulphur content could be used (prior to the global sulphur cap), other areas allow HFO with scrubbers with EGCS discharge pH of 4, in some areas scrubbers are allowed, but the pH must be over 6, and some areas require MGO to be used. Depending on the ports of call there can be two route options between ports. The VPO needs to make preliminary calculations for all the alternative routes since STM and the distance and time spent in various emission areas vary greatly and affect bunker planning.

3.3 Planning

The second part of *Appraisal and planning checklist* deals with planning. The planning checklist for departure and arrival includes two items that will be part of departure/arrival briefings and BRM and are not considered at this point: engine configuration and reference of changing steering mode position. The engine configuration for arrivals and departures is mostly standard, on diesel-electric vessels often two or three engines, and if there are any exceptions, they are discussed during the BRM. The navigator (person doing the maneuvering) will inform the bridge team during the briefing when they intend to change to wing/center console.

3.3.1 Finalizing the track

A preliminary track is made already during the appraisal stage, but after all the necessary information has been gathered the track is finalized. Waypoints are edited and radius is selected bearing in mind speed required for the leg. Even if speed required is not very high, large radius is preferred for sea passage to minimize the rate of turn and heeling during turns, cruise ships generally prefer to keep the ROT under ten degrees or less. If STM is very low, then the radius can be reduced to avoid the turn taking too long. In confined waters, especially in ports and on approaches, the radius is less than a mile, normally 0,5NM since the speed will be low and the ship will be sailing in hand steering.

If there are no ENC or RNC available and the ship needs to use paper charts the planning must be done on those charts and the waypoints transferred to ECDIS. In many areas without ENCs the paper charts are old and not WGS-84 compatible. If the chart has a known datum, there is often a note telling the user how to convert positions on the chart to WGS-84. Sometimes the chart is so old that the datum cannot be determined and there is no way to tell what the difference is compared to WGS-84. In this case the off-track function in ECDIS will not give any indication if the ship is sailing in safe waters and the watchkeepers will need to rely on PI lines and plot the positions by visual or radar bearings.

Route Safety Corridor for each leg must be established for route checking, the safety corridor will also be used for route monitoring later on. How the corridor is done depends on the model of the ECDIS on board. The older NACOS systems allow only a symmetric track limit to be set and the route check is done on wider limits, which are then changed to actual track limits after the track is approved. Newer systems and other manufactures allow separate safety corridor and track limit, with different values on port and starboard. The safety corridor must be wide enough that all possible dangers are detected even if the ship is forced to deviate from the track e.g. for collision avoidance. In certain parts of the world, specifically in Asia, traffic density is high and quite large deviations can be expected.

In NACOS systems waypoint and track notes are added after the track is finished. Waypoint notes are reminders to the watchkeepers for example for manning change, environmental limits, reporting, speed limit or expected reduced UKC. Track notes are more general, and they do not vary much from cruise to cruise. The most important information in track notes is the chart coverage, if there is no full ENC coverage then the applicable ARCS/paper chart numbers are listed in the track notes for the watchkeepers' reference. Otherwise the track notes mainly lists things that the watchkeepers need to pay attention to (such as safety contours, reporting, environmental limits and gangway) and refers to the appropriate document, e.g. HESS-MS or the voyage portfolio. Not all EDCIS manufactures use waypoint and track notes, for example on Furuno ships the notes need to be added to the voyage & port notes.

During the planning the VPO will run preliminary route checks every once in a while to make sure that they have not missed any ECDIS provided information, but the final checks are made after the route is finalized and the safety depth calculation are done. During the appraisal and planning stages the VPO must ensure that adequate UKC is maintained. If the reliability of the surveys is unknown or there are other concerns about the actual depth, an additional safety margin is considered.

Sometimes there are two alternative routes for a voyage, for example one that might be preferable, but which might not be usable due to weather or other environmental conditions at the time of the actual cruise. If there is more than one option the VPO will make full voyage plan for all the alternatives, and the track used will be chosen closer to the departure date.[42]. The VPO needs to calculate all possible options and make sure that the voyage plan is finalized for all of them. For example weather forecast and whale sighting reports are monitored closer to the departure date, and all the information gathered together with the voyage plan will support the Master's decision when choosing the route to take.

When there are no more changes expected to the track the VPO will run a final route check with settings recommended by the Carnival Corporation and using the calculated ECDIS safety settings. If the ECDIS model allows the safety settings to be linked to each waypoint only one route check is required, but at least in older ECDIS where the user has to change the settings manually, the check must be run with every separate set of safety settings. After the tracks are finalized, they are converted to different formats used by programs other than ECDIS. For example all routes must be downloaded into the weather program, but it cannot read the ECDIS format, also navigation applications such as iSailor or pilots' PPU need a different format.

3.3.2 Safety depth calculations

Voyage planning policy provides a UKC Computation Form (see Appendix 2) that needs to be filled in taking every leg into consideration, and it must be used to determine the ECDIS safety depth settings. The voyage must be developed in at least three sections: departure, sea passage, arrival, but if necessary, the voyage can be divided into several sections in the safety depth calculation. For example the approach to Panama Canal would be considered open water, but in the canal itself shallow water contours would be used with a change back to open water contours on the other side.

[42] For instance, there are two route alternatives for Charlottetown P.E.I. to Quebec City, going east and west of Prince Edward Island. The western route is shorter, but the Northumberland Strait between the island and the mainland is quite shallow and restricted not allowing passage at full speed, and there is a wind speed limit for passing under the Confederation Bridge. During the lobster season the ship needs to follow the recommended (longer) route, and restricted visibility may pose a problem in the strait. Also, after clearing the strait the ship will need to sail 150NM at 10 knots due to the whale water restrictions, increasing the STM after whale waters to 20kn. The eastern route is much longer, but the ship has to sail only 25NM in the static speed restriction zone allowing lower overall STM. However, most of the track will pass through the dynamic speed restriction zones, and if the Canadian authorities decide to close the dynamic sectors when the ship is passing through, the ship will not be able to make the ETA to Quebec and might need to cancel the call altogether.

Sometimes the sea passage needs to be separated into coastal waters and deep waters with different contours.

The calculation is always done using the maximum draft, usually maximum speed is also used even on slow speed runs to accommodate for any possible changes in schedule due to weather or emergencies. Water density and potential heeling angles are estimated. For tidal ports the lowest astronomical tide value is used to make sure that the ship can sail in and out even if arrival or departure times change unexpectedly. In shallow ports with several meters of tide this is not always doable, and then the lowest possible tide value is used for calculations with a note in the voyage plan about the tidal window. The VPO checks manually the route to find out the shallowest charted depth and lowest ZOC. There is an option not to apply the ZOC, but this is used only if the minimum UKC is not achieved otherwise and it is known to be safe to disregard the extra safety margin given by ZOC calculation.

The safety depth calculation will result in safety parameters to be inserted in the ECDIS, and it will indicate if minimum UKC is achieved or not. If it is not, then the plan must be adjusted. Often reducing speed will be enough as long as it does not affect the schedule, also adjusting the tide value can give the needed extra margin. Often in ports where the ship calls regularly and the past experience tells that the water depth is sufficient the ZOC can be disregarded, same as in the US where the charts often have only U as ZOC. If there is no other way to comply with the minimum UKC then a risk assessment has to be conducted (see Appendix 3). The first draft is made by the VPO listing measures that are to be in place when entering the port, the Master includes his comments and last the company will check the assessment and supplement it if necessary.

3.3.3 Speed schedule and tidal windows

To make sure that the track is doable timewise a final speed schedule is made with ETD, CSV, time at sea, ESV and ETA to berth, including notes on clock/date changes and different route alternatives, also possible speed limit areas are taken into consideration (see Appendix 4). Sometimes the maneuvering characteristics of the vessel or proximity of navigational hazard will impose restrictions on what can be considered safe speed and speed reductions must be taken into consideration in the speed schedule. High speed runs should be avoided in areas known for marine mammal activity even if there is no official speed limit[43]. Although the ICN schedules received from the office include average speed the schedules are known to be incorrect and after doing their own calculation the VPO can find STM over or on the upper limit of ship's maximum speed in which case departure and/or arrival times may need to be adjusted. A detailed calculation is made including e.g. ETA to each waypoint, track distance, course, ROT and planned speed. This can be done either on the ECDIS if the system allows it, or on a separate spreadsheet (see an example in Appendix 5), and it will be used as basis for environmental, WTD and BRM schedules. How detailed the speed schedule and voyage plan are depends partly on how user-friendly the ECDIS is. Some models, such as Transas, allow the VPO to adjust calculations and include parameters to suit the vessel's needs reducing necessity to make separate spreadsheets[44].

If there is any concern that the time outside environmental limits is not enough for discharges the VPO tries to amend the track or speed schedule to accommodate for that and presents the options to the Master. Sometimes the arrival/departure times need to be changed to make sure that there is enough storage available for wastewater, or initial STM is increased allowing the ship to stay outside longer to be able to finish discharges. After all the tracks and the speed schedules have been finalized the Master will review and approve them providing his input, and after that the VPO will finalize the planning.

Tides and currents were checked at the appraisal stage, and after the route and the speed schedule are finalized, they are reviewed again to find out the expected conditions and make sure that the ship will be able to pass critical points. Some narrow

[43] HESS-MS Marin Mammal Avoidance
[44] Some Transas ECDIS models allow the user to link safety contour settings to all waypoints. This enables the ECDIS to change contour settings automatically when passing the waypoint (giving the user an alert that the contours are going to be changed). Speed limits can be entered by the user to be taken into account in the calculations. The user can freely enter ETA/ETD for any waypoint, also time spent at a waypoint, e.g. in a lock, resulting the speed calculation giving ETA to every waypoint making a separate spreadsheet unnecessary.

passages, such as Seymour Narrows in Western Canada or China Strait in Papua New Guinea, have very strong tidal streams and it is not advisable, or even possible, to pass through during unfavorable conditions. Sometimes a higher initial speed is required to arrive at a strait before the current gets too strong, but detailed calculation must be done to make sure that speed does not affect for example environmental discharges negatively. The VPO will make a few calculations using different speeds to give the Master a time window when the critical point can be passed, and to show how it will affect STM. There have been cases where the tidal streams have been miscalculated for example in Pentland Firth, resulting in incidents and near-miss situations when the ship has found herself in dangerous conditions.

Lower speed is preferred due to bunker consumption, but if there is an alternative of a longer route versus a shorter one with initial high speed to reach a critical point at a certain time with a low speed required afterwards, it can be quite a puzzle for the VPO to provide the Master with all information to support his decision making. For example a passage from Portree, Isle of Skye to Kirkwall, Orkney Islands has two route alternatives: southern via Pentland Firth or northern via Fair Isle Channel. The speed required for the northern route is 19,7kn, for the southern route it is 15,4kn. However, if the tidal window in Pentland Firth is unfavorable the ship would need to make for example 21kn to reach the western entrance in time and a minimum 19kn to pass through the strait with a speed required of 6kn afterwards, maybe a bit more if she needs to go outside 12NM for discharges[45]. The tidal window for Pentland Firth, weather, bunker consumption and tidal streams for the whole passage need to be considered and calculated in order to reach a decision that is safe and most efficient.

[45] As an example HAL ship m/s Rotterdam could make the northern route with three engines, dropping down to two after passing the Fair Isle Channel, depending on the strength and direction of tidal streams. For the southern route she would need four engines initially, dropping down to three at some point before Pentland Firth and running on two engines after the firth. In one case the decision was made to take the northern route although the currents north of Orkney were unfavorable as the difference in fuel consumption was not that big and the passage through the firth would have meant increasing the manning level to yellow in the middle of the night.

3.3.4 User Chart Objects

Environmental limits are marked on the ECDIS already at the appraisal stage, but other essential UCOs are drawn after the track is finalized. Depending on the sailing area this job can take quite some time. At least one parallel index (PI) is drawn for every leg if possible, except for very short or very long ones, clearing bearings and dead range are added when applicable. Same is done on paper charts if they are in use. Any other notes deemed necessary are added, e.g. if the discharge requirements in a port differ from the general requirements in the area a note on the ECDIS is good to have in addition to a waypoint note, a remark in the Voyage & Port Notes and the environmental schedule. Excessive clutter on the ECDIS should be avoided, and non-vital information is added to the voyage portfolio only, but any hazards not clearly visible on the ECDIS must be marked.

Own safety lines are added if needed. Usually the safety contour is used as the default alarm when crossing into unsafe water and in fairly deep waters crossing the safety contour is normally not necessary. Some countries make ENC cells with the depth contour interval of one meter, and in these areas it is easy to configure the ECDIS without crossing the safety contour. The safety depth calculations have been done earlier and at this point the method for crossing the safety contour is chosen depending on the Master’s preference and the make of the ECDIS, all ECDIS models do not allow the safety contour set lower than the safety depth. Method 1 is normally the preferred way to configure the ECDIS. If crossing a safety contour is necessary then own safety lines are drawn around dangers within the safety contour, i.e. around the safety depth soundings. In Method 2 the safety contour value is less than the safety depth and own safety lines must be drawn around all safety depths in the area, isolated danger symbols are not shown. Some Masters prefer to sail in “white water”, i.e. not crossing the safety contour, and in shallow areas this means that the safety depth calculations must be adjusted if the ECDIS does not allow Method 2 to be used. If planning is done on RNCs the ECDIS safety settings do not apply.

Contingency plans for approaches are considered at this stage taking into account ship’s maneuvering characteristics. If the approach is shallow and high swell can be expected the stabilizers cannot be used, and an assessment must be made if it possible to board the pilot in actual sea conditions.

Cruise ships have a large windage area, which can become an issue when approaching a port with a narrow fairway or limited room for maneuvering, especially as in many small ports there are no tugs available. The VPO must calculate maximum swept path for all narrow channels and fairways and make a note of the maximum drift angle on the ECDIS to function as decision support on the approach/departure. The commit point must be marked on the ECDIS including drawing the track for abort maneuver with radius and final safe heading, taking into account tactical diameter, advance and transfer. Contingency anchorage is marked; if there is no contingency anchorage available anywhere near the port then a note will be made in the Voyage & Port Notes. No-go limits are marked if not clear otherwise, and speed range, planned navigable corridor, reserve, passing distances, swept path and stopping distance are considered. Turning circle is drawn as a UCO with a note of its diameter. Often also distances between breakwaters or piers are marked for quick reference.

3.3.5 Alarm management

To be able to utilize the safety features of ECDIS the chart alarms must be activated. SMS policies for voyage planning and INS require efficient alarm management and the alarm management checklist is to be filled out as part of the voyage plan (see an example in Appendix 6, the format of the checklist depends on the make and model of the ECDIS and can vary quite a lot depending on what kind of alarm groups are available in INS). The alarm settings are changed at same waypoint as ECDIS safety contour settings, so mostly there are three set of alarm settings: departure, sea passage and arrival.

First the look-ahead sector is defined. The width is given in either meters or nautical miles and depends on how confined waters the ship is passing. The length of the sector can be either in nautical miles or time, although time is the preferred setting as it works on any speed and if STM is radically changed due to any reason, the bridge team does not need to adjust the length manually. In some ECDIS models the user can choose if the alarms are on track or ahead; choosing track will check only along the track, the ahead function will use the look-ahead sector which will work also if the ship deviates from the track. In most ECDIS models the user can choose which chart alarms they want activated, and in Special Areas also which types of areas will generate an alarm. Alarm management is needed to ensure that the alarm system supports the operator instead of causing distraction. A minimum speed can be selected in order to avoid too many alarms while maneuvering. When configuring the look-ahead sector it is best practice not to be excessive. Depending on the manning level there are four to seven persons in the bridge team and the alarms are not there to warn the bridge team of dangers they are aware of, but as a safety net to catch a mistake nobody noticed. On NACOS ships the alarms are usually activated only on the ECDIS, not on Multipilots, to avoid too many alarms and warnings. The alarm management includes also the echo sounder alarm. Alarm settings other than safety contours can be changed at OOW's discretion if so required.

3.3.6 Reporting requirements

Ships have to submit various reports to different government agencies, ports and pilots. Many of the reports do not concern the VPO (such as immigration or health declaration), and on cruise ships there is a dedicated Port Paper Officer (PPO) who is responsible for ensuring that the reporting regulations are met. The VPO is still responsible for pure navigation-related reports, such as notices to pilots or traffic controls, but some of the reports overlap and the VPO needs to either assist the PPO or coordinate with them the responsibilities. For example Canadian PAIR and ECAREG[46] reports are taken care of by the team navigation, whereas somewhat similar pre-arrival report to Singapore is done by the PPO with input from the VPO.

[46] Pre-Arrival Information Reporting form is sent to Transport Canada 96h before entering Canadian waters and is similar to pre-arrival reports in other countries. ECAREG (Eastern Canada Vessel Traffic Services Zone) Report is sent e.g. minimum 24h before entering the area/departing from berth, and before departure/after arrival and on other specified conditions.

Some reports are only a call on VHF when passing a VTS reporting point, though there might be several calling points with different channels and some traffic controls ask for a lot of details such as bunker figures. Sometimes the report can be an email with a few words, but more often than not either a specific spreadsheet, sometimes several pages long, has to be used, or the report must be in a certain format. In many countries the authorities do not communicate with each other and the ship will need to send the same information to several places. The timeline for reporting, such as notices to pilots, varies from 1h to 48hrs. The ship may need to send up to five different reports a day and missing a report can have consequences, ranging from delayed pilot embarkation to the local authorities prohibiting the passage. As part of the voyage plan a reporting matrix is prepared with templates for separate reports making it easier for the bridge team to follow up on reporting requirements that need to be done as part of watchkeeping. Mostly the information required is quite basic, but occasionally the VPO needs to answer questions on the color and mark of the funnel (Hainan Strait, China) or the bilge-keel radius (Panama Canal), and security related reports usually ask for a sailing plan with at least a few waypoints. Some ports require the ship to send in a Vessel Arrival Information Sheet (VAIS) with e.g. ship's particulars, bollard SWL and type of mooring lines. This is common for ports with challenging swell or tidal conditions where ships are required to use shore tension system, or where the pilots need to calculate dynamic draft to see whether the vessel can enter.

Many of the fees the ship has to pay are based on number of people onboard, GT or such, but if the fee is even partly based on the area the ship is sailing in (as in Fiordland, New Zealand), the VPO must fill in a report to the responsible authority as soon as possible after the passage to inform them which areas the ship has sailed through. If any report needs to be sent immediately after the ship has exited the area, the VPO will prepare a draft and makes a note in the voyage plan so that the watchkeepers know they will need to fill in the report.

3.3.7 Berth information and docking plan

Docking plan is made as far as possible and supplemented later if needed. If the berth is confirmed and the ship has docked there before, old docking plans can be used showing the bollard and line arrangements and the gangway position (see an example in Appendix 7). Every time a ship visits a new port or docks at a new berth photos are taken of mooring arrangements, and these photos are included in the docking plan with a note of the stage of tide, so that when the ship comes back to the port the VPO can with the help of the pictures and information included anticipate expected conditions. In some places the port will make a docking plan, but it is not usually sent to the ship until a couple of days before the call. If the ship has never visited the port before docking plans from other ships can be downloaded from MIN to give an idea of what is expected. The agents are often asked to send berth information (length, height, depth at LW) including photos, also Google can help providing pictures. Mostly the material received from the agent is relevant and accurate, but especially in ports that do not have many cruise ship calls the information can be erroneous and the ship needs to be prepared for unexpected challenges like not having enough bollards or the gangway door being below the dock level.

Designated cruise ports often have a shoreside gangway or jetway available, but in most places the ship has to use own gangway. Most cruise ships have shell doors for gangways on three decks in addition to the boat deck, and some even have an accommodation ladder, but some ships have shell doors only on two decks and if the dock is high or the tidal range is several meters, this can become a problem. Even if there is a shoreside gangway available, the gangway angle can become too steep for passengers if the port cannot provide a setup to reduce it, such as a box or container, and the gangway angle calculations for all stages of tide are part of the docking plan (see Appendix 8). Ports are generally eager to assist the ship and try to provide a gangway if the ship’s own gangway cannot be used, but there have been occasions when the passengers have been tendered ashore although the ship has been alongside, only because there was no solution to the gangway problem. It can take a couple of months for the port to find a gangway, or build one, so the berth information has to be checked early enough to find a solution in case issues are expected. In rare cases the company has even considered cancelling the port if there is no guarantee that passengers can go ashore.

Heavy loading is normally done on a turnaround day or in a major port, and if the port knows that the tidal range will affect the times marshalling area or provision shell doors are accessible, the agent will normally notify the ship of the timeframe the loading is possible. Major ports are generally used to dealing with cruise ships and there are seldom issues related to loading, the VPO just needs to check that the relevant shell doors are reachable, e.g. they are next to the main pier and not a dolphin.

3.3.8 Second person check

As per HESS-MS policies the EO is required to review the environmental restrictions in the voyage plan and when finalizing the voyage plan the VPO will go through the planned route with the EO, who will check that the environmental lines are drawn on the ECDIS and all relevant regulations are included in the plan. All environmental restrictions must be appropriately displayed on the ECDIS as per HESS-MS environmental policies. After the VPO is happy with the route, a second person, normally the assistant navigation, will run both an electronic and visual route checks on appropriate scale with correct display setting to confirm that the route is good and fulfills all requirements. The VPO will double check the material the assistant navigation has prepared, e.g. gangway angle calculations or that correct time zone is used in the tidal chart/stream printouts.

3.3.9 Operational schedules

The voyage plan includes some information that is relevant not only for the bridge team, but for various departments on board, and this information needs to be disseminated in an easy-to-read format. Schedules are made for anticipated watertight door (WTD) conditions and manning levels (see appendix 9). The times are naturally only approximate, but the schedules will give the rest of the ship, in particular those working below the water line, an idea when they can expect that the WTDs must remain closed. The manning level schedule (so called BRM schedule) will give the senior deck and technical officers a timeline when they are likely needed for increased manning level, and it also gives the rest of the ship an indication on when the bridge and ECR will be in closed condition and no calls other than in an emergency are accepted. WTD condition and BRM level can be changed at any time if the OOW feels it is required, but during a routine voyage the schedules are more or less followed. The ECR can increase their manning level for instance if they encounter a problem with a piece of equipment, but the bridge does not need to follow unless it is a question of major malfunction. However, if the OOW decides to change the manning level, generally the ECR will need to follow the bridge. This is quite common in areas with restricted visibility where the bridge will go to yellow manning in case of fog.

WTD and BRM schedules are simple Excel spreadsheets that ships can modify as they like, but the environmental schedule (ENV) is common for every Carnival Corporation ship and the standard format must be used (see Appendix 10). Ships have itineraries that vary greatly and the standard ENV schedule does not suit every ship, which makes it labor intensive to create if the ship is not on a regular 7-day run. The ENV schedule gives estimated times for crossing environmental zones and lists 14 discharges or emissions showing if they are allowed or not within that particular zone. In addition to discharge regulations any possible special areas or marine sanctuaries must be noted with expected entry/exit times. There is one page per day and every page is signed by the VPO and the EO after s/he has checked and approved the schedule. The ENV schedule is relevant for deck and engine for planning where discharges can be made and what is allowed.

One schedule unique to cruise ships is casino limits. Most countries allow the ship's casino to be open when the vessel is underway, but some countries prohibit casino operations within their territorial waters. As a part of voyage plan the VPO needs to make an approximate schedule when the ship is going to cross the limits, make a note on ECDIS and discuss the plan it in detail with the casino staff especially if the casino needs to be closed on a sea day. In Australia every state has different rules on casino operations with limits ranging from 3 NM to 12NM, and the bridge team has to be aware of when to give notices to the casino. During a coastal passage ship may need to go in and out of casino limits several times, and the casino normally needs several notices, both an hour before closing and when crossing the line, both by phone and email.

3.3.10 Finalization of the plan

At the end of the planning phase the assistant navigation will assemble a document called Voyage & Port Notes. There is no standard format and ships do what suits their needs best, on some ships the document is several pages long, on others there is just bare minimum (such as in an example in Appendix 11). The voyage and port notes combine the most important information in an easy-to-read format, and any information that is essential but is not included in any of the other documents will be added to the voyage and port notes, such as requirements for tugs or escort vessels, shore tension mooring or environmental expected conditions like swell or current in a port etc. Emergency contact numbers for ports are listed, including the agent's details, firefighting, ambulance and law enforcement numbers if these exist or are known. The voyage and port notes often summarize reporting requirements with applicable VHF channels for quick reference for the bridge team, although these are also added as printouts from ADRS 6. Information that is included in waypoint notes or UCOs can be mentioned also in the voyage and port notes, such as speed limits or special hazards to navigation.

The company voyage planning policy requires the VPO to put together a voyage portfolio with all relevant information. In practice the voyage portfolio is most often a binder kept on the bridge for easy access for watchkeepers, although some ships use a digital portfolio in OneNote instead of printouts. The voyage portfolio contains[47]:

- Waypoint list including track information, ETAs and waypoint notes signed by the VPO, assistant navigation, S/C and Master,
- Speed schedule,
- Safety depth calculations,
- Risk assessment if required,
- Alarm management,
- ENV, WTD and BRM schedules,
- Voyage and port notes,
- Track notes (on NACOS ships),

[47] HESS-MS Voyage Support Portfolio

- Tide tables and current information. In the tidal graph the gangway position must be marked, and if shifting the gangway is required the times must be indicated (see Appendix 12),
- Docking plans including pictures of the port and mooring arrangements during previous calls. Previous docking plans are also laminated and put in binders on mooring decks for reference. If it is a new port and the ship does not have docking plans yet, pictures from the agent, MIN or the internet are included.
- Voyage planning checklist signed by the VPO, the assistant navigation and the EO for applicable parts,
- Printouts from ADRS, sometimes also from SDs,
- Local regulations
- Weekly AVCS Readme-file
- Any other information deemed necessary or of interest for watchkeepers.

After all planning is finalized, but before the actual cruise, the VPO must hold a voyage overview meeting (VOM) with a minimum Master, Staff Captain, Chief Engineer and EO attending, sometimes the Staff Chief Engineer and the Stability Officer will attend also, on some ships the attendance of all deck and engine officers are required. VOM is not a detailed BRM held for the bridge team, but a general overview of the whole cruise concentrating on environmental aspects with environmental limits and restrictions considered and agreed on with reference to STM and times outside/inside environmental zones. Any other potential issues that need to be taken into account are discussed. The Chief Engineer informs the team about expected bunkering, and possible stability or wastewater storage issues are brought up. If there are any complicated requirements due to e.g. fuel changeovers for ECA zones these are discussed at VOM, but also a separate meeting for all OOWs and EOOWs is arranged a day or two before the actual passage so that everybody will be on the same page on what is going to be expected, and the VPO will provide both the bridge and ECR a timeline when 1, 2, and 3 hour notices for the changeover are likely to be given.

A review of the route shall be conducted within 24 hours of the planned departure to check any ENC updates, new navigational warnings and weather forecasts. At some point during the day of departure the bridge team will have a BRM meeting to discuss both the upcoming voyage and considerations for departure and arrival, such as expected environmental conditions, maneuver, reserves, contingencies etc.[48] When the pilot comes on board a short departure briefing will be held so that the pilot can give his input to the plan.

3.4 Execution

Execution of the voyage plan begins when the ship leaves the berth and continues until the voyage is completed. According to IMO Guidelines for Voyage Planning "the voyage or passage should be executed in accordance with the plan or any changes made thereto"[49]. The track is to be followed as far as possible, deviation is allowed for collision avoidance and weather-related reasons. The watchkeepers need to follow the reporting matrix and ensure that all relevant reporting is done in time. Some reports can be made at a later point of time and these reports are usually taken care of by team navigation.

During the execution phase the bridge team should take into consideration the reliability and condition of the vessel's navigational equipment. If any concerns are experienced for example with gyro or GPS a more frequent position checking might be in order using methods not relying only on satellite position fixing.

At departure ETA is set in the INS to enable the bridge team to monitor the speed required and adjust the engine power to achieve it. Mostly the ETA is set for pilot boarding position, but if the vessel has to pass a waypoint at a certain time due to tidal conditions or regional speed limit, this waypoint is set as the ETA waypoint. For example Kanmon Strait in Japan can be passed preferably with the current 2-4kn against, and passage is not allowed with following current, so if the ship misses the tidal window there will be several hours delay. In the planning stage the VPO has

[48] In addition to voyage planning the team navigation has multiple other tasks including compiling a so-called sunrise-sunset schedule. As the name says it lists calculated sunrise and sunset times for each day for the vessel's estimated position, and among other things the schedule is used in daily BRMs to indicate if the approach and departure will be during daylight hours. If the port is unfamiliar to the team and requires complex maneuvering it is preferable to arrive in daylight, and if ETA to pilot station is close to sunrise the arrival time could be adjusted accordingly.
[49] IMO Resolution A.893(21) – Guidelines for Voyage Planning 4.1

calculated required speeds both for the midway waypoint and the final pilot boarding waypoint to make sure that it is possible for the ship to achieve speeds required.

The active route must be downloaded also in the weather program, which is also used for daily position reports to the company. Weather forecasts are monitored constantly, and if significant deterioration is expected action needs to be taken to ensure safe passage while adhering to the schedule if possible. If restricted visibility is expected the Master normally puts in his night orders a fog schedule, i.e. which of the senior officers is to be called in case the bridge needs to increase the manning level due to low visibility. If tropical storms or hurricanes are causing concern shoreside weather routeing service is utilized, and the bridge team constantly monitors the track of the storm. The Master shall consider "whether any particular circumstance … introduces an unacceptable hazard to the safe conduct of the passage; and thus whether that section of the passage should be attempted under the conditions prevailing or likely to prevail"[50]. Occasionally a call is cancelled due to environmental conditions, and either an alternative port is considered or the STM is adjusted to the next port of destination. During the voyage planning process areas and points of concern have been identified, such as areas with heavy traffic or adverse sea conditions, and the bridge team is made aware where these can be expected and when increase in manning level or change of engine configuration might be called for.

Environmental schedule is made at the planning stage identifying the times when various discharges are allowed, or emissions and ballast operations are limited. Every day the Stability Officer will make daily stability orders detailing which permeate or sewage tanks are to be used and which ones must be discharged and in what sequence and give instructions on any possible (de)ballasting and freshwater production/consumption sequence. The stability orders are signed by the Staff Captain and distributed to the bridge and ECR. During the execution phase the bridge team must follow the stability orders and environmental schedule to make sure that stability is maintained and required waste streams are discharged while the ship is complying with environmental regulations. A minimum speed of 6kn is required for any discharge

[50] IMO Resolution A.893(21) – Guidelines for Voyage Planning 4.3

when at sea, if the ship needs to slow down for any reason, the bridge watchkeepers need to remind the ECR to close the discharges. The bridge is required to provide sufficient notice to ECR before entering or existing areas with discharge or emission restrictions. The minimum times are set in the Carnival Corporation SMS, but often the bridge and ECR agree on giving even earlier notices.

During execution and monitoring phases circumstances may arise which may require the voyage plan to be reviewed or altered. The voyage plan has taken into consideration normal deviations from the planned route due to collision avoidance, which in some parts of the world, especially in Asia, can be several miles off the track. Unexpected events, such as a medical debark or technical failure, can cause a major deviation requiring a new voyage plan to be made. If the VPO is not available, the Master can appoint any deck officer to amend the voyage plan. The process is basically the same. Most of the appraisal has been done already, but anything not included in the original plan, e.g. reporting or port information for the alternative port, is checked. After the track has been amended both an electronic and a visual route check are carried out with appropriate ECDIS settings. The Master needs to sign the amended plan to confirm that he has approved it.

3.5 Monitoring

Monitoring the ship's progress along the pre-planned track is a continuous process and the voyage plan must be available at all times on the bridge for the watchkeeping officers to be able to check that the plan is followed. On Carnival Corporation ships this is achieved by the voyage planning portfolio, which includes all the necessary information from waypoint radii and safety parameters to reporting and expected meteorological conditions. According to the IMO Guidelines the progress of the vessel should be closely and continuously monitored and any changes to the plan must be made according to the guidelines and clearly marked.

Carnival Corporation gives the minimum ECDIS settings for monitoring[51]:

- Look-ahead function and chart alarm set as appropriate, included in the VP portfolio
- Visibility groups “Standard” plus spot soundings (shallow), submarine cables and pipelines, all isolated dangers and miscellaneous (other). However, ships normally choose to use more stringent settings with the visibility groups set to “All” and ticking off the groups not applicable at the time, such as magnetic variation.
- Shallow water danger “ON”
- Appropriate safety depth/contour for each stage
- Accuracy symbols “OFF”
- Scale dependent objects “Within effective scale”
- “Ignore scale minimum” deselected
- Date dependent object ”Within current date”

The bridge team must use all available means to monitor the ship’s progress and many of these are included in the voyage plan. Wheel over points (WOP) and wheel over lines (WOL) are generated when the radius for the turn is chosen. In most ECDIS models the WOP is marked automatically, but in some models the WOL needs to be drawn using UCOs. PIs are used whenever possible and they are drawn in the ECDIS, sometimes also a note can be made in the waypoint notes. If there are appropriate radar conspicuous reference targets available dead range can be used, usually for passages in archipelagic waters. Also clearing bearings are useful, especially on approaches.

There are no rules which scale the radars or ECDIS must be on, this is left to the watchkeepers’ discretion. However, the navigator and the co-navigator must use different scales on their radars with the navigator usually monitoring the immediate situation and the co-nav looking further ahead. Safety corridor and look-ahead sector are decided already at the planning stage and included in the VP portfolio, depending on the ECDIS model they can also be visually displayed on the ECDIS screen. Look-ahead sector can be changed by the watchkeepers if deemed necessary.

[51] HESS-MS ECDIS on Board Familiarization

Depending on the make of the INS the bridge team has various tools to help them with monitoring, such as vectors, curved heading line and predictor. Chart underlay on the radar can give indication if there is an issue with a sensor, but in areas where there is a datum mismatch the operator needs to determine if the overlay mismatch is due to a sensor error or the quality of the ENC. The operators must understand and continuously evaluate the information provided by the system.

The watchkeepers are encouraged to develop a scanning pattern similar to airline pilots, enabling them to pick up any signs of malfunction at earliest possible stage. All faults do not trigger an alarm, and it is left to the watchkeepers to notice if something is amiss, e.g. a rudder indicator not working correctly can be detected only by comparing it to other indicators. Especially on older ships there might not be any alarms for significant changes such as steering mode. On some ships it is possible to accidentally change from trackpilot to hand steering without any alarms sounding, and the only way for the watchkeepers to recognize this change immediately is to monitor the Multipilot screen as the steering mode indication will change from “trackpilot” to “off”.

Alarm management is an important part of watchkeeping, and many of the alarms are related to either sensors, traffic or ECDIS therefore relating directly to voyage planning and monitoring. Bridge Alert Management (BAM)[52] distinguishes between four alert priorities, all of which are not applicable to voyage monitoring, but more to general watchkeeping duties. According to BAM the alert messages should be completed with aids for decision-making as far as practicable.[53] Every alert or alarm has to be acknowledged and investigated to identify the cause.

Chart alarm and echo sounder settings are included in the voyage plan, also the points where the settings need to be changed. Each watchkeeper chooses their preferred collision warning alarm settings. Sometimes alarms can present a distraction while not providing a relevant warning, and the bridge teams are allowed to mute or deactivate

[52] IMO MSC 302.(87) Performance Standards for Bridge Alert Management
[53] IMO Performance Standards for Bridge Alert Management MSC 302.(87) 8.1

the distracting alarms, but it can only be done by the Master's approval and the whole bridge team must be aware of which alarms are disabled.[54] Often modifying the threshold value is enough and the watchkeepers are allowed to do this if needed, e.g. the echo sounder alarm for sea passage is usually set for deep water, and if the track passes over an isolated shallow patch the alarm will go off. In this case the watchkeepers will adjust the echo sounder alarm temporarily and change it back to the original settings once past the shallow area. If there are larger areas with shallower water, then usually the voyage plan will treat these as a separate section in the UKC calculation form.

The INS has a built-in sensor monitor, which constantly compares sensors against each other and alerts the user if the difference exceeds the threshold limit. IMO recommends that officers should "undertake all available measures to check the position…such as radar and visual observation methods"[55]. This is normally done by using lines of position (LOP), mostly a radar bearing and distance, but two or more visual bearings can also be used. In areas where there is no ENC or RNC coverage available and paper charts are used for navigation, using LOPs in addition to other monitoring techniques such as PIs is paramount as ECDIS alarms and safety settings are not applicable. When sailing with paper charts the Carnival Corporation has laid down the minimum requirements for position fixing: in restricted waters the position fix must be made, if possible, every six minutes, in coastal waters every 12 minutes and in open waters once an hour[56].

Carnival Corporation requires that watchkeepers determine gyro error at least once a watch, if it is not possible then a compass comparison must be made to ensure that there is no creeping gyro error that goes undetected. When doing the gyro error also the magnetic compass deviation is checked.

In addition to all electronic equipment checks the Carnival Corporation instructs the watchkeepers to use also visual clues to monitor ships position, such as lighthouse

54 HESS-MS Integrated Navigation System
55 SN.1/Circ. 255Additional Guidance on Chart Datums and the Accuracy of Positions on Charts
56 HESS-MS Company Navigational and Watchkeeping Orders

characteristics. The Corporation standing orders requires the watchkeepers to inform the Master if a lighthouse is spotted in an unexpected place or its characteristics do not match what was expected[57].

According to IMO Guidelines one of the objectives of a voyage plan is protection of marine environment. Environmental considerations are part of the voyage plan, and monitoring discharges ensures that the plan is followed. The watchkeepers must be aware of which discharges are going overboard at any given time, and they need to keep an eye on the integrated control and monitoring system to double check that the ECR is doing the correct thing. Depending on the system the bridge team can see which valves are open, and which tanks are being emptied or filled and at what rate, giving them possibility to challenge the EOOW in case the actions do not seem to correspond with what was discussed. If the ship has an energy efficiency optimization tool such as Eniram, the watchkeepers need to monitor it and take action, e.g. (de)ballasting or changing engine configuration, to keep it in green. Exact engine configuration for a voyage cannot be pre-planned as it depends on several variables. STM gives an approximate guidance, but in the end the configuration depends on which engines are available, possible maintenance issues, environmental conditions, such as wind and current, and delays or changes to ETA.

Although the watchkeepers are solely responsible for monitoring the ship's progress, occasionally there is another pair of eyes doing the same job. Every HAG operating line has its own Fleet Operations Center (FOC), which gets live data from the bridge and various equipment on board enabling the FOC operators to monitor where the ship is sailing and what it is doing. They are able to see radar and ECDIS data on board, as well as the electronic logbook and status board. If the bridge is equipped with CCTV there is a possibility that the FOC gets also live feed from the camera. The main reason for FOC's existence is emergency preparedness. They are equipped to assist in various ways if any of the ships is in distress, like taking over the job of contacting any shore-side authorities or services allowing the vessel to concentrate on dealing with the emergency. Once a day the Stability Officer sends a copy of loading condition to the

[57] HESS-MS Company Navigational and Watchkeeping Orders

FOC, so that in case of an emergency they have stability data available and although damaged stability support is outsourced to a specialized company, the FOC is also able to provide advice and assist the vessel with stability calculations.

Since emergencies are rare monitoring the ships’ performance is part of their daily duties. If FOC spots something that does not look quite right, they will contact the ship and ask for clarification, for example they might recognize that wrong baseline has been used for environmental lines.

Monitoring is mainly understood to include ship’s progress along the pre-planned track and operational alarms, but at least on cruise ships the watchkeepers need to monitor also the bridge email, although it cannot be considered a navigational instrument or an alarm on operational conditions. Emails are naturally not checked during busy navigational situations, but if the time allows the watchkeepers are advised to check if there are any incoming messages that may affect the vessel’s voyage. Pilots and agents can send information which requires the vessel to take action and amend their voyage plan, usually adjusting the speed, but occasionally also changing the track.

4 SHORE-BASED VOYAGE PLANNING TODAY

Most of voyage planning today is still done onboard by deck officers. There are some projects trying to engage the shoreside operations more in the process, but often it is a question of ETA adjustments or efficiency, not a full-scale voyage plan. In the future when the unmanned and autonomous vessels will start operating, all stages of voyage planning from appraisal to monitoring are going to be done ashore or done by a machine. Although there already has been test runs with autonomous vessels, they have been short distances in a restricted area. The execution and monitoring phases will be part of deck officers' job description for many years to come, and it is likely that the appraisal and planning stages are moved to shoreside before unmanned vessels become a reality in large scale.

As of today there are no actors doing full-scale voyage planning shoreside, and it would also be quite challenging to achieve. The first step has been taken in many places around the world offering the seafarers ready-made passage plans for ports or coastal areas. However, it is not a question of a full voyage plan with all the details required, but a recommended track, sometimes with only waypoints and courses, sometimes including more details. IMO Guidelines require the VPO to consider ship specific data, but general passage plans are not able to accommodate this, although for example in the Great Barrier Reef there are three versions of passage plans depending on the vessel's draft.

These kinds of port passage plans are common in Australia and New Zealand, where many major ports publish them on their websites, for some ports it is possible to obtain the plans via agent. They are a recommendation, not requirement, but even if the ship's plan would deviate from the port's recommendation, the pilots will follow the local plan. For example in Sydney, Australia, the passage plans are meant for cruise ships only, although most likely the pilots use the same approach route for all vessels since it is a question of a relatively long pilotage, and the route to the cruise ship terminals will differentiate only in the far end of the harbor.

4.1 Fiordland, New Zealand

The Fiordland National Park is part of the Southland Region located in the southwest of New Zealand's South Island. Fiordland consists of several sounds and fjords in a remote wilderness area with very little population. It is a popular travel destination and cruise ships sailing in the area visit Milford Sound (a UNESCO World Heritage site, which is actually a fjord), and if the time allows, they will transit one or two of the other sounds for scenic cruising. The sounds are deep but narrow with tidal streams and swell from the ocean adding to the challenge of navigating in the area. Weather can be rainy and windy with winds gusting to over 70 knots even during the regular cruise season from October to April. A pilot is required for all the sounds, but due to the remoteness of the area there is only one pilot boarding ground in Milford Sound, and the pilot will stay onboard for the whole duration of the Fiordland transit (dis)embarking in Port Chalmers or Dunedin.

Environment Southland, which is the regional authority regulating maritime activity in the area, requires cruise ships operating in the Southland Region waters either to have a resource consent or they have to sign into the Deed of Agreement, which is the norm. The Deed places environmental obligations on the companies including a zero-discharge regime, and it includes regulations to manage the risks associated with ship movements in enclosed waters, for example by limiting the number of cruise ships, so that no more than two ships are in any passage or fjord at any one time.

Cruise ships sailing in Southland Region tend to be mid-size or expedition ships, as the area is not suitable for large ships. Number of visits by cruise ships has increased from 34 in 2006/2007 to 116 in 2018/2019, with 133 visits scheduled for 2019/2020 season. In the Milford Sound basin the local tour operators have 150+ scheduled movements every day adding to the amount of traffic in confined waters[58] with kayakers and private boats on top of that. As there is very limited accommodation available in Milford Sound, most visitors come for a day and due to long distance to

[58] Cleaver, Lyndon

the nearest town, all the visitors tend to congregate during roughly the same hours creating congestion.

In February 2017 cruise ship L'Austral struck a stony bank during entry to Milford Sound narrowly avoiding significant damage to the vessel and environment. Although the accident was mainly attributed to a lack of proper BRM, there were several contributing factors, as usual. The New Zealand Transport Accident Investigation Commission identified issues with planning, execution and monitoring stages of the ship's voyage plan. Although the track itself was similar to the Fiordland Pilotage SOPs, the ECDIS was not configured properly, the ship was off the planned track, and there was no agreement on reserve, i.e. how far off the track the ship would be allowed to deviate. Key lessons include a note that "a ship's passage plan is more than just the planned track for the ship to follow. Every part of a ship's voyage must be planned, and all members of the bridge team be fully familiar with and agree to the plan. This is a cornerstone of good bridge resource management"[59]. At the time of the accident it was dark, and as there are no visual navigational aids in Milford Sound the ship was solely relying on electronic navigation equipment. According to the TAIC "conducting 'blind pilotage' with large ships in confined waters represented risks that had not been fully considered by Environment Southland"[60]. After the accident Environment Southland has improved their safety management system for cruise ships, and as part of that started to enforce their passage plans.

The passage plans were initially originated already in 2008 by both Environment Southland and Maritime New Zealand, the maritime regulator in the country. The actual passage plans were put together by experienced Southland pilots and pilot auditors from Maritime New Zealand. Environment Southland has published Pilotage Standard Operating Procedures, which include passage plans for all the sounds allowed for cruise ship transit. The plans are available on their website, and the agents are supposed to pass them onto the ships as part of local regulations. These general passage plans are more extensive than government agency plans tend to be including not only

59 TAIC Final Report MO-2017-202 / 1.9
60 TAIC Final Report MO-2017-202 / 1.6

waypoints, courses and distances, but also WP radius, recommended speed, ROT, PIs, WOPs with range/bearing, and waypoint notes. The pilots have their own Portable Pilot Units (PPU) and the actual passage plan is agreed to during the master/pilot exchange, but it is preferable if the ship's voyage plan is identical to the pilot's from the beginning so that the whole bridge team has a shared mental model.

4.2 The Great Barrier Reef, Australia

The Great Barrier Reef (GBR) was the first ever Particularly Sensitive Sea Area (PSSA) named by IMO, today also the adjacent Torres Strait and Coral Sea are included. Sections of the reef are complex to navigate with confined waters and strong tidal streams, and to help to protect the GBR a Designated Shipping Area (DSA) is charted throughout the GBR, penalties apply to vessels that enter any other zone outside the DSA. REEFVTS monitors 6000km of coastline. Traffic conditions in the GBR area are generally light when compared to the major shipping routes in Asia and Europe, the REEFVTS monitors over 11,250 vessel movements per year over the vast area[61]. Parts of the GBR are remote, and subsequently VHF coverage is limited in some areas. All vessels are required to set up their Inmarsat-C so that they can receive messages from VTS for ship encounter information and maritime safety information. The ships are required to send their general route plan in the pre-entry report. There are no intermediate position reports required, as the vessels are continuously tracked by radar, AIS and Automated Position Reports (APR) via Inmarsat-C, comparing this data to the route plans provided by the vessels in their pre-entry report.

Since 2011 the Australian Maritime Safety Authority (AMSA) has published the 102-page long document Queensland Coastal Passage Plan (QCPP), which covers the GBR and Torres Strait area[62]. The purpose of the QCPP is to "improve pre-pilotage communications between coastal pilotage providers, the vessels they service, and the pilots embarked within these vessels. The QCPP improves the readiness of vessels

[61] https://www.amsa.gov.au/safety-navigation/navigating-coastal-waters/great-barrier-reef-and-torres-strait-vessel-traffic (Referred 27.6.2019)
[62] Adams, Conrad

transiting coastal pilotage areas within the Great Barrier Reef and Torres Strait by ensuring that voyage plans, waypoints and other planning considerations have been completed in a standardized manner"[63].

The coastal pilotage area does not cover the whole GBR and pilot is required only for certain parts of the passage. Depending on the ship's speed and route, the passage through GBR can take up to 48 hours. Normally only one pilot will board for the whole length of coastal pilotage, and pilots will routinely leave the bridge when the vessel is transiting the less complex or less navigationally challenging areas. Even when the pilot is on the bridge often the OOW will maintain the conn.

According to the Australian law the pilot must "prepare a detailed passage plan for the pilotage of a ship that uses the approved passage plan model, specific to the ship being piloted"[64]. The QCPP is this plan, and AMSA encourages the vessels to prepare their voyage plans accordingly. Usually the pilot will contact the vessel a couple of weeks prior to the transit and ask the vessel to forward their voyage plan so that it can be checked beforehand. In places where there is more than one route alternative, the QCPP gives three different options depending on the vessel's draft: shallow (<7m), moderate (7-10.5m) or deep (>10.5m). The passage plans include waypoints, courses, distances and PIs, plus a couple clearing bearings for deep draft vessels. Torres Strait has variable and complex tidal system, with large tidal range and streams up to eight knots. Australian regulations permit vessels of up to 12.2m static draft to transit the Torres Strait if they are maintaining the nominated UKC requirements. The UKC management system predicting a vessel's dynamic UKC in real time is in use, using data from environmental sensors, and it is obligatory to all vessels with draft exceeding 8m.

Since the pilot is required to be on the bridge for certain sections only, the QCPP includes instructions on points when the OOW should call the pilot, and usually the pilot will ask these points to be marked on ECDIS. VTS entry/exit reporting points are

63 QCPP page 8
64 QCPP page 8

also marked in the QCPP planning chartlets. AMSA encourages vessels transiting any of these coastal pilotage areas to consider the information contained within the QCPP when preparing their voyage plans, and to ensure that the QCPP is available on the bridge.

4.3 Norwegian Digital Route Service

Norwegian Coastal Administration (NCA) has a bit more ambitious project in the testing phase. NCA has made reference routes covering ports and coastal passages in southern and southwestern Norway, all of Norway should be included in the digital route service in 2020. Reference routes are available for downloading free of charge, and unlike other government-provided plans, which usually come in an Excel or PDF format, the Norwegian reference routes are in RTZ format which can be loaded in the ECDIS directly thus minimizing a chance of errors. NCA has used vessel dimensions of 150m LOA and 9m draft for the routes, and turn radius of 0,1NM has been used on most waypoints[65]. Due to these parameters the reference routes cannot be used directly on larger vessels without amendments. There are also routes for large cruise ships, but at the moment only to Stavanger and Haugesund. For these routes the dimensions of all cruise ships which have called the given ports have been taken into account.

The Norwegian digital route service is taking a step further when it comes to providing the user with useful information. Unlike many other shore-based plans where all the routes follow the centerline of the fairway, in Norway the in- and outbound routes are separated where possible using the whole fairway area thus making the traffic situations easier for the watchkeepers allowing them to follow their track without deviating too much in meeting situations. During the planning phase the VPO is supposed to identify the navigable waters and mark the no-go areas but depending on the quality of the planning this might not be done, and a preliminary track taking this into account will make the work easier for the bridge team.

[65] https://www.routeinfo.no/ (Referred 28.11.2019)

In addition to routes all ports, port facilities and quays in the area are listed, and clicking on a port or a dock a list of routes to and from the dock come up together with the UN LOCODE. If the facility owners would cooperate with NCA dock information could be added to the service, as for now all the information provided comes from NCA. On the route info website the user can choose a visual display of base map, chart or ENC. Clicking on a route opens a list of VTS information and local regulations applicable to that route giving the user a good overview. At this time the system is still in the testing phase and information provided is quite limited not covering everything, e.g. speed limits are not mentioned at all, and most local regulations deal with maximum draft allowed or restrictions on passing other vessels. If all information related to a route was included it would ensure that the VPO had easy access to all relevant information.

4.4 Shore-based voyage planning in Finland

Today Finland does not provide shore-based voyage planning in form of preliminary routes. ENSI (Enhanced Navigation Support Information) project provided tankers sailing in the Gulf of Finland with a way to share their route plans with the VTS enabling the VTS to check the routes and offer feedback in order to prevent accidents. As part of the service the vessels received other relevant information from the VTS, such as ice, traffic, environmental condition or port information. This required internet connection and a suitable PC or tablet. The original aim of the project was to expand the service to all vessels, but it was discontinued in 2019 as the ships did not feel it provided any added value.

The voyage plans for sea trials at Meyer Turku are made by the shipyard project outfitting manager together with sea trial masters who come from Finnpilot. Pilots are familiar with the fairways and they are responsible for conning the vessel out to sea. The actual sea trials are conducted on the open sea in the northern Baltic, but the shipyard does not make a detailed voyage plan for this part as there are many variables influencing the trials. The vessel does not enter any other state’s territorial sea are, but otherwise there are no restrictions for the trial area. The shipyard makes a preliminary plan for the test sequence, but as many tests require certain conditions, such as wind speed or wave height, the test sequence needs to be modified often and thus the voyage plan can be amended several times a day.[66]

As per Pilotage Act “the pilot shall present the master of the piloted vessel with a passage plan based on up-to-date charts and any other information and instructions necessary for the safe passage of the ship”[67]. In Finland the pilots are required to be able to utilize the whole fairway area. Finnpilot has a comprehensive route bank including waypoint radii and XTE-areas, pilots have access to the route bank, and they can adjust the routes as they wish. The ships have their own tracks, but the quality of passage planning varies from ship to ship, sometimes the vessel has planned the route using small craft fairway for example. If a vessel’s route plan differs greatly from the pilot’s the pilot must be able to justify why they want to use their own plan, but generally there is a clear reason for this, and vessels accept it.[68]

A Swedish study on shore-based pilotage noted that if the crew is well-prepared, the pilot could be a more passive role, more supporting the crew’s decisions than helping to make them[69]. In Finnish waters the depths can vary within the fairway area and a route running over a 10m patch would not be suitable for a vessel with a deeper draft, while going around the same patch would not make sense in case of a smaller vessel. How to navigate in areas like this is left to each pilot’s discretion.

Remote pilotage is not yet available in Finland, but legislation has been recently changed (2019) to allow testing of remote pilotage in certain restricted fairway areas subject to permit. Shore-based or remote pilotage is pilotage where the pilot is still responsible for pilotage although s/he is not be on board the vessel, it is not same as navigational assistance provided by VTS. Most countries with shore-based pilotage offer it only as supplementary service used in case of bad weather preventing the pilot from embarking safely. Finnpilot has started preliminary work for testing shore-based

[66] Klami, Laura
[67] Pilotage Act 8§
[68] Taipale, Olli
[69] Bruno, Karl & Lützhöft, Margareta

pilotage, and some tests have been run in a simulator, but the project is just in the beginning[70].

VTS Finland is equipped to provide all levels of VTS service: Information Service, Traffic Organization Service (TOS) and Navigational Assistance Service (NAS). As per Finnish law VTS is allowed to give navigational assistance to vessels if it is required by navigational situations or challenging weather or ice conditions, but assistance is only advisory and is provided within the VTS areas at open sea to the vicinity of pilot boarding places and outer anchorages.[71] In daily operation the VTS supports safety of navigation by providing information to ships and monitoring their progress, warning them if they seem to be running into danger.

Archipelago VTS is involved in an e-navigation implementation project called EfficientFlow, which intends to help to optimize the traffic flow in restricted waters between Turku and Stockholm by sharing real-time voyage plans from participating vessels. VTS Finland is also going to participate in another e-navigation project related to voyage planning, STM BALT SAFE, which is aimed for tankers sailing in the Baltic, and it is testing and developing electronic route plan exchange both ship-to-ship and between ships and ship reporting system centers including automated reporting. As part of the ongoing e-navigation development VTS software is updated to allow the use of e-strips[72], so that the VTSO always has the most up-to-date information available.

[70] Taipale, Olli

[71] Vessel Traffic Service Act 2 Chapter 6§

[72] E-strips are similar to the method used by air traffic controllers for information management. Each ship in the VTS area has an e-strip where information about ETA, berth assignment etc. appears. E-strips are connected to Finnish PortNet-system so all information in PortNet updated by agents or ports will appear automatically on vessel’s e-strip. The VTSO sees the strips on their screens and moves them between categories when needed, e.g. vessel is docked or leaves the area, so that the VTSO has an overview which vessels are moored within a port or are sailing within their sector.

5 E-NAVIGATION

IMO defines e-navigation as "*the harmonized collection, integration, exchange, presentation and analysis of marine information on board 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*"[73]. E-Navigation is a broad concept involving both shipboard and shoreside operations, and it encompasses also parts of the voyage planning process.

E-navigation's goal is to provide tools to make navigation and communications more reliable and user friendly by for example standardizing bridge design, navigation equipment, information structure and formats used at the same time providing support for decision making while reducing the workload.

5.1 IMO e-navigation strategy

IMO's strategy summarizes the advantages of e-navigation seen from the VPO's point of view: "*Mariners require information pertaining to the planning and execution of voyages, the assessment of navigation risk and compliance with regulation. This information should be accessible from a single integrated system*".[74] Standardization increases similarities in operation between nations and vessels, which in turn will increase safety and efficiency, reducing risk of accidents. One the objectives of IMO's Guidelines for Voyage Planning is to increase efficiency and to protect the marine environment, and e-navigation will aid this by using dynamic route planning and coordinated arrival times thus reducing steaming distances and ensuring just-in-time arrival together with voyage planning tools, such as software with artificial intelligence-aided planning, that help identifying navigational hazards.

[73] IMO MSC 85/26/Add.1, Annex 20, 1.1
[74] IMO MSC 85/26/Add.1, Annex 20, 8.2.1

IMO's e-navigation Strategy Implementation Plan (SIP) introduces five e-navigation solutions[75]. The first solution, S1, is harmonized bridge design including Integrated Navigation System (INS) performance standard. Standardized mode of operation (S-mode) for all navigational equipment would ensure that relevant information is displayed using symbols and terminology familiar to all users making it easy for the bridge team to operate the equipment and understand the presented information. This includes for example standard default settings, complying with IMO's Bridge Alert Management (BAM) performance standard and indication on information accuracy and reliability.

S2 is to standardize reporting, and as far as possible, make it automated to reduce non-navigational work of the bridge team. This can be achieved for example by automated collection of internal ship data and standardized formats for ship reporting agreed by Administrations in order to enable "single window" reporting worldwide.

The third solution, S3, seeks to improve reliability and integrity of bridge equipment and navigation information including indication when the equipment is not working satisfactorily. To achieve this a standardized self-check/built-in integrity test (BIIT) should be developed. Ensuring reliable and resilient Position, Navigation and Timing (PNT) data is essential and performance standard for PNT data processing should aim for consistent approach to avoid differing systems in different regions.

S4 covers integration of information received via communication equipment and presentation of it in graphical displays such as radar or ECDIS. Common Maritime Data Structure should be developed together with standardized interfaces for data exchange to enable transfer of information from communication equipment to navigational systems.

Harmonized and improved communications between shore and ships regarding information related to maritime services is the fifth solution, called S9. The aim is to identify the possible communications methods that might be used, such as maritime

[75] IMO E-Navigation Strategy Implementation Plan

cloud. Maritime Service Portfolios (MSPs) include a variety of shore-based services such as VTS, SAR, MSI, chart update service, weather forecast providers, etc. who all produce information that needs to be disseminated to ships in an efficient and timely manner, and services required by vessels such as pilotage and tugs.

Solutions S2, S4 and S9 focus on efficient transfer of information and data between users, both ship and shore, while solutions S1 and S3 are meant to improve the way how the information is used on board.

In short, e-navigation systems should strive for the same objectives as any other navigational system: support good decision making, improve efficiency and prevent single person error. If the bridge team has easy access to relevant information, they will be able to respond and to solve problems easier. To achieve this IMO suggest that all shipboard systems should include analysis functions to "support the user in complying with regulations, voyage planning, risk assessment, and avoiding collisions and groundings including the calculation of Under Keel Clearance (UKC) and air draughts"[76]. Also shore-based systems such as environmental impact, incident preventions or risk assessment should support analysis function.

IMO has identified Risk Control Options (RCOs) which are broadly defined measures helping to assess e-navigation solutions. IMO's e-navigation SIP identifies seven RCOs[77]:

1. Integration of navigation information and equipment including improved software quality assurance,
2. Bridge alert management,
3. Standardized mode(s) for navigation equipment,
4. Automated and standardized ship-shore reporting,
5. Improved reliability and resilience of onboard PNT systems,
6. Improved shore-based services,
7. Bridge and workstation layout standardization.

76 IMO MSC 85/26/Add.1, Annex 20, 8.2.7
77 IMO E-Navigation Strategy Implementation Plan p.23

The RCOs include measures that call for usable, reliable and resilient systems on board with centralized and standardized presentation of information. New means of PNT and increased automation together with automatic and digital distribution of information from shore-based stakeholders would help the development and implementation of e-navigation solutions.

5.2 Implications of e-navigation for the VPO

E-navigation can make the VPO’s job easier both in the appraisal and planning stages. If all information is accessible from a single system, it is less likely that any important information is overlooked, and time spent on planning will decrease. Today information still needs to be gathered from several sources, although some countries have websites that try to offer a single window access to government provided data. In Canada e-Navigation Maritime Information Portal website provides information on e.g. charts, tides, weather, ice conditions, navigational warnings and notices to mariners. However, the website is not fully operational and some of the information is easier to find in BA publications. If a ship passes through several areas or countries during its voyage the VPO would need to search for information on several websites if all countries chose to publish the information in this way. The risk with relying too much on internet-based services is that ships without internet do not have access to the information, and if the website provider is not diligent in keeping the site updated the users can be faced with annoying problem of clicking links that refer to non-existing pages, which is a problem with for example Canadian Maritime Information Portal.
Easy access to reliable and fail-safe environmental data (such as wave and current forecasts, water level and buoy status) supports decision making on board when deciding which route to take or if the conditions are so bad that the passage should not be attempted at all.

Under Keel Clearance Management systems (UKCM) are used in many ports and areas, particularly in Australia, where shallow waters combined with complex tidal conditions can make navigation on deep-draft vessels challenging. UKCM system uses ship’s actual stability information together with hydrodynamic modeling of the area in order to predict the dynamic motion of the ship such as squat and heel. This information is then combined with the latest bathymetry and observed data from environmental sensors, like tide, tidal stream and wave sensors, calculating an accurate estimate of a ship's UKC in real time. The system allows pilots to plan and monitor safe passages of large vessels.

Execution phase is where the advantages of e-navigation has been seen already in some countries. Harmonized and simplified information exchange will reduce reporting requirements, and automated and standardized reporting will ensure that all reports that need to be sent are remitted in time thus reducing navigators' workload. One example is Australian MASTREP (Modernized Australian Ship Tracking and Reporting System) covering the whole Australian coast[78]. All reporting requirements are fulfilled by AIS and ships do not need to report by radio or any other means. In the GBR area information about expected traffic situations is communicated to the ships via Inmarsat-C.

Norway uses SafeSeaNet[79] as a single window reporting portal from ship to ports and authorities shoreside. It includes various mandatory information from pilot ordering and border crossing notifications to security notifications and waste declarations. The ship's agent fills in some of the information on their part, such as pilot orders, and the ships can see this when they log in. SafeSeaNet is meant to do exactly what is one of the objectives of e-navigation: reduce administrative workload and the number of notifications. According to the Norwegian Coastal Administration the number of the notifications from ships to authorities has been reduced from 330 000 to 85 000 (74% reduction) since 2004 when SafeSeaNet Norway was first introduced.[80]

The problem with the Norwegian SafeSeaNet is that it is built from the shoreside users' point of view. Although the website looks simple enough often ships have difficulties to fill in required information and need assistance from the agent. Another drawback

78 ADRS 6

79 SafeSeaNet is "a vessel traffic monitoring and information system" which "enables European Union Member States, Norway, and Iceland, to provide and receive information on ships, ship movements, and hazardous cargoes" (EMSA, Referred 13.5.2020)

80 https://www.kystverket.no/ (Referred 9.12.2019)

is that SafeSeaNet requires internet access, and in many parts of Norway this is not possible due to satellite coverage, meaning that either the report cannot be sent at all or the ship needs to send an email to the agent with all the details required and the agent will fill in SafeSeaNet.

Some systems implementing e-navigation principles, such as Sea Traffic Management, allow compliant ships to see each other’s planned routes improving the navigators’ situational awareness, especially in coastal or otherwise restricted waters, and giving them a better picture of how other vessels around them may influence their voyage and thus allowing watchkeepers to be proactive and plan their maneuvers ahead of time.

Monitoring of a voyage plan will also benefit from e-navigation. It is normal for a bridge to have hundreds of alarms relating to not only navigation, but also technical systems, communication and, in some cases, cargo. These alarms are usually located all over the bridge, and often give little indication of severity of the problem, which can become a distraction as the watchkeepers need to interrogate every alarm to find out if it can be disregarded or if immediate action is required. Standardized functions between various manufacturers would improve navigators’ ability to monitor alarms without being distracted from the task of conning the vessel, especially watchkeepers new to the vessel would benefit from standardization. Also, integration would make alarm monitoring easier, for example presenting all navigation related information on ECDIS instead of separate Navtex or AIS screens.

Monitoring is not something that is done only on board by the watchkeepers. Ship’s passage is monitored also by various shoreside actors using different grades of technology ranging from reports made by VHF to radar surveillance and automated tracking. NCA is developing systems for dynamic risk monitoring, which should help to identify potentially dangerous situations and risk vessels as early as possible enabling the VTS to intervene. Dynamic risk monitoring is an automated system that analyzes vessels’ sailing pattern in real time based on traffic data available today[81]. This data is then combined with a static analysis of risks based partly on different

[81] Hagen, John Erik. Implementing e-Navigation, p.114

parameters such the number of passengers, type of cargo, or earlier recorded events. Sometime in the future a system that gives automatic notice to the ship running into danger could be developed.

In near future artificial intelligence and augmented reality will provide additional assistance to navigators, but to facilitate the work on board the technology should be based on users' needs, otherwise it is more likely to increase the workload and add to distractions instead of improving safety.

5.3 Sea Traffic Management

Sea Traffic Management (STM) is a concept defined in MONALISA 2.0-project. It is one of several projects worldwide that has concentrated on exchange of information both on board and ashore, which is essential in e-navigation. In the MONALISA 2.0-project three improvement phases were identified, and these were used as a base for STM[82]. During the improvement phase 1 the planning of the voyage is expected to benefit from digitalized information and standardized route format. The next improvement phase, expected to run 2020-2025, introduces information sharing platform SeaSWIM, which provides supporting services and allows authorized actors to access to the voyage plan decreasing the need for emails, it will increase the verification of routes as well. Shore-based service providers, such as VTS or route optimization services, are able to offer improved service as they will have access to all needed information. Improvement phase 3 will introduce STM-services integrated into shipping companies planning systems, and new actors can be expected to emerge, providing complex voyage optimization support and route verification services. Many monitoring tasks will become more automated and third parties can offer services such as route check and optimization.

STM is based on information exchange and this includes also looking into how the maritime single window reporting could be adjusted to permit automatic handling of

[82] STM Master Plan

information, like pilot ordering[83]. A global maritime digital infrastructure should allow sending and receiving standard messages seamlessly. In STM information owners select who can see their data, so that business sensitivity issues are avoided.

STM Validation Project, which finished in 2019, looked into current maritime transport systems, operations, and interactions between maritime actors focusing on berth-to-berth voyage. The aim was to develop data sharing services to allow maritime stakeholders on board and ashore to make decisions based on real-time information[84]. Services could include for example route optimization services, ship-to-ship route exchange, port call synchronization and enhanced monitoring.

STM relies on four enablers:

1. Port Collaborative Decision Making (PortCDM) is meant to support just-in-time operations within ports by gathering all available information and using this information to create a common situational awareness for all actors. To achieve this continuous interaction is required by the actors involved in a port call.

2. Voyage Management deals with both the planning stage and monitoring the execution of that plan. It involves decisions about a voyage, such as route of a ship and its interaction with other vessels in its vicinity. The goal is improved route planning, route exchange, and route optimization before and during the voyage, and to achieve this voyage management offers tools to connect ships, add intelligent processes and provide secure and transparent information exchange to all stakeholders.

3. Flow Management seeks to optimize the traffic flow in congested or navigationally challenging areas by providing support to both VTS control and

[83] Koivisto, Heikki
[84] STM Validation Project - Final Report p.98

ships. Coordination and information sharing are used to build situational awareness and enhance decision-making.

4. Sea System Wide Information Management (SeaSWIM) provides a "framework for the harmonization of data formats and standards for information management and operational services"[85]. SeaSWIM includes for example the Maritime Connectivity Platform (MCP) which combines the Maritime Service Registry where all STM services by various providers are registered, and the Maritime Identity Registry where all users are authenticated.

STM Validation project was a testbed for various e-navigation systems both in simulated environment and in real life. The testing phase involved six shore centers, nine ports, 12 simulator centers and 311 ships. STM Validation project validated the following services[86]:

- Route Cross-check, the intended voyage plan is sent to a shoreside service provider for cross-checking,
- Route Optimization, the means to optimize ship's route in reference to different environmental or traffic parameters,
- Ship to Ship Route Exchange, to increase situational awareness and enable the OOW to plan ahead,
- Baltic Navigational Warnings, allows only those navigational warnings that are relevant to the ship to be sent directly to ECDIS,
- Enhanced Monitoring, sharing the ship's planned route with VTS,
- Port Call Synchronization, port will provide the vessel with information to allow it to arrive just-in-time,
- Port Call Optimization, key actors within a port sharing their plans with the whole process chain to improve resource utilization,
- Winter Navigation, information about routes, convoys, etc. preferably transmitted directly to navigation system,

[85] STM Validation Project - Final Report p.10
[86] https://www.seatrafficmanagement.info/stm-services/ (Referred 17.4.2020)

- Importing Pilot Routes, importing and merging the routes,
- Search and Rescue, MRCC will be able to send areas and routes directly to SAR-units' navigation system.

Information exchange in form of route sharing plays an important part in STM. Enabling route sharing both between ships will allow ships to make decision at longer range than only the conventional monitoring of the surroundings makes possible. Ship-to-ship route exchange will provide the next seven waypoints of another vessel and the route segments are broadcast via AIS[87]. Shore-to-ship route exchange allows the VTS to send a route suggestion to the vessel. The VTS can also cross check a ship's route against navigational hazards, and if the vessel deviates from their planned route or schedule the VTS can monitor and challenge the vessel.

From the STM route template service vessels can download routes used by the pilots thus enabling the VPO to plan the route without needing to re-plan it later and allowing the bridge team to share the same mental with the pilot. The analysis has shown that STM services are beneficial in areas where ships are able to navigate fairly freely without being constrained by other traffic or no-go areas, however, the value of available STM services in areas with regulated traffic could not be proved[88].

STM services were tested in simulators to find out benefits and risks from the seafarers' point of view. Generally the mariners had a positive attitude towards STM, providing that safety has priority over costs, and that they will receive training for using the services. The ECDIS/STM client interface received some negative comments during the simulation exercises for being not very user-friendly, but this is understandable as the STM Validation Project established the groundwork on which the services will be developed and built upon[89].

End-user feedback for the STM Validation Project indicates that digital information sharing can improve situational awareness and operations both on board and shoreside.

[87] Aylward, Katie, p.12
[88] STM Validation Project - Final Report p.6
[89] Siwe, Ulf, p. 3

Result from simulator studies suggest that STM services may improve communications and decrease bridge team workload, giving the navigators more time to respond to challenging situations. Workload for other actors than the bridge team might increase as some services are not aiming to reduce the workload, but for example enhance shoreside operations or promote safety[90].

The project resulted for instance in STM solutions developed by several ECDIS and VTS manufacturers, new standards for message formats which are in progress of being approved, and a STM clause adopted for standard charter parties by BIMCO[91]. Some of the operational services developed during the project will remain operative including the Nordic Pilot Route Service (NPRS), navigational warnings in the Baltic Sea and winter navigation services, which all provide information relevant for a specific route and time in opposite to regular broadcast to all ships.[92]

One result of the STM validation project is establishing of the International PortCDM Council (IPCDMC) which is to provide an international governance body for STM in ports. IPCDMC is promoting harmonized collaboration and data sharing of port-call operations globally by having in place various measures such as a standard for port call message format S-211 or a system of indicators and warnings allowing actors to coordinate actions[93].

Concepts defined in Sea Traffic Management are used in several ongoing implementation projects, and some future projects are in the planning phase. Real-Time Ferries (RTF) uses the on-board knowledge of delays to inform their customers about the changes to the schedule. BALT SAFE provides STM services to tankers in the Baltic, and in the first phase 50 tankers will have their ECDIS updated to be able to exchange their routes both with each other and VTS. VTS centers in Finland, Sweden and Estonia will also have their software updated for the same purpose.[94] VTS

90 STM Validation Project - Final Report
91 https://www.bimco.org (Referred 18.4.2020)
92 STM Validation Project – Final Report p.6
93 www.ipcdmc.org (Referred 19.4.2020)
94 https://www.seatrafficmanagement.info/news/wartsila-contracted-to-install-route-exchange-on-50-ships/ (Referred 25.4.2020)

Finland or GOFREP do not yet provide fully automated and standardized ship-to-shore reporting in accordance to IMO's e-navigation RCO 4[95], although some of the information is received automatically from PortNet the ships still need to report to the traffic control on VHF.

In order for STM services to work effectively collaboration is required throughout the whole shipping industry. A non-profit industry consortium, Navelink, was founded by Kongsberg, Saab and Wärtsilä in December 2019 and run by Combitech aims to develop and operate infrastructure for the STM ecosystem, working together with relevant authorities, partners and other actors. The infrastructure is an open platform and is pushing for development and implementation of international standards trying to accelerate digitalization in the maritime sector and provide a common basis for delivering services and develop software.[96]

5.3.1 EfficientFlow

EfficientFlow is one of the ongoing projects, and among its objectives is the aim to develop new e-navigation services in order to optimize traffic in restricted waters between Finland and Sweden, mainly in Turku and Stockholm archipelagoes. Better coordination of meeting, overtaking and crossing situations is to be achieved by information exchange ship-to-ship and ship-to-shore, but the final operational decisions are still left to the master. Information will be provided to all ships during the planning and execution stages of their voyages[97].

A key player in EfficientFlow is a shore-based operator, in practice VTS, who has a complete traffic image together with the planned routes for the participating ships. Today VTS in Finland connects all ships sailing in the VTS area to a route in their own system enabling the operators to simulate ships' ETA to key waypoints. This

[95] IMO E-Navigation Strategy Implementation Plan
[96] https://www.seatrafficmanagement.info/news/industry-consortium-contracted-to-run-stm-infrastructure/ (Referred 23.4.2020)
[97] EfficientFlow Concept of Operations 2.3

information is then passed on to the ships so that they can make their own arrangements. When STM technology becomes available to ships, vessels that are equipped with it will be able to calculate where meeting/overtaking will take place and determine what speed would be best to avoid meeting in a narrow place, having this information they can then agree on passing arrangements. The system could be used also to synchronize approaches to port although this is generally not a big problem in Finland. In order to optimize arrival time the speed should be adjusted earlier than after the pilot station.

Both ships and shore operators participating in EfficientFlow require a certain type of software that enables them to share the information in real time. ECDIS on board should be able to receive routes from other vessels and use these routes to calculate meeting positions taking into account speed limitations. If a fairway is closed for some reason the shoreside operator can suggest a new route. If vessels are able to calculate the meeting position themselves, it would decrease radio communication from VTS. In the EfficientFlow study made in Stockholm archipelago, some vessels found the amount of communication from VTS too frequent and disturbing, although most users were happy with it[98].

The software used by VTS Finland gives warning if a vessel exceeds the speed limit, but the advantage of STM is that VTS will see the vessel's planned speed calculated in the voyage plan, and that speed can be used in simulation of meeting positions. STM-compliant VTS software should also give warning if the planned speed is more than the speed limit.

Fairways leading to Finnish ports are generally narrow and meeting/overtaking is prohibited in certain areas. VTS-software gives a warning to the operator if meeting is expected in a restricted area, and the information is then passed on to the ships. VTS Stockholm does not have this service, but the pilots can calculate the meeting point on their PPUs, although the calculation is done only using ships' actual speed, not the planned speed. With STM-compliant equipment the role of VTS as intermediary will

[98] EfficientFlow Report on Traffic Analysis and User Needs

decrease as ships will be able to do the simulation on board and the accuracy of the simulation increases in some cases when the system allows planned speed as parameter[99].

Testing phase for EfficientFlow is ongoing and is expected to end in November 2020. Pilots' have received PPUs that can be used for the information exchange, and VTSs in Finland and Sweden have software that can perform the tasks required. 15-20 vessels, mainly ferries, have STM functionalities installed in their navigation system. During the testbed user feedback will be collected together with traffic analysis to identify user needs onboard and on shoreside. Ship simulators may be used for testing to collect feedback in a controllable environment.[100]

[99] If only actual speed is allowed for the simulation the calculation will not be accurate if the vessel has not got the speed up after departure or has slowed down for some reason.
[100] EfficientFlow Concept of operations document 5.2

6 SHORE-BASED VOYAGE PLANNING IN THE FUTURE

On many ships the deck officers doing the planning feel that they do not have enough time to do it properly. On cargo ships the VPOs might not see the need to document the voyage plan in every small detail the same way as on cruise ships, and the quality of the plan might be not as high. Naturally, cargo vessels require less information in their voyage plans than cruise ships do as their itineraries are generally less complex and they do not need to take into account any activity resulting from having thousands of people on board.

Often the ships within a company share their routes with each other when required if the INS make and model make it possible, but not all models allow saving the routes in a format that can be read by other types of INS. In larger companies or on ships with varied itinerary the VPOs would benefit greatly from having part of voyage planning done shoreside. For example Carnival Corporation has 100+ ships with 100+ voyage planning officers doing planning for the same routes over and over again. The corporation does assist voyage planning a bit by providing an environmental matrix listing allowed discharges. The matrix is a great help for the VPOs, as it would be difficult, even impossible, and time consuming to try to find out specific environmental regulations in various countries and areas the ship is sailing in.

If the company would provide pre-planned routes including UCOs for environmental limits, the workload for VPOs would decrease noticeably, especially on ships in worldwide trade and varied itineraries. Although tracks made shoreside would still need to be checked and adjusted on board to suit the ship, having preliminary tracks would give more time for the VPO to concentrate on parts of voyage planning which are ship specific, such as environmental schedule or docking plans. Drawing environmental lines takes considerable time and there is a risk for errors. Although more and more countries include their baselines in ENCs, many do not but instead provide a list of coordinates with positions in minutes and seconds. Manually entering tens of coordinates in ECDIS is asking for mistakes, when errors could be eliminated by using ready-made, checked UCOs. Many deck officers in Carnival Corporation operating lines have voiced a wish that the company would take more ownership in voyage planning.

Voyage planning partly done shoreside will probably become more common in the future when demands set for a voyage plan increase while the number of officers on board does not, and as artificial intelligence-aided software becomes more common it could enable shoreside personnel to become more involved in the planning process. Nothing in IMO's guidelines for a voyage plan ("the development of a plan … and monitoring of the vessel's progress"[101]) stipulates that the plan must be made or executed on board.

On manned ships execution and monitoring will still be done on board, but there is nothing preventing appraisal and planning stages from being done at least partially elsewhere. When the degree of automation increases also part of monitoring will be transferred to a shoreside operation center, and a service provider could sell ready-made plans also to shipping companies. Extensive shore-based planning is not reality yet, but planning assisted by e-navigation –related technological developments is already making VPOs' lives a bit easier.

IMO is working on standardization of INS, radar and ECDIS displays in order to harmonize the way information is presented. The improvement is meant take effect in January 2024, with all other displays on the bridge to follow from July 2025. The intention is to integrate e.g. regulatory information and weather so that information is available in one window. This will make the appraisal stage of voyage planning simpler and faster as the VPO does not need to gather all the necessary information from several sources. Having the ability to display new or local regulations on screen is a clear advantage as it will allow the VPO to have accurate knowledge of various regulatory regimes, information that is not always easy to find. As per IMO e-navigation SIP RCO3: "*Safe navigation relies on the ability of key personnel of the*

101 IMO Resolution A.893(21) – Guidelines for Voyage Planning 1.1

bridge team to easily operate navigational equipment as well as to comprehend the information that is presented to them"[102].

New standards for ECDIS will allow applications such as time-varying data, information exceeding traditional hydrography such as tides and currents, or use of web-based services for acquiring, processing, analyzing, accessing and presenting data. Some standards are already in testing phase such as UKC Management systems or Marine Radio Services [103]. For example, NOAA is currently developing products and services which will allow existing software to automatically read and process NOAA marine navigation data, such as surface currents and high-resolution bathymetry[104].

Artificial intelligence-aided planning and autonomous vessels are not strictly speaking "future" as the technology exists already and is available for commercial use. However, the technology is not yet widespread, and its importance will only increase with time to come, but the world's first company to operate autonomous vessels, Massterly, has already been established by Kongsberg and Wilhelmsen[105].

6.1 Artificial Intelligence-aided planning

Although today appraisal and planning are mainly done on board, there are some data solutions in line of intended new requirements from IMO available to aid the voyage planning process. Simple artificial intelligence-aided planning has been around for quite some time already in various weather routing software used on board. Vessel has downloaded their planned route in the software and after choosing parameters, like wave height or direction, the program has calculated the best possible route. Today there are more sophisticated programs available, which include navigational

102 IMO E-Navigation SIP p.23
103 IHO Circular Letter 54/2019
104 https://www.nauticalcharts.noaa.gov/ (Referred 5.6.2020)
105 www.massterly.com (Referred 27.5.2020)

information and warnings. Augmented reality solutions are starting to emerge to assist the bridge team in execution and monitoring stages.

6.1.1 AI-aided software

Some of these solutions are integrated in ECDIS, providing information such as tides and currents from ATT for example, while some are separate software. The amount of information available in these programs is wide-ranging. Some are pure weather data programs used for weather routing, and this kind of software does not have any navigational information although they may show ECAs or other MARPOL areas, which does not have any real value from the voyage planning point of view as the VPO and the watchkeepers would need to see this kind of information on ECDIS. If the route must be adjusted due to weather conditions and a simulation is ran on the weather software, the MARPOL limits can give a rough idea if the new route is going to have an impact on allowed fuel type or discharges, but still the actual planning would be done on ECDIS. Passage planning software, like Navtor's NavStation or ChartWorld's MyRA, generally offer somewhat automated planning using artificial intelligence, or integrate extra information in the program, but as of today there are no programs available that would include all the information required for a voyage plan, and human input is still a necessary part of the process.

Navtor incorporates all ADP, AENP and NavArea warnings as overlays in their software. Navtex stations, position fix and PIs are added automatically to the plan, and it also shows which ENC cells the ship needs for the intended voyage. UKC calculations are filled in automatically for each leg using dynamic draft based on planned speed, the user can then enter different parameters for the calculation. Weather routing is part of the program[106].

Total Marine Solutions (TMS) is an American company specialized in environmental regulation globally[107]. They have developed an environmental compliance solution

106 Fossmark, Gaute
107 http://www.tms-fla.com/ (Referred 6.4.2020)

called Ocean Guardian, a database including international, national, regional, port and company regulations assisting vessels and shipping companies in planning their environmental operations by offering advice and simplifying regulatory requirements. Ocean Guardian's environmental rules are integrated into NAVTOR's voyage planning software, which does give the VPO easy access to all regulations, not only mandatory rules on e.g. emissions but also port restrictions. This kind of service does give added value that many companies and VPOs would find useful. Especially port regulations, such as if ballast operations or painting is allowed, can be difficult to find out beforehand.

ChartWorld offers a digital routing service My Route Appraisal (MyRA), which provides vessels with a proposed ECDIS-ready voyage plan. A port information database FindaPort and a weather routing program SPOS are integrated in the software[108]. After the user chooses the ports of rotation and the pilot stations the program will calculate the shortest and the most cost-efficient route using bathymetry from ENCs. The software generates a navigationally safe track taking into account e.g. TSS (and possible restrictions due to the nature of the cargo), vessel's draft in relation to depth soundings, and other vessel measurements such as air draft and maximum LOA/ beam in locks and canals[109]. Ship-specific safety contours and safety corridors are added automatically. UKC is calculated with dynamic draft, and shipping companies can define how the safety depths are calculated for their vessels using their own safety margin policies.

MyRA provides a list of the publications required for the voyage and includes information from some publications such as ADP. In the future hopefully AENP information will be available also as an overlay. Since AENP is not geo-referenced this is not possible yet, but ChartWorld is working on the problem together with UKHO[110]. NavArea warnings and T&Ps are plotted directly in the ECDIS, and also

108 www.chartworld.com/web/on-route/routing-tools (Referred 15.5.2020)
109 Schwarz, Oliver
110 Schwarz, Oliver

listed in the voyage plan for each leg for reference. Plan includes information about the ENC cells, such as ZOC, ECA and MARPOL areas[111].

NAPA's Fleet Intelligence provides voyage optimization tool that can be integrated with MyRA[112]. The user can choose either the fastest or most economic route, i.e. weather- and/or fuel optimized route. The software combines weather routing including currents with parameters such as speed, RPM, engine load or arrival time. Calculation for the influence of different fuel types and emission control areas will be available in the future. Operational efficiency of past voyages is automatically evaluated and analysed taking into account weather and other factors affecting the voyage, this data can then be used to optimize future voyages on the same route. Different route alternatives for the same voyage can be compared to find the most efficient one.[113] The route derived from NAPA's Voyage Optimization tool takes into account some navigational requirements, for example straits and TSS[114].

Wärtsilä Navi-Planner offers similar service. Route optimization takes into account parameters such as weather, currents and ship-specific power demand and consumption. The software will prepare a voyage plan based on e.g. navigation info, ships' dimensions and hydrodynamics choosing the shortest possible route. The user can define additional parameters. The automatic route generation is also applicable for rivers and channels. In the future when STM is used to coordinate port arrival times Navi-Planner is able to dynamically adjust the route and speed to ensure just-in-time arrival[115].

Some of the features in voyage planning software are more useful than others, while some of the extra features have a limited value for voyage planning, such as many programs plotting T&Ps directly on ENCs when most countries in fact already include

111 www.chartworld.com/web/on-route/myra (Referred 23.4.2020)
112 www.napa.fi/news/napa-and-chartworld-partner-to-provide-artificial-intelligence-driven-voyage-optimization/ (Referred 23.4.2020)
113 Manderbacka, Teemu
114 https://www.napa.fi/software-and-services/ship-operations/napa-fleet-intelligence/voyage-optimization/#overview (Referred 4.5.2020)
115 Argyros, Dimitris

T&Ps in their ENC updates. However, listing the T&Ps by leg helps the VPO to easily identify that there are notices in force. What features a VPO finds most valuable depends naturally on the type of ship and the trade it is employed in.

Electronic check function in ECDIS proves that software is good at finding pieces of information that a human might miss if it is not presented as visual information, but when using AI-assisted planning it is still imperative that the VPO does a proper cross check of the plan and does not blindly trust the software-generated plan. When doing voyage planning on cruise ships at least two officers have checked the plan before it is presented to the master, and before execution the plan will be discussed at BRM with the whole bridge team.

AI-aided voyage planning software is probably most beneficial for cargo ships, especially those on long distance trades where voyage optimization really can make a difference. Vessels employed in short coastal voyages do not benefit greatly from voyage optimization as most of the time the vessels are generally following the shortest safe route already and there is only limited sea room for any deviations due to shallows and restricted areas. Some features would be useful for voyage planning officers on cruise ships, such as safety depth calculations included automatically, or detailed environmental regulations integrated in the software. Voyage planning on cruise ships is much more complex than on cargo vessels, and voyage planning software cannot replace human involvement entirely although it could ease the workload.

The advantage with software separate from ECDIS is that the onshore operations of the company have access to the same information, and if the office has know-how, they can crosscheck the vessel’s plans and even assist with the planning. Depending on the equipment and INS setup on board the navigators likely would find it easier if all the extra information was integrated in the ECDIS. Even if the route from the software is ECDIS-ready, easy to transfer and can be edited in ECDIS, transferring the routes is one extra step and if the watchkeepers want to check any information provided only in the software while on watch they need to step away from the conning position.

6.1.2 Augmented reality

The navigator has to make sure that the vessel is in safe waters and maintain situational awareness of the surroundings at the same time. Whether the ship's position is plotted automatically on an electronic chart or radar references are used, the navigator must look down on their instruments to verify ship's position, same is done for traffic monitoring and collision avoidance. Reducing this Head Down Time (HDT) enables the navigator to pay more attention to their surroundings. Augmented reality can integrate information provided by the system with the physical environment and thus assist in reducing HDT by displaying the most important navigational information in a way that facilitates the navigator's eye movement[116].

Tests conducted on board used graphics fixed to an imaginary sphere around user so that the graphics follow the user's movements, but it was shown not to work in a ship environment as the vessel's movement affected the users negatively. Attaching the AR graphics to physical surfaces improved the user experience[117]. Displaying AR graphics without wearable equipment can be obtained in different ways. Furuno Envision AR Navigation System uses a forward-facing camera with a separate display on which the image from the camera is shown with navigation data superimposed as an overlay[118]. The system uses either fixed screens or tablets. Ulstein has developed Ulstein Bridge Vision that uses infographics displayed on bridge windows and which can be controlled by hand gestures[119].

Visual clues can help navigators to recognize impending collision or grounding. AR combines real-life data with virtual overlay, for example a CPA/TCPA note can be attached to a moving object and this extra layer of information will stay fixed to the reference object even if the observer turns their head[120]. Navigational and geographical information, such as heading, track or no-go areas, are presented as a transparent layer

116 Hareide, O.S. & Porathe, T.
117 Frydenberg, S., Eikenes, J.O. & Nordby, K. Serendipity in the Field.
118 www.furuno.com/special/en/envision/ (Referred 17.5.2020)
119 https://ulstein.com/innovations/bridge-vision (Referred 17.5.2020)
120 Hareide, O.S. & Porathe, T.

on top of the water surface[121]. In reduced visibility or adverse weather AR can support the navigator by making information clear and making other vessels or objects more visible. In confined waters, heavy traffic or when navigating in ice visualization of the planned track projected on the window will enhance the navigator's situational awareness.

Although augmented reality is a useful tool for assisting in monitoring the execution of a voyage plan, it cannot be considered shore-based voyage planning as such. However, in the future when the technology develops it might be used by shoreside actors like VTS to point out information to the vessel, for example an unlit buoy or a temporary restricted area could be highlighted in the AR system to notify the vessel of the nonconformity. STM route exchange allows a VTS to send a proposed track to a vessel if e.g. a part of the fairway is closed and the traffic needs to be diverted, perhaps in the future this kind of information exchange can also include information that the on-board AR system could make more visible for the bridge team.

6.2 Autonomous and unmanned vessels

Development of Maritime Autonomous Surface Ships (MASS) is getting up to speed, and their voyage planning will be done shoreside of necessity. In the beginning autonomous ships will be small, operating on short routes in restricted areas with little other traffic, and operated or monitored by a remote operation center with an alternative of having some crew onboard ready to intervene if necessary. It is likely that as the degree of automation increases the crew will conn the vessel in more challenging navigational areas, whereas on the open sea the role of automation will become more important. Bridge Zero (B0) concept developed by ABB Marine & Ports aims to utilize the crew resources more efficiently by enabling an unmanned bridge in certain conditions similar to E0 ECR. If environmental conditions, technical and equipment status, and traffic situation allow the OOW could leave the bridge unmanned. The criteria for B0 limit values would be dependent on range, time and

121 Frydenberg, S., Eikenes, J.O. & Nordby, K. Exploring Designs.

distance enabling the OOW to reach the bridge with ample time to evaluate the situation and take action[122].

It will take several years before unmanned vessels are operating in larger scale. There are development projects that have aimed for deep-sea traffic, e.g. MUNIN, but most projects concentrate on short-sea shipping and liner traffic, partly because the repetitive pattern of operations makes modeling easy, and also because it is not viable to leave the engines used on ships today unattended for a longer period of time[123]. Demands on regulations, maintenance and connectivity still limit the adoption of Bridge Zero for deep-sea shipping in the near future[124]. The degree of automation will naturally make a difference in who will be doing the actual planning, in the beginning with partial automation the crew on board would still be responsible for voyage planning although some parts of the task might be delegated to shoreside or AI-aided software.

Projects dealing with the development of MASS concentrate naturally on the technology required to operate autonomous vessels, and thus cover the execution and monitoring stages of voyage planning. Appraisal and planning processes are at this stage left to less attention; they will become more important when autonomous vessels start sailing longer voyages outside restricted areas.

There are already intelligent awareness solutions commercially available assisting the bridge team in monitoring the surroundings of vessels and detecting objects that would be hard or impossible to see due to e.g. weather or darkness[125].

122 https://new.abb.com/news/detail/24651/b0-a-conditionally-and-periodically-unmanned-bridge (Referred 15.5.2020)
123 www.imarest.org (Referred 14.5.2020)
124 www.imarest.org (Referred 14.5.2020)
125 https://www.rolls-royce.com/media/press-releases (Referred 3.5.2020)

6.2.1 IMO and MASS

IMO recognizes four levels of automation[126] of which the first one is already in use on all modern merchant vessels:

- Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
- Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location, but seafarers are on board.
- Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.
- Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

Autonomous vessels are still such a new concept that there is not much regulations governing their use, but IMO has published Interim Guidelines for MASS Trials in order to "*assist relevant authorities and relevant stakeholders with ensuring that the trials of Maritime Autonomous Surface Ships (MASS) related systems and infrastructure are conducted safely, securely and with due regard for protection of the environment*"[127]. The guidelines are based on the principle that the autonomous vessels must be operated at least on the same level of safety than manned ships, and that effective risk management must be in place.

In their Strategic Plan for 2018-2023 IMO includes MASS in the strategic direction SD 2 *Integrate new and advancing technologies in the regulatory framework*. Maritime Safety Committee is working on a scoping exercise, aiming to complete it in 2020[128], in order to determine how MASS can be incorporated in IMO instruments. The scoping exercise will look into a number of issues ranging from the human element including e.g. safety, pilotage and interactions with ports, to protection of the

126 www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping (Referred 2.5.2020)
127 IMO MSC.1/Circ.1604 1.1
128 IMO Resolution A.1110(30) - Strategic Plan for the Organization for the six-year period 2018 to 2023

marine environment and response to incidents. The different levels of automation must be defined and described, and for all of the levels there should be a scoping exercise to test the resiliency and reliability of technical systems including communications and software. Also the human element both for onboard and shoreside personnel within the different levels should be included whether it is a question of a remote-controlled vessel with various degree of input from the shore control center or an automated ship with an advanced decision support system making all operational decisions with minimal intervention of a human operator.

The introduction of MASS will have an impact on several existing treaties which will need to be adapted to cover MASS operations. The Maritime Safety Committee (MSC) is looking at regulations governing safety (SOLAS), collision regulations (COLREG), search and rescue (SAR), training (STCW) and loading and stability (Load Lines, Tonnage Convention, Safe Containers). The Legal Committee has numerous conventions under consideration, such as various liability, pollution and salvage conventions.[129]

6.2.2 MUNIN-Project

Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) was a research project studying the concept of autonomous ships, which was finalized in 2015. They defined autonomous as “a vessel primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station”[130]. The project concentrated only on unmanned operations during deep-sea voyages, not approaches or congested waters, as it is likely that the first autonomous operations on large cargo vessels will be open sea passages with the crew being in charge of the more demanding coastal navigation. The vessel type chosen for research was a dry bulk carrier in intercontinental trade, since this type of vessel is well adapted to autonomous operations due to long, uninterrupted deep-sea voyages without several ports of call,

129 IMO http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-98th-session.aspx (Referred 3.5.2020)
130 MUNIN http://www.unmanned-ship.org/munin (Referred 10.4.2020)

often slow steaming and carrying cargo that does not require much care. MUNIN project was technology-orientated developing a suitable mixture of automated and remote technology to operate autonomous vessels, aiming for unattended bridge during deep-sea voyages similar to unattended engine room that already exists. In addition they looked into risks, legal aspects and economics of autonomous operations[131].

The project identified different systems required to control the vessel:

- Advanced Sensor Module taking care of lookout duties by combining sensor data from navigational systems such as radar,
- Autonomous Navigation System following a predefined voyage plan, with ability to autonomously adjust the route if required e.g. for collision avoidance or weather change,
- Autonomous Engine and Monitoring Control system monitoring the technical systems while trying to optimize efficiency,
- Shore Control Centre monitoring and controlling autonomous vessel. The shore control center would have both nautical officers, who monitor several ships at the same time and can control the vessel e.g. update the voyage plan or the operation envelope of the system, and engineers, who assist the operator in technical questions and are in charge of the maintenance plan making sure that the technical systems are in reliable condition for the next journey. The shore control center includes a team that can take over the direct control of the vessel if needed.

Appraisal and planning for an open sea passage are not very demanding, and MUNIN did not look into on board route planning, but instead concentrated on ways to deal with execution and monitoring of the voyage.

The main focus of MUNIN was to develop systems able to reliably detect dangerous situations and take appropriate action in an environment where there are also conventional vessels operating. The autonomous navigation system, also called deep-

[131] MUNIN Final Brochure

sea navigation system, takes into account the ship's particulars and technical condition as well as the traffic situation and weather conditions[132]. The system is able to determine COLREG-obligations and maneuver the vessel according to the rules. Meteorological forecasts are used to optimize the voyage plan and the system can operate the vessel in immediate and harsh weather conditions. In case of an unexpected situation the system will try to resolve the problem within its limits, if this is not possible a remote operator will take over. This type of autonomy reduces human supervision but maintains safety at the same time.

In addition to deep-sea navigation system a remote maneuvering support system was developed. It predicts anticipated vessel movements calculating the outcome of various rudder or engine commands and can be used both for collision avoidance and for complex maneuvers in restricted waters, such as ports. The system can be used both in autonomous as well as remote navigation.

Most of the time the ships are operating without any need for intervention from shore center, only in cases where the automated onboard systems cannot safely handle a situation, assistance will be provided. The limits for what is considered safe are customizable within the so-called operational envelope, setting navigational boundaries. The operational envelope will also include other factors such as visibility, wave height and traffic. Some tasks are still performed by the shore-based personnel, such as maintenance planning and VHF communications, although with the advance of e-navigation the number of reports required to be made on VHF is likely to decrease. If communications with the shore center are lost in case of an emergency, the ship will activate the fail-safe-mode.

MUNIN relies on shore-based operators as the autonomous systems cannot handle complex situations. According to the cost-benefit analysis this concept will strike a balance between technological complexity and economic rationality, making it a viable option[133].

132 MUNIN Final Brochure p.8
133 MUNIN Final Brochure p.11

6.2.3 One Sea- ecosystem

One Sea is a Finnish driven research collaboration led by DIMECC aiming to gather key players to develop a maritime ecosystem for autonomous operations by 2025[134]. Big Data with devices and solutions able to utilize the data create environment capable of independent decision-making. Increased efficiency will be reached by optimized operations with artificial intelligence choosing between the safest, most economical and ecological options. As human error is the greatest cause of accidents at sea AI-operated vessels would reduce the number of incidents by removing a major root cause[135].

One of the partners in the One Sea ecosystem is Kongsberg, who is engaged in several ongoing MASS and Intelligent Awareness projects. In Finland the company is involved in the development of remote operation solutions. The voyage planning process itself does not greatly differ from conventional vessels, but at Remote Operations Center (ROC) there must be enough resources to deal with both the appraisal/planning process as well as execution and monitoring[136].

Same principles govern the planning process on MASS as on conventional vessels, although the planning on MASS is done with AI-aided software, so it is a combination of human and machine input. On autonomous vessels the track XTD is likely to be quite large, so that the vessel will stay within the area that has been checked already during the planning phase even if a large deviation is required due to collision avoidance. On some conventional vessels conditional no-go areas are used, giving a choice to enter an area in an emergency, but on MASS the no-go areas are absolute, the vessel can either navigate in the area or not, although the ROC has always the option to override. As with conventional ships an autonomous vessel can enter areas otherwise avoided, such as an oncoming traffic lane in a TSS, if situation so requires as long as it is navigationally safe to do so[137].

134 Haikkola, Päivi
135 https://www.oneseaecosystem.net/about/ (Referred 3.5.2020)
136 Westerlund, Anton
137 Westerlund, Anton

For monitoring existing sensor technology is used and improved, there is no new technology under development just for the use of MASS. The vessel can manage traffic situations independently up to certain degree depending on the level of technology, but if parameters are exceeded the system will go to fail-safe mode and the ROC will take over. Unmanned vessels are not going to sail in heavily trafficked areas any time soon, but sometime in the future they may encounter situations like in Figure 5, which shows a normal traffic in Asian waters. For now Kongsberg is concentrating on developing MASS operating in short-sea trade[138] where this type of situation does not exist and is not planned for.

Figure 5. Traffic in the Gulf of Tonkin, South China Sea

Another project Kongsberg is involved in is the fully electric Yara Birkeland, world’s first autonomous container ship with zero emissions. Yara Birkeland was originally meant to be delivered in 2020 and move from manned to remote and finally fully autonomous operation by 2022, but the project has been postponed due to the coronavirus pandemic[139]. The vessel will utilize fusion data from all systems together with control algorithms to create a detailed 3D image of the operational area.

138 Westerlund, Anton.
139 https://navigatormagazine.fi/uutiset/meriteollisuus/vaikutuksia-myos-suomeen-yara-pani-itseohjautuvan-laivan-koipalloihin/ (Referred 4.6.2020)

Advanced decision support systems and collision avoidance technology enabling the vessel to avoid any obstacles detected by sensors ensure that the vessel can be operated safely and will be in compliance with COLREGS.[140] Yara Birkeland will be monitored by three separate ROCs which can handle all aspects of operation, not only emergencies and exception handling but also operational and condition monitoring as well as surveillance of the vessel's surroundings.[141]

140 https://www.kongsberg.com/maritime/support/themes/autonomous-shipping/ (Referred 30.5.2020)
141 https://www.kongsberg.com/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/ (Referred 30.5.2020)

7 DISCUSSION

Information required for a voyage plans varies greatly depending on the type of vessel and its trade. Cruise ships have relatively small draft (generally less than 9 m) so the water depth tends not to be too restricting in open waters, although many cruise ships sail in areas and visit ports where large cargo ships do not go and where draft can pose a problem. On the other hand cargo ships might need to take into account restrictions due to the nature of their cargo, e.g. tanker traffic is regulated in many places around the world.

The amount of detailed voyage planning done on cruise ships may seem excessive for officers working on ferries or cargo ships, and it is true that a lot of it is not needed on ships sailing in liner traffic or with less complex itineraries and less people on board. However, for cruise ship VPOs there is no choice, partly so that the VPO is able to prove that all aspects of the voyage are covered if ever a problem would arise. Mostly because lot of the information is actually needed, for instance, if a vessel were to arrive at a berth where she cannot use ship’s gangway and the port does not have a shoreside gangway available the passengers would not be able to go ashore or tendering operation would need to be set up with no notice.

Environmental considerations on a cruise ship are not like on any other ship type. Thousands of people on board generate daily hundreds of tons of wastewater with only limited tank capacity for storage. Cruise ships often operate fairly close to the coast and many visit environmentally sensitive areas where getting rid of the wastewater is not easy. The time spent inside an environmentally restricted area needs to be taken into consideration in voyage planning, and sometimes adjustments in the itinerary or the intended route are necessary to ensure compliance with environmental regulations. On a cargo ship the only overboards would likely be ballast and occasional OWS, and any discharges can easily be agreed between the bridge and ECR without any pre-planned time windows for discharging. Many shoreside actors are keen to protect the marine environment, but people with experience in shipboard operations are not always consulted when drafting new regulations, sometimes resulting in rules that are difficult for ships to comply with[142] instead of facilitating environmental planning onboard or for example providing shoreside facilities for waste discharges.

Voyage planning is labor intensive work taking a great deal of time if done properly. To ease the workload onboard some parts of planning could well be done shoreside, but still today most of the work is done on board. Some areas and ports, in Australia and New Zealand in particular, provide passage plans, i.e. ready-made routes with waypoints and courses, sometimes including a lot more information. Some countries like Norway provide plans in RTZ-format which can be installed directly on the ECDIS. These passage plans are official ones used by the pilots, and the ships are strongly encouraged to use them in their voyage planning so that everybody has the same mental model before pilotage starts. Although these kinds of passage plans are helpful for the VPO they do not reduce the workload significantly.

The one single improvement which would make most difference for the efficiency of the whole voyage planning process is the single window principle. Appraisal is the most time consuming stage of the process and if all available information was integrated into one source, the VPO would not need to spend time searching for it[143], especially if they do not know if the information exists in the first place (e.g. does a port have a speed limit or not?), and they could be certain that all aspects were covered and no information was missing[144]. The industry naturally has a long way to go to

142 Mexico introduced marine sanctuaries that cover most of the Pacific coast and extend far out to sea leaving only small gaps were discharges are allowed. For cruise ships this can pose a problem.

143 For example, there are several Particularly Sensitive Sea Areas around the coast of Australia which are well marked in ENCs. When picking report on ECDIS in some of the areas a note comes up that special discharge limitations might apply, and a reference is made to Seafarers Handbook for Australian Waters. The handbook in its turn only refers to a government environmental agency's website where no further information can be found. On one occasion after emailing back and forth with the government agency for several days the VPO learnt that there were no special requirements in force for the vessel during that particular cruise. It took quite some time and effort to find out that no limitations applied.

144 Hong Kong is a prime example of how easy it is to miss important information. On the approach from SW there is a strait between two islands that has deep water and no navigational hazards except one anchorage area. BA Sailing Directions even give instructions for passing through the strait and nowhere can any indication or visual clues be found that the passage is actually prohibited. Only when interrogating the ECDIS in the nearby TSS or running an electronic route check a warning comes up.
The whole port area is covered by speed limit ranging from 8 to 15 kn. Sailing Directions mention the range, but not in which areas the speed limits are in force, and this information is not included in the ENC either (as per March 2019). The only way to find out the speed limit areas is to search for the information on the port website where it is available only in Chinese or ask the agent to send a chart (and provide English translation) where the different areas are color-coded.

reach this goal, and like the final report of the Sea Traffic Management Validation Project noted: the development must be based on user needs, and the whole industry must cooperate in order to make it happen. Even if the quality of hydrographic data can be increased fairly easily (as individual hydrographic offices can make this happen and no input from other actors outside the country is required) integrating e.g. local environmental regulations in the data calls for wide-ranging collaboration between stakeholders.

The best option from the navigators' point of view would be to have all information accessible in the ECDIS and not in a separate software. Even if a voyage planning software produces the track in an ECDIS-compatible format it has happed that for unknown reason an ECDIS has not been able to read the transferred file. Another advantage with the single window access integrated into ECDIS is that the watchkeepers would be able to double check the information when on watch without leaving the conning position.

Visualization of information would enhance both VPO's and navigators' situational awareness, but too much information on an ECDIS screen makes it cluttered making it harder to find out quickly the most relevant data. The user should have the opportunity to choose which layers they want to see, and for optimized user experience every type of information should have their own layer. For example information on MARPOL areas is not interesting for the VPO if they are checking the chart coverage, while for instance all areas where navigation is restricted or forbidden should be visible for the watchkeepers without a need to pick report.

The equipment available today must develop in order to considerably save time for the VPO. As an example, the amount of warnings in a route check is too much, same warning pops up several times. Some models give coordinates for each warning and when clicking on the warning ECDIS zooms into that position. Some other manufacturers, even new models, list warnings only by leg, and when clicking on the warning only the coordinates for the starting waypoint of the leg is given, which is useless especially if it is a question of a long leg.

Single window reporting with as much automation as practicable would be another improvement reducing the workload and allowing the navigators to concentrate on watchkeeping without worrying if all necessary reports and notifications have been sent. On a national level this should be achievable without too much effort, a few countries have already taken steps towards this. Norway uses SafeSeaNet for all pre-arrival reporting, and the vessel can easily see which reports are required, which ones are still missing and can see e.g. pilot and berth information. Position reports must still be entered manually into the system, whereas Australia has automated position reporting system already in place so there is no reporting required over radio.

AI-aided software decreases the time the VPO needs to spend with the planning, but there is still some way to go until the software will be on the level where it will free the VPO from most of the planning-related work. Dropping and adjusting waypoints is the easy part of the process, most of the time involved is either during the appraisal stage or when drawing UCOs such as PIs or own safety lines, and AI-aided software provides help with only a small part of this kind of work[145]. Exchange and integration of data from several different sources would give added value to the equipment and software[146].

Route planning today must to be done by trained navigators who know what they are doing. With AI-aided software even people with less experience could so at least part of the work, although the plan must always be cross-checked by a competent person. This would enable moving at least part of the process shoreside. AI-aided planning saves time, but truly valuable it will become in the future if a single window approach is adopted. The amount of information that needs to be incorporated in the software is

145 If for example all ENCs had depth contours with one-meter intervals the safety contours could be used as no-go areas and there would not be need for drawing own safety lines. As most ENCs do not have this possibility safety contours are crossed regularly resulting in extra work for marking the no-go areas in the ECDIS.

146 Transas ECDIS has allowed downloading a file with tidal stream predictions for the next day in European waters. After installing the file and running the speed calculation for the track, the ECDIS indicated the average direction and strength of the tidal stream for each leg. The VPO could easily see if they were going to have the stream with or against, and the calculation also indicated the speed required at each leg to keep the average STM for the whole voyage. This saved time considerably as otherwise the VPO would have needed to calculate streams from tidal atlas hour by hour and if the streams were strong even a quite small change in SOG would result in calculations being incorrect.

huge and a lot of cooperation is required between stakeholders before all information will be accessible in a standardized format.

Even when the degree of automation increases as long as the voyage planning process (including execution and monitoring) is kept fairly traditional with conventional equipment on board, the navigators need to be competent deck officers with solid navigation skills and an understanding of what they are looking at. When automation and artificial intelligence become more common and shoreside operations take over many tasks now performed on board the question is if traditional navigators are best for the task. When many processes will become more automated and sophisticated the focus of the required training is likely to shift. For comparison, air traffic controllers do not need to be trained pilots in order to be able to perform their job safely and efficiently.

Competent and well-trained personnel is still needed with implementation of e-navigation, otherwise there is a risk of over-reliance on technology. If technology is used to replace experienced seafarers the result can be loss of seamanship, and deterioration of BRM and best practices. Technology developers need to have a clear picture of what type of product the end user requires in order to minimize the risk that the human element is inappropriately substituted by technology. If too much reliance is based on technology alone, technical failures can cause a vessel to be deemed unseaworthy[147].

If voyage plans are made shoreside the responsibilities should be made clear. Although the plan must be checked on board before execution as the Master and OOWs are responsible for it, there should be some kind of guarantee that the person who has made the plan in the first place is competent for the job. All shipping companies do not have the expertise in the office to provide assistance with the planning, and not necessarily the understanding why a vessel might need to deviate from a plan. When appraisal is done on board the VPO is able to build a good overview of the intended

[147] MSC 85 annex 20, 7.1

route during the process, with shoreside planning the information should be presented in a manner that is clear and easy for the navigators to comprehend.

All ships will benefit from technology developed for MASS, such as better sensors or obstacle detection. A shoreside monitoring center can help with decision-making also on board a manned vessel, reducing human error, sharing the workload and ensure compliance with regulations.

8 CONCLUSIONS

The complexity of a voyage plan and the time spent on making it depends on the vessel and its trade. Information needs to be gathered from multiple sources and is not always easily available. Considering the increasing number of demands and regulations the standardization and integration of data would make the process more efficient, decrease the VPOs' workload and increase safety. There is definitely a possibility to move some of the planning process to shoreside, either to shipping companies (if they have competent personnel), by using AI-aided software or giving the task to a separate service provider. ROCs will be making voyage plans for MASS, but the service could be utilized as well on manned vessel willing to outsource parts of the planning process or monitoring of the voyage execution. There is also a chance for new service providers to enter the market with products enabling companies to outsource parts of the voyage planning process.

Although the officers on board must be familiar with the voyage plan, nothing prevents at least part of the process being done shoreside as long as all information is presented to the navigators in a format that is easy to read and comprehend. AI-aided planning software and government provided passage plans can be of assistance in the voyage planning officer's work, but their scope is still quite limited. In the future when the technology develops, and especially if all information can be accessed from a single window, time spent on appraisal and planning stages will decrease considerably and most of the process could be done shoreside leaving the officers on board more time for other tasks. Sharing the information between different actors will be the key. If data formats in the whole industry, both shoreside and onboard, are standardized it will lead to better connectivity and the data can be utilized more efficiently to benefit all stakeholders.

It is not exactly correct to call AI-aided planning or autonomous vessels "future" since the technology is in use already. As the stage of development is still fairly rudimentary and the importance of the technology will only increase with time, the products we will see in twenty years from now are expected to be on a totally different level compared with what is available today.

The future will bring a huge change for officers responsible for navigating ocean-going vessels. From relying on a magnetic compass and a sextant in the past to digital navigation of today the shipping will move towards automated, AI-controlled processes where humans will mainly have a role of monitoring. Navigating navigator will still be needed for many years to come, although their job will be made easier with technological advancements. Better use of data and dissemination of information is likely to increase safety and efficiency of shipping.

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APPENDIX 1

APPRAISAL AND PLANNING CHECKLIST

From: to:	Track Number			Track Notes				
Voyage Appraisal Guide	**Planning Checklist**							
Chart type coverage and appropriate scale	**Berth to berth**	**N/A**	**Yes**	**Departure/Arrival**	**N/A**	**Yes**	**N/A**	**Yes**
Datum mismatch areas and GNSS error areas	VTS reports/traffic info				**Depature**		**Arrival**	
ECDIS & ENC Safety Notices such as Read Me File	Track Control System settings			Commit Point				
Navigational Warnings	Visual and Radar monitoring/PIs			Contingency plans				
Local Notices to Mariners, T&Ps and Admiralty Information Overlay (if supported)	Echo Sounder Alarm			Speed range/limits, ROTs, heeling limitations				
Nautical Publications	Speed restriction			Reference of changing steering mode position (centre or wing)				
Tidal and current information	ECDIS Safety Parameters			Swinging circles, drift angles, swept path, wind load				
Weather and climate information	Waypoint notes			Reference for: swing, WOP/WOL, maneuvering				
Port information / Port Study	Manning status (BRM)			Safe clearances				
Ship characteristics (draft, air draft, etc.)	MARPOL lines/environmental limits			Berth location				
Environmental aspects (e.g. regulatory requirements, sensitive area, etc.)	Chart type: ENC/RNC/Paper			Engine configuration				
Security/High Risk Areas	Contingency Anchorage			*To include* *- Depth contours* *- Activate all layers on the ECDIS display* *- Isolated Shallow Water Dangers. Set to "On"* *- Quality of the data (ZOC) Set to "On"*				
Local agents, Pilots, Port Authorities, Port Facilities	Restricted areas							
Departure / Arrival only	Territorial waters							
Port Information, Pilots boarding ground, tugs, escort vessels, expected traffic, restrictions	Transit info			*Sign when completed*	**Voyage Planning Officer**		**2nd person**	**EO**
Communication channels (VTS, Harbour, Pilots, tugs, CG, agency)	Track, Radii, WOP/WOL			**Visual check**				
Environmental expected conditions, wind, tide, current, weather, visibility	Safety margins, No-Go areas			**Electronic check**				
UKC, Safety Depth/Safety Contour and Air Draft; - Ref MAR1301 C Appendix	Special areas			**Environmental check**				
Obstructions and hazards to navigation marked (if not clearly displayed on the ECDIS)	ECDIS position cross-check frequency (LOP, Radar bearings/distances, depth soundings).			**Ready for Master's review**				
	SRtP Compliant (if applicable)							

APPENDIX 2

SAFETY DEPTH CALCULATION

VOYAGE	From	Dep. Date		To	Arr. Date
	San Francisco	05/07/19		Ketchikan	05/10/19
OWN SHIP VALUES (update with the ship-specific particulars before continue)					
Block Coefficient [CB] *(Used for Squat Calculation)*	0,69	Open Water: Squat [m] = (1 x CB x V²) / 100 Prismatic Channel: Squat [m] = (1,43 x CB x V²) / 100			
Fresh Water Allowance (FWA) [m]	0,151	DWA = FWA*(1025-d)/25 (Note: DWA = Dock Water Allowance)			
Own Ship Beam [m]	30,80	Draft Increase = Beam/2*Sin(List Angle)+(Draft(Upright)*Cos(List Angle)-Draft			
Own Ship Length [m]	219,4	Draft Increase = Length/2*Sin(Pitch Angle)			
	INPUT TABLE				
	Departure				Arrival
	1 - RESTRICTED	2 - SHALLOW	3 - DEEP		5 - RESTRICTED
	Waypoint #1	**Waypoint #4**	**Waypoint #7**		**Waypoint #29**
Choose **STATIC DRAFT** [m] Value in SW	7,7	7,7	7,7		7,7
Choose **WATER DENSITY** [kg/m³]	1025	1025	1025		1025
Choose **POTENTIAL HEELING ANGLE** [°]	0,0	1,0	2,0		0,0
Choose **POTENTIAL PITCHING ANGLE** [°]		0,0	1,0		
Choose MAX SPEED (kn) for the leg *(Used for Squat Formula Calculation)*	10,0	18,0	22,0		10,0
Choose **CHANNEL or OPEN WATER** *(Used for Squat Calculation)*	Open Water	Open Water	Open Water		Open Water
Choose to use the **Calculated SQUAT** Or: Use **Own Squat** Value	Calculated Squat	Calculated Squat	Calculated Squat		Calculated Squat
Input if **OWN SQUAT VALUE** is Chosen	---	---	---		---
Choose **TIDE value [m]** from Table: *Use + for values Above Chart Datum* *Use - for values Below Chart Datum*	0,0	0,0	0,0		0,0
Choose the **MINIMUM CHARTED DEPTH** [m] *(Used for the ZOC Correction)*	11,2	16,0	30,0		14,0
Choose **ZOC AREA**	B	B	U		A1
APPLY ZOC Correction?	YES	YES	YES		YES
If **NO** is chosen: *(State the reason from the Drop Down Menu)*	---	---	---		---
Additional Safety Margin (ZOC D or U) *(if demeed necessary)*	0,0	0,0	0,0		0,0
	CALCULATIONS FOR THE ABOVE TABLE (NO ACTION REQUIRED)				
DRAFT INCREASE FWA [m]	0,00	0,00	0,00		0,00
ADJUSTED STATIC DRAFT [m]	7,70	7,70	7,70		7,70
DRAFT INCREASE FOR HEEL [m]	0,00	0,27	0,53		0,00
DRAFT INCREASE FOR PITCHING [m]	0,00	0,00	1,91		0,00
SQUAT [m]	0,69	2,22	3,32		0,69
DYNAMIC DRAFT [m]	8,39	10,19	13,46		8,39
SAFETY MARGIN/MinimumUKC* [m]	0,77	0,00	0,00		0,77
ZOC Table Calculated Values [m]	1,22	1,32	3,50		0,64
ZOC Correction [m]	0,45	1,32	3,50		0,00
SAFETY DEPTH [m]	9,6	11,5	17,0		9,2
	CONTOUR SETTINGS				
	Waypoint #1	**Waypoint #4**	**Waypoint #7**		**Waypoint #29**
SHALLOW CONTOUR [m]	8	10	13		8
SAFETY DEPTH [m]	9,6	11,5	17,0		9,2
SAFETY CONTOUR [m]	10	12	17		10
DEEP CONTOUR [m]	15	15	30		15
	UNDER KEEL CLEARANCE				
UNDER KEEL CLEARANCE [m] *(Charted Depth + Tide) - Dynamic Draft*	2,8	5,8	16,5		5,6
Minumum UKC Complied? YES/NO	YES	YES	YES		YES
YES: *If Charted Depth > Safty Depth* **NO:** *If Charted Depth < Safety Depth*	1,6	4,5	13,0		4,8
NOTES					
* Restricted - charted depth less than 15m: Safety Margin = 10% of the static draft.					
Shallow - charted depth 15m to 30m: Safety Margin = no minimum UKC					
Deep - charted depth more than 30m: Safety Margin = no minimum UKC					

APPENDIX 3

RISK ASSESSMENT

Ship	ms Maasdam								
Voyage Deployment Area	Utheemu, Maldives								
Time Of Year	07-Feb-19								
Step 1: Spot the Hazards		Step 2: Identify the potential severity (Use Table A)		Step 3: Determine Likelihood (Use Table B)		Step 4: Calculate Risk		Step 5: Mitigate risk where identified as Very High and High
Identify potential hazardous activity	What are the associated risks?	Categorize potential severity by marking it 1 – 5	Severity Level	Mark likelihood1 - 5	Likelihood	Risk Score	Table DRisk Level	List implemented control
Time of the year	NE monsoon, average wind speed 15-20 kn	1	Insignificant	3	Likely	3	Medium	Voyage planning, BVS, WRI
Geographic location		1	Insignificant	1	Rare	1	Low	
Navigation Hazards	No official ENC/ARCS coverage on appropriate scale, surveys from 1835 (MAR-1105-D13)	5	Catastrophic	1	Rare	5	Very High	Shore side planning Bathymetric chart / ENC Voyage planning On approach echosounder alarm, speed, lookout
Maneuvering restrictions	Depths on approach / anchorage	1	Insignificant	1	Rare	1	Low	Bathymetric chart / ENC Voyage planning
Prevailing wind and weather conditions	Easterly wind, swell historical average NE-ly <2m	1	Insignificant	3	Likely	3	Medium	Voyage planning, BVS, WRI
Pilots	Not government pilot available	2	Minor	2	Unlikely	4	Medium	Voyage planning

APPENDIX 4

SPEED SCHEDULE

Speed Schedule: Voyage 935

21-Day Northern Pacific Adventurer

San Francisco - Yokohama // 9 - 31 July 2019

Revised: 22 December 2018

Version: 1.0

Departure				Port-CSV			At Sea			Arrival					ESV-Port					Total
Location	ETD (LT)		TZ	Dist	TTG	Time	Dist	TTG	STM	Location	ETA (LT)	TZ	UTC	Dist	TTG	Docked		Port		Miles
San Francisco, US	9 Jul 2019 Tuesday	17:00	-7	16 nm	1:30	18:30	5 nm	0d 00:20	15,0 kts	Enter whale waters	9 Jul 19 18:50	-7	10 Jul 2019 01:50	0 nm	0:00	9 Jul 2019 Tuesday	18:50	Transit		21 nm
Enter whale waters	9 Jul 2019 Tuesday	18:50	-7	0 nm	0:00	18:50	34 nm	0d 03:25	10,0 kts	Exit whale waters	9 Jul 19 22:15	-7	10 Jul 2019 05:15	0 nm	0:00	9 Jul 2019 Tuesday	22:15	Transit		34 nm
Exit whale waters	9 Jul 2019 Tuesday	22:15	-7	0 nm	0:00	22:15	717 nm	1d 14:45	18,5 kts	Victoria, Canada	11 Jul 19 13:00	-7	11 Jul 2019 20:00	4 nm	1:00	11 Jul 2019 Thursday	14:00	Dock		721 nm
Victoria, Canada	11 Jul 2019 Thusday	23:00	-7	3 nm	0:59	23:59	79 nm	0d 06:00	13,2 kts	Seattle, US	12 Jul 19 06:00	-7	12 Jul 2019 13:00	4 nm	1:00	12 Jul 2019 Friday	7:00	Dock		86 nm
Seattle, US	12 Jul 2019 Friday	16:00	-7	3 nm	1:00	17:00	359 nm	0d 20:45	17,3 kts	Pine Island PSN	13 Jul 19 12:45	-8	13 Jul 2019 20:45	0 nm	0:00	13 Jul 2019 Saturday	12:45	Transit		362 nm
Pine Island PSN	13 Jul 2019 Saturday	12:45	-8	0 nm	0:00	12:45	299 nm	0d 17:15	17,3 kts	Twin Island PSN	14 Jul 19 06:00	-8	14 Jul 2019 14:00	0 nm	0:00	14 Jul 2019 Sunday	6:00	Transit		299 nm
Twin Island PSN	14 Jul 2019 Sunday	6:00	-8	0 nm	0:00	6:00	16 nm	0d 01:00	16,0 kts	Ketchikan, US	14 Jul 19 07:00	-8	14 Jul 2019 15:00	4 nm	1:00	14 Jul 2019 Sunday	8:00	Dock		20 nm
Ketchikan, US	14 Jul 2019 Sunday	17:00	-8	8 nm	1:30	18:30	221 nm	0d 12:30	17,7 kts	Sitka, US	15 Jul 19 07:00	-8	15 Jul 2019 15:00	3 nm	1:00	15 Jul 2019 Monday	8:00	Anchor		232 nm
Sitka, US	15 Jul 2019 Monday	17:00	-8	3 nm	1:00	18:00	554 nm	1d 12:45	15,1 kts	Kodiak, US	17 Jul 19 06:45	-8	17 Jul 2019 14:45	5 nm	1:15	17 Jul 2019 Wednesday	8:00	Dock		562 nm
Kodiak, US	17 Jul 2019 Wednesday	18:00	-8	5 nm	1:00	19:00	607 nm	1d 12:00	16,9 kts	Dutch Harbor, US	19 Jul 19 07:00	-8	19 Jul 2019 15:00	4 nm	1:00	19 Jul 2019 Friday	8:00	Dock		616 nm
Dutch Harbor, US	19 Jul 2019 Friday	18:00	-8	4 nm	1:00	19:00	650 nm	1d 12:00	18,1 kts	Nome, US	21 Jul 19 07:00	-8	21 Jul 2019 15:00	2 nm	1:00	21 heinä 2019 Sunday	8:00	Anchor		656 nm
Nome, US	22 Jul 2019 Monday	0:00	-8	2 nm	0:30	0:30	1345 nm	3d 07:30	16,9 kts	Petropavlovsk, Russia	26 Jul 19 04:00	+12	25 Jul 2019 16:00	12 nm	2:00	26 Jul 2019 Friday	6:00	Dock		1359 nm
Petropavlovsk, Russia	26 Jul 2019 Friday	18:00	+12	12 nm	1:15	19:15	885 nm	2d 17:45	13,5 kts	Kushiro, Japan	29 Jul 19 10:00	+9	29 Jul 2019 01:00	3 nm	1:00	29 Jul 2019 Monday	11:00	Dock		900 nm
Kushiro, Japan	29 Jul 2019 Monday	18:00	+9	3 nm	1:00	19:00	576 nm	1d 09:10	17,4 kts	Enter speed limit	31 Jul 19 04:10	+9	30 Jul 2019 19:10	0 nm	0:00	31 Jul 2019 Wednesday	4:10	Transit		579 nm
Enter speed limit	31 Jul 2019 Wednesday	4:10	+9	0 nm	0:00	4:10	8 nm	0d 00:40	12,0 kts	Exit speed limit	31 Jul 19 04:50	+9	30 Jul 2019 19:50	0 nm	0:00	31 heinä 2019 Wednesday	4:50	Transit		8 nm
Exit speed limit	31 Jul 2019 Wednesday	4:50	+9	0 nm	0:00	4:50	6 nm	0d 00:25	14,4 kts	Yokohama, Japan	31 Jul 19 05:15	+9	30 Jul 2019 20:15	4 nm	1:15	31 heinä 2019 Wednesday	6:30	Dock		10 nm
							6361 nm	16d 04:15	16,4 kts											6465 nm

REMARKS					
CLOCK CHANGES:	13 July	at 02:00 clock's set 1 hour back	from	GMT -7 to GMT -8	Sea Day
	22 July	at 02:00 clock's set 1 hour back	from	GMT -8 to GMT -9	Sea Day
	23 July	at 02:00 clock's set 1 hour back	from	GMT -9 to GMT -10	Sea Day
	Dateline	24 July does not exist in ship's calendar, ship's time will go from 23 to 25 July @02:00 on 24th			
	24 July	clocks forward 23 hours @ 02:00	from	GMT -10 to GMT +13	Sea Day
	26 July	at 02:00 clock's set 1 hour back	from	GMT +13 to GMT +12	Arrival Petropavlovsk
	27 July	at 02:00 clock's set 1 hour back	from	GMT +12 to GMT +11	Sea Day
	28 July	at 02:00 clock's set 1 hour back	from	GMT +11 to GMT +10	Sea Day
	29 July	at 02:00 clock's set 1 hour back	from	GMT +10 to GMT +9	Arrival Kushiro
Notes:	San Francisco-Victoria inside 24' STM=18.4kn, outside STM=18.5kn				

NACOS Track catalog: 2019v935NPacific	
0110	SANFRAN - VICT OUT24
0200	VICTORIA - SEATTLE
0300	SEATTLE-INSIDE-KETCH
0400	KETCHIKAN-SITKA
0500	SITKA-KODIAK
0600	KODIAK-DUTCH HARB
0700	DUTCH HARBOR-NOME
0800	NOME-PETROPAVLOVSK
0900	PETROPAVLO-KUSHIRO
1000	KUSHIRO-YOKOHAMA

APPENDIX 5

WAYPOINT LIST

Voyage Plan - Waypoints / Waypoint Notes

HALONG BAY, VIETNAM ----- HONG KONG, CHINA // NACOS Track: 0710 HALONG-HONGKNG ECA

	Date	Time	Man. Time	TZ	Distance:	Miles	Average Speed (kn)	For the P(x) Column use:
Departure	02/27/19	18:00	0:10	+7	Dock / Anchorage -- Pilot Station:	15	9.8	P(x) - Pilot Station - ETA/ETD Waypoint
Pilot Station/ETD WP - (P1)	02/27/19	19:45			Pilot Station (P1) -- Pilot Station (P2):	465	14.4	F(x) - ECA/VGP Emmision Zones
Pilot Station/ETA WP - (P2)	03/01/19	6:30			Pilot Station -- Dock / Anchorage:	3	2.8	E(x) - 12NM/4NM Environmental Zones
Arrival	03/01/19	8:00	0:15	+8				Z(x) - Highlight

WP#	Waypoint Name	Latitude		Longitude		Course	Track	Track D.	Radius	RL/GC	Speed	plSpd	ROT	ETA (BT)	TZ	P(x)	WP Notes row 1	WP Notes row 2	WP Notes row 3	WP Notes row 4	WP Notes row 5
0001	OFF BERTH	20° 56.815'	N	107° 03.904'	E									02/27/19 -- 18:10	+7		RED MANNING	ANCHORS CLEARED	WTD CLOSED	ALARM SET #1	CONTOUR SET #1
0002	BUOY P 18	20° 56.041'	N	107° 04.185'	E	161.3°	0.8	0.8	1.00	RL	9.8		9	02/27/19 -- 18:15	+7						
0003	BUOY P 16	20° 55.592'	N	107° 04.364'	E	159.6°	0.5	1.3	1.00	RL	9.8		9	02/27/19 -- 18:17	+7						
0004	EXIT CHANNEL	20° 52.019'	N	107° 05.770'	E	159.8°	3.8	5.1	1.00	RL	9.8		9	02/27/19 -- 18:41	+7						
0005	8 KNOTS FOR TURN	20° 51.315'	N	107° 07.473'	E	113.9°	1.7	6.8	0.80	RL	9.8		12	02/27/19 -- 18:51	+7						
0006	HON MIEU	20° 48.967'	N	107° 08.464'	E	158.5°	2.5	9.4	1.00	RL	9.8		0	02/27/19 -- 19:07	+7						
0007	PILOT	20° 43.265'	N	107° 10.870'	E	158.5°	6.1	15.5	2.00	RL	9.8		5	02/27/19 -- 19:45	+7	P1	GREEN MANNING	ANCHORS SECURED			
0008	CHANGE CONTOUR SET	20° 39.556'	N	107° 19.608'	E	114.4°	9.0	24.5	3.00	RL	14.4		5	02/27/19 -- 20:22	+7		ALARM SET #2	CONTOUR SET #2			
0009	OUTSIDE 12NM	20° 33.524'	N	107° 37.600'	E	109.7°	17.9	42.4	3.00	RL	14.4		5	02/27/19 -- 21:36	+7	E1	OUTSIDE SPECIAL				
0010	ENTER ECA	20° 20.629'	N	108° 20.987'	E	107.6°	42.6	85.0	3.00	RL	14.4		0	02/28/19 -- 00:33	+7	F1	INSIDE ECA WATERS				
0011	INSIDE 12NM	20° 07.536'	N	109° 04.982'	E	107.6°	43.3	128.3	3.00	RL	14.4		5	02/28/19 -- 04:33	+8	E2	ALARM SET #3	CONTOUR SET #3			
0012	BN CEFENG	20° 05.680'	N	109° 23.240'	E	096.2°	17.2	145.6	3.00	RL	14.4		5	02/28/19 -- 05:45	+8						
0013	INSIDE 4NM	20° 05.645'	N	109° 39.460'	E	090.1°	15.2	160.8	3.00	RL	14.4		0	02/28/19 -- 06:48	+8	E3					
0014	ENTER SPEED LIMIT	20° 05.628'	N	109° 46.998'	E	090.1°	7.1	167.9	3.00	RL	14.4		5	02/28/19 -- 07:18	+8	Z1	SPEED LIMIT 10KN				
0015	CAUTIONARY AREA	20° 11.137'	N	110° 23.609'	E	080.9°	34.8	202.7	3.00	RL	*10.0*	10.0	3	02/28/19 -- 10:47	+8						
0016	BY BUOY 18 RED	20° 14.296'	N	110° 28.969'	E	057.9°	5.9	208.6	3.00	RL	*10.0*	10.0	3	02/28/19 -- 11:22	+8						
0017	EXIT SPEED LIMIT	20° 14.143'	N	110° 38.493'	E	091.0°	8.9	217.6	3.00	RL	*10.0*	10.0	0	02/28/19 -- 12:16	+8	Z2					
0018	BUOY NO8	20° 13.973'	N	110° 49.056'	E	091.0°	9.9	227.5	3.00	RL	14.4		5	02/28/19 -- 12:57	+8						
0019	BUOY NO4	20° 15.267'	N	110° 56.446'	E	079.4°	7.1	234.5	3.00	RL	14.4		5	02/28/19 -- 13:26	+8	Z3	ALARM SET #4	CONTOUR SET #4			
0020	HAINAN STRAIT EAST	20° 15.030'	N	111° 05.600'	E	091.6°	8.6	243.1	3.00	RL	14.4		5	02/28/19 -- 14:02	+8						
0021	OUTSIDE 4NM	20° 37.782'	N	111° 52.102'	E	062.4°	49.2	292.3	3.00	RL	14.4		0	02/28/19 -- 17:26	+8	E4					
0022	OUTSIDE ECA/12NM	20° 45.259'	N	112° 07.408'	E	062.4°	16.2	308.4	3.00	RL	14.4		5	02/28/19 -- 18:33	+8	F1	OUTSIDE ECA WATERS	OUTSIDE 12 NM			
0023	INSIDE ECA/12NM	21° 31.124'	N	113° 43.036'	E	062.8°	100.3	408.7	3.00	RL	14.4		5	03/01/19 -- 01:30	+8	F2	INSIDE ECA WATERS	INSIDE 12 NM			
0024	INSIDE 4NM	21° 45.752'	N	114° 04.932'	E	054.3°	25.1	433.8	3.00	RL	14.4		5	03/01/19 -- 03:14	+8	E5					
0025	DANGAN ISLAND	22° 00.154'	N	114° 27.045'	E	054.9°	25.1	458.9	3.00	RL	14.4		5	03/01/19 -- 04:58	+8						
0026	ENTER HK WATERS	22° 05.816'	N	114° 25.139'	E	342.7°	5.9	464.8	3.00	RL	14.4		0	03/01/19 -- 05:23	+8	Z4	FUEL CHANGEOVER	HFO->MGO			
0027	ENTER TSS	22° 13.500'	N	114° 22.550'	E	342.7°	8.0	472.8	2.00	RL	14.4		7	03/01/19 -- 05:57	+8						
0028	BUOY TCS2	22° 13.500'	N	114° 17.613'	E	270.0°	4.6	477.4	1.00	RL	14.4		14	03/01/19 -- 06:16	+8		ANCHORS CLEARED				
0029	BUOY TCS3	22° 14.100'	N	114° 16.700'	E	305.4°	1.0	478.4	1.00	RL	14.4		14	03/01/19 -- 06:20	+8		ALARM SET #5	CONTOUR SET #5	SPPED LIMIT 10KN		
0030	HONG KONG PILOT	22° 16.270'	N	114° 15.800'	E	339.0°	2.3	480.8	0.50	RL	14.4		28	03/01/19 -- 06:30	+8	P2	RED MANNING				
0031	LEI YUE MEN	22° 17.006'	N	114° 14.518'	E	301.8°	1.4	482.2	0.50	RL	2.8		5	03/01/19 -- 07:00	+8						
0032	ENTER FAIRWAY	22° 17.676'	N	114° 12.924'	E	294.4°	1.6	483.8	0.25	RL	2.8		11	03/01/19 -- 07:34	+8						
0033	DOCK	22° 18.131'	N	114° 12.776'	E	343.3°	0.5	484.3	0.25	RL	2.8		11	03/01/19 -- 07:45	+8						

APPENDIX 6

ALARM MANAGEMENT (for ships with NACOS 4 or 5 ECDIS)

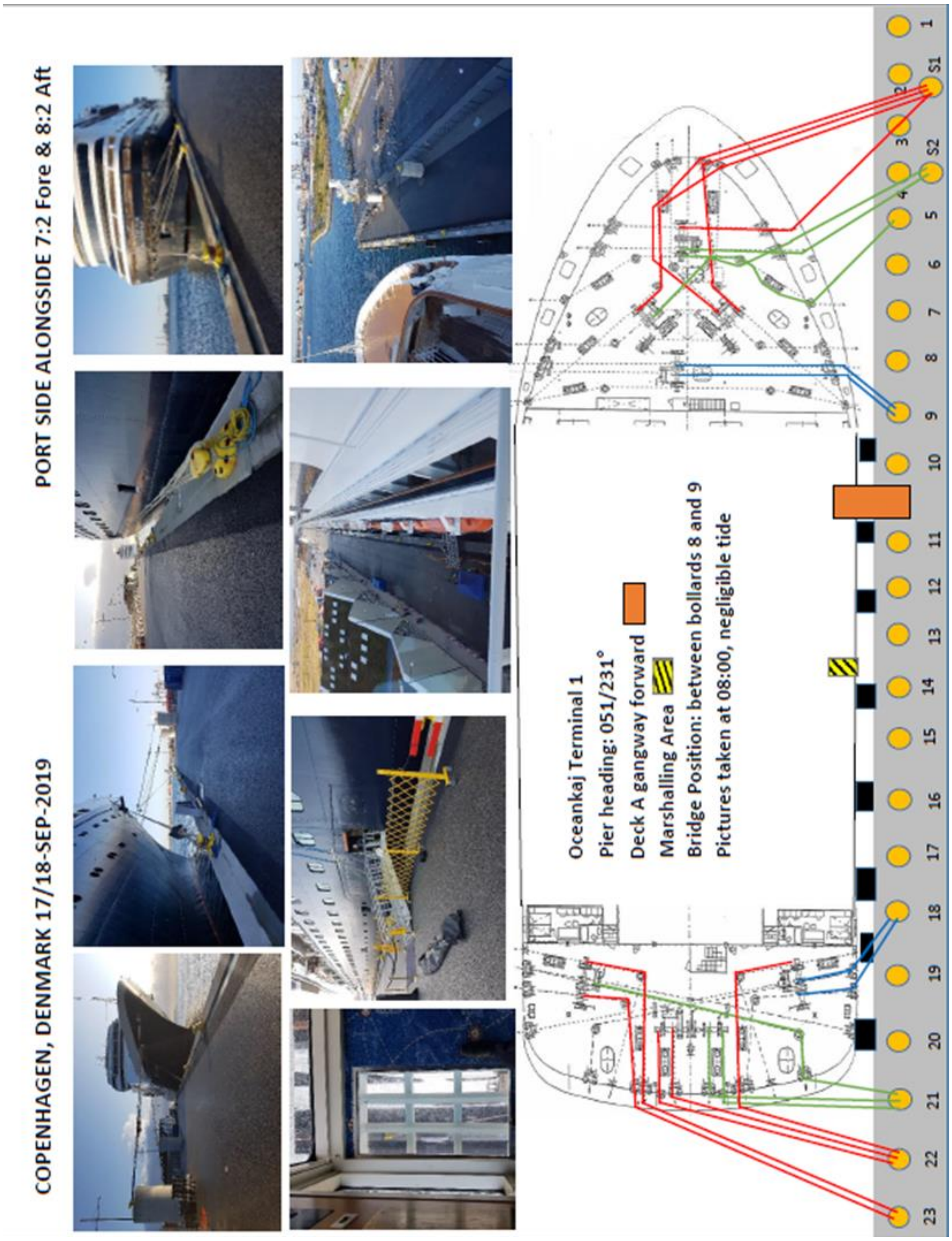
ALARM MANAGEMENTCHARLOTTETOWN ----- QUEBEC // NACOS Track: 0051 CHAR-QUEBEC-WEST

NAVIGATION	1-Enclosed Waters Waypoint #1			2-Restricted Waters Waypoint #9			3-Open Waters Waypoint #22			4-Restricted Waters			5-Enclosed Waters Waypoint #44		
Minimum Speed (kn)	3,0			6,0			6,0						3,0		
Ahead Sector Width (NM - m)	49 m			0.5 NM - 926 m			3.0 NM - 5556 m						250 m		
Distance (NM)	500 m			2.5 NM - 4630 m			2.5 NM - 4630 m						3.0 NM - 5556 m		
Time (mins)	1,0			6,0			6,0						6,0		
	SAFETY CONTOUR														
	Nav	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**				**Nav**	**Co-Nav**	**ECDIS**
On Track	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF				OFF	OFF	OFF
Ahead	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
Visible	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
	NAVIGATION HAZARDS														
	Nav	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**				**Nav**	**Co-Nav**	**ECDIS**
On Track	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF				OFF	OFF	OFF
Ahead	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
Visible	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
	SPECIAL AREA														
	Nav	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**				**Nav**	**Co-Nav**	**ECDIS**
On Track	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF				OFF	OFF	OFF
Ahead	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
Visible	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
	DEPTH ALARM SETTING														
	Nav	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**	**Nav**	**Co-Nav**	**ECDIS**				**Nav**	**Co-Nav**	**ECDIS**
	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON				OFF	OFF	ON
Depth Limit (m) (NACOS)*	3			5			24						5		
Depth Limit (m) (Echo Sounder)*	3			5			24						5		

*Added Value to Depth Sounder Alarm settings (UKC + x(m))					
NACOS (m)	1	3	15		2
Echo Sounder (m)	1	3	15		2

APPENDIX 7

DOCKING PLAN



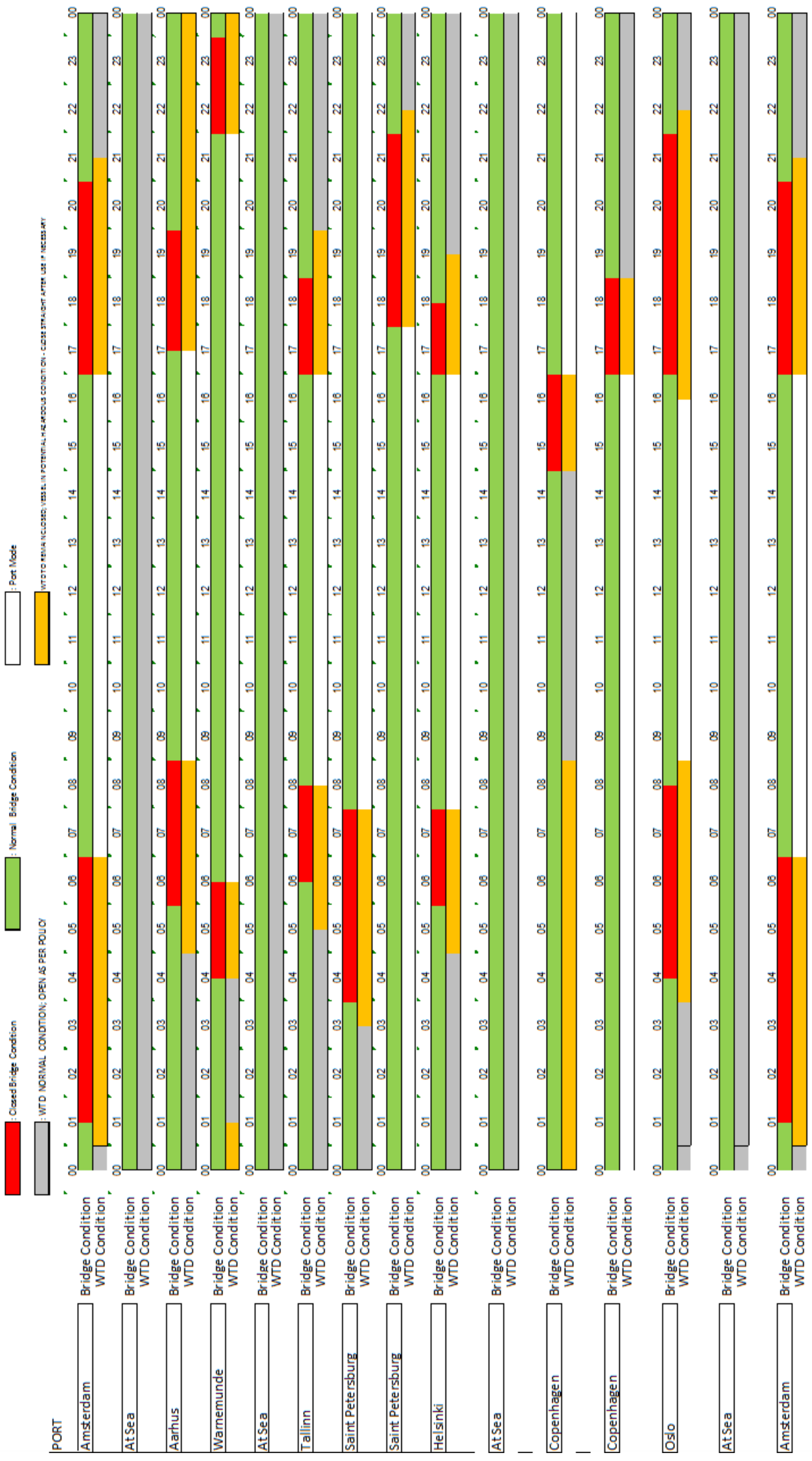
APPENDIX 8

GANGWAY ANGLE CALCULATION

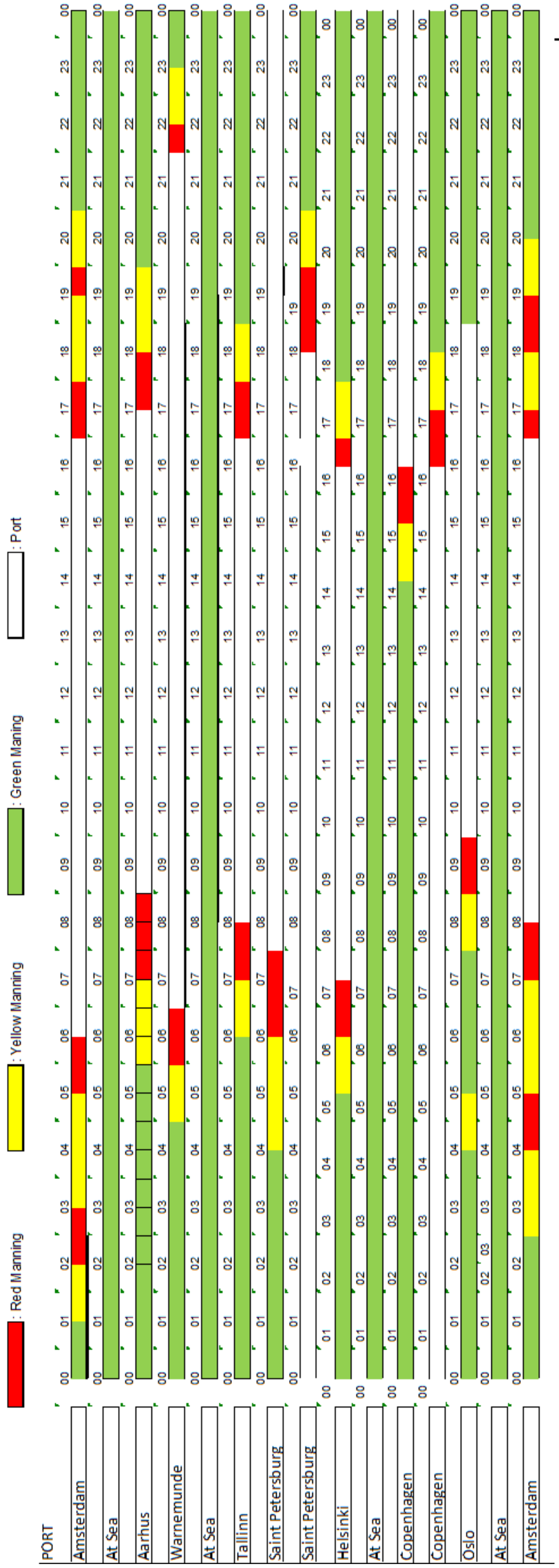
Gangway Calculations										
MS Rotterdam			Port				Date			
			Dublin				29 Sptember 2019			
Height of Quay above Chart Datum (m)	6		Boxes used? No		Total height (m)		6			
Input values										
Height of tide			Breakdoor height above waterline Tm = 8.2m				Gangway length			
LW	0		Deck A	3,4			Short	4		
HW	4,5		Deck 1	6,3			Long	9,5		
Arrival	3,7		Deck 2	9,1			Shoreside	12		
Departure	3,4		Deck 3	12			Ganway used	12		
Results										
Height of gangway above quay depending on list										
Deck A				Deck 1				Deck 2		
	0°	-1°	1°		0°	-1°	1°		0°	-1°	1°
LW	-2,6	-2,3	-2,63	LW	0,3	0,6	0	LW	3,1	3,4	2,8
HW	1,9	2,2	1,6	HW	4,8	5,1	4,5	HW	7,6	7,9	7,3
Arrival	1,1	1,4	0,8	Arrival	4	4,3	3,7	Arrival	6,8	7,1	6,5
Departure	0,8	1,1	0,5	Departure	3,7	4	3,4	Departure	6,5	6,8	6,2
Angle of gangway in °											
LW	-12	-11	-12	LW	1	3	0	LW	15	16	13
HW	9	10	8	HW	22	24	21	HW	34	35	33
Arrival	5	7	4	Arrival	19	20	17	Arrival	31	32	30
Departure	4	5	2	Departure	17	19	16	Departure	30	31	28

APPENDIX 9

WATERTIGHT DOOR SCHEDULE



BRM SCHEDULE



The Bridge manning level is subject to change by the Master. The Master will ensure that the manning level on the bridge is appropriate for the risk and workload. The OOW can at any time s/he feels the need, increase the manning level.

ENVIRONMENTAL SCHEDULE (This is an old schedule format made prior to global sulphur cap, but after Carnival Corporation decided to forbid all discharges for their vessels inside 12 NM. In the earlier versions there were additional columns for inside/outside 4 NM.)

DAILY ENVIRONMENTAL SCHEDULE *** THE TIMES LISTED ARE FOR PLANNING PURPOSES ONLY AND TIMES MAY CHANGE. OOW APPROVAL MUST ALWAYS BE OBTAINED PRIOR TO OPENING ANY OVERBOARD VALVE OR CONDUCTING ANY OF THE LISTED ENVIRONMENTAL ACTIVITIES ***
v00: May 2019
This Environmental Schedule must be maintained for at least 6 years. It must be maintained by the EO for 3 years, after which it may be transferred ashore and maintained by the Company.

Ship / Voyage details			
	Ship Name	MS ROTTERDAM	
	Voyage ID	V595	
	Date	22 AUG 2019	
	Voyage Leg	Akureyri	

TIME		FROM 0:00 TILL 1:00	FROM 1:00 TILL 5:00	FROM 5:00 TILL 10:00	FROM 10:00 TILL 20:00	FROM 20:00 TILL 23:30	FROM 23:30 TILL 23:59
SHIP'S LOCATION		Inside 12 NM from Baseline	Outside 12 NM from Baseline	Inside 12 NM from Baseline	In Port/ Anchorage	Inside 12 NM from Baseline	Outside 12 NM from Baseline
WAYPOINTS / NOTES				NO AAQS ALLOWED IN EYJAFJORDUR FJORD, CHANGE TO MGO	NO AAQS ALLOWED IN EYJAFJORDUR FJORD	NO AAQS ALLOWED IN EYJAFJORDUR FJORD. WHEN OUTSIDE THE FJORD CHANGE TO HFO AAQS	
	Special Area / Marine Sanctuary/ Antarctica	NO	NO	NO	NO	NO	NO
	Emission Control Area	NO	NO	NO	YES, See comments *	NO	NO
Discharges	Treated Bilge Water discharge	NO	YES	NO	NO	NO	YES
Discharges	Treated Sewage/Treated Grey water (For Alaskan Waters, refers to the Alaska operation Tab)	NO	YES	NO	NO	NO	YES
Discharges	Untreated Grey Water discharge	NO	YES	NO	NO	NO	YES
Discharges	Comminuted Food Waste discharge	NO	YES	NO	NO	NO	YES
Discharges	Non-comminuted Food Waste discharge	NO	NO	NO	NO	NO	NO
Discharges	Biomass from AWWTS						
Discharges	Boiler Blow Down discharge	NO	YES	NO	NO	NO	YES
Discharges	Pool/Recreational Water discharge	NO	YES	NO	NO	NO	YES
Discharges	Ballast water Operations	NO	YES (Treated/Managed)	NO	NO	NO	YES (Treated/Managed)
	Distillation and Reverse Osmosis Brine discharge	YES	YES	YES	NO	YES	YES
	Side Shell washing / Painting	YES	YES	YES	In Port (YES-only after approved by the local authorities)	YES	YES
Air / AAQS (EGCS)	Fuel Sulfur Limit	1.5% Max	1.5% Max	1.5% Max	0.1% Max	1.5% Max	1.5% Max
Air / AAQS (EGCS)	Incinerator Operations	No	Yes	No	No	No	Yes
Air / AAQS (EGCS)	AAQS (EGCS) Operations	YES, IMO	YES, IMO	YES, IMO	YES, IMO	YES, IMO	YES, IMO

Special Area / Marine Sanctuary/ Antartica	Master to gain authorization from Icelandic Coast Guard prior to deballasting within EEZ
In an Emission Control Area Comments *	Ships when operating in Iceland's EEZ, use maximum 1.5% sulphur. When at berth/anchor, use maximum 0.1% sulphur (in port changeover within 1 hr after arriving at berth - may change back within 1 hr before departing berth). AAQS (EGCS) can be used instead of switching fuel as an allowed alternative means of compliance. In Eyjafjordur (S of 66N) only MGO.
Fuel Sulfur Limit Comments	Iceland EEZ Max 1.5% sulphur, Iceland berth/anchor max 0.1% sulphur
Pool/Recreational Water discharge	Discharge only outside 12' from baseline, speed >6kts
Prepared by: First Officer / VPO:	
Reviewed by: Environmental Officer:	

APPENDIX 11

VOYAGE & PORT NOTES

FULL ENC COVERAGE	**GMDSS:** NAVAREA I AOR-E NAVTEX O **NP:** E-NP 37/40

Departure: Liverpool, UK

Tugs: Not compulsory, but port guideline is to have one tug assisting when swinging in the river. Agent will consult the pilot about the requirement.

Tides: Expected tidal levels 6.5-7.2m above chart datum during the pilotage. Minimum tidal level of 3.5m above CD required for UKC. On 10th August tidal window is from 03:15 to 12:30 and from 16:10 to 01:10 (11th August). As per pilots no issues during our call.

Contact: Emergency Tel: 999

Arrival: Dublin, Ireland

Tugs: Available on request

Berth: Ocean Pier 37, length 242m. Dock height 5.5m. Deck 1 gangway possible all time, A deck can be used from arrival to 13:00 and from 18:00 to departure.

Tides: Minimum UKC 1m. Expected tidal level during the pilotage 2.8-3.5m above chart datum. Minimum tidal level of 2m above CD required for UKC. On 11th August the tidal window is from 05:00 to 13:15 and from 17:35 to 01:45 (12th August).

Speed: Breakwater 9kn, from Eastern Breakwater (berth 50a) 4kn

Notes: Information from the port study. Outside breakwaters on flood tide unpredictable strong N-ly current, perpendicular to the ship. Alters direction to following the channel once inside the breakwaters. Ebb current not as strong as flood at the breakwaters when N-ly wind. Port study made for docking in western basin, we are going to eastern basin.

Contact: Emergency Tel: 999

APPENDIX 12

TIDAL CHART