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VOYAGE PLANNING IN ECDIS

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1. INTRODUCTION

The **aim** of this paper is to emphasize the need for a structured approach to the development of tools for navigation support in ECDIS. To this purpose this paper focuses on voyage planning in ECDIS, outlining a more formal approach, to provide a basis for the development of tools for automated navigation support.

The outline of this paper is as follows:

First it will present some considerations regarding the development of ECDIS functionality,

- then it will get into a definition of voyage **planning,**
- followed by a conceptual framework of **integrated navigation**, which is then used as
- the basis for a more detailed look into the **voyage-planning** process.
- This is followed by an impression of what could be envisaged as automated support tools for voyage planning.
- Some concluding remarks are made in the final paragraph.

2. ECDIS AND NAVIGATION SUPPORT

The electronic chart development started with the sole purpose of replacing the paper chart. Soon it was realised that the electronic chart functionality

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could be expanded to a navigation information system; the name changed from electronic chart into electronic chart display and information system, ECDIS. However, the term 'information system' can still be interpreted as a system which is simply able to display the stored data. In that case the discussion is reduced to the selection of data to be stored, the data structure and the symbology or display format. This basic interpretation does not lead to much added value. The added value improves significantly when the system integrates the available data into improved information products. This synergistic approach usually requires the data to be structured into objects and attributes which can be used in processing algorithms. The real value of ECDIS is determined by its synergism.

When designing support tools we tend to ask the practitioner what he requires. Often however the practitioner is focused on the current procedures and the workload involved. The result may easily be the development of a support tool which in essence is an automated replica of the manual procedure, thus failing to improve the solution because the underlying issue was not identified. Development of support tools should therefore be based on a thorough analysis of the problem to be solved. It should also be borne in mind that the tool should fit into the logical process it is supposed to support, i.e. the tool should provide the required information with the information available in that phase of the process.

The latest report of the workshop on development of Marine Information Objects (MIO) for ECDIS [ECDIS/MIO] showed some of the aforementioned in the resulting recommendations.

The point that is made here, however, is that the development of navigation support tools for ECDIS is rather a result of individual ideas than the results of a structured analysis of the navigation process. It is the author's view that the development of new ECDIS functionality should be founded on some reference-model of the navigation process, identifying logical structure and processes eligible for automated support, possibly including agreed priorities. Manufacturers could then focus their efforts to substantiate the identified functionality, standardisation forums could concentrate on the required data structures, and data suppliers could focus on providing the required data in the required structure in order of the agreed priorities.

The next paragraphs will focus on voyage planning as an area eligible for automated support by ECDIS.

3. VOYAGE PLANNING

3.1 Voyage Planning defined

Voyage planning can be defined as:

the systematic process in which a sailing order is translated into an optimal navigation plan and detailed navigation scenario to fulfil the mission, having considered all relevant information.

The sailing order may differ for the different user groups: transport, fishery, offshore, navy, coastguard et cetera, but there will generally be a mission element and a constraints element that are to be satisfied by the voyage plan. Often the constraints are defined in terms of time, or economy, but they may also include criteria such as ship's motion or temperature constraints.

Voyage Planning is meant to provide:

- Prevention of potential conflicts or dangerous situations;
- Optimisation of planning for specific planning factors;
- A detailed scenario for the execution;
- A reference to compare the actual voyage progression with the planned progression.

Typical of voyage planning is the great diversity of data to be collected, consulted and integrated into both the overall voyage plan, and the detailed navigation scenario for every watch.

3.2 Voyage Plan and Integrated Navigation

This paragraph aims to identify voyage planning in the context of an integrated navigation system. Navigation can be defined as the process of controlling the movement of a craft from one state (position, course, speed, etc.) to another state, under predefined conditions.

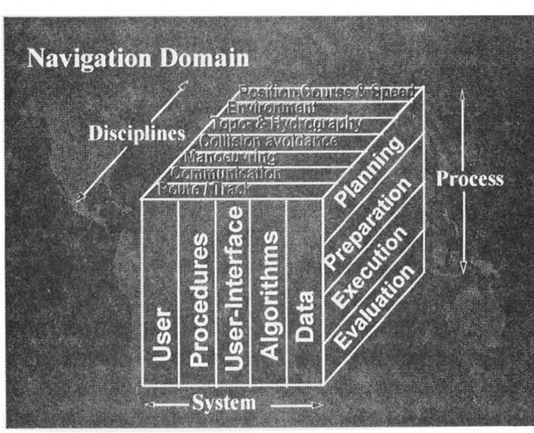

Fig. - 1: The Navigation Domain

From the perspective of elementary **navigation disciplines** (Fig. 1), this definition encompasses a broad variety of subjects, ranging from positioning, meteorology, tides, tidal stream, ocean current, hydrography and topography to anti-collision regulations, communication and ship manoeuvring .

From the **process perspective** navigation is comprised of the consecutive phases of planning, watch preparation, watch execution, and evaluation.

There is also the **system perspective** where we can discern the elements of data, algorithms, user-interface, procedures and the navigator.

With this cube-like model (Fig.1) of the navigation domain in mind we can discern various sorts of system integration. First there is integration of different navigation disciplines, which we could refer to as synergistic integration. Then there is the integration across the various phases of the navigation process, where the products of each navigation phase could be transferred to the next phases. In the system dimension integration is concerned with the allocation of tasks to either the system or the user, based on human factors methodology. In the data segment integration is concerned with data models, data standards and data quality.

In view of the focus of this presentation I will not go into a detailed discussion of integrated navigation. The remainder of this presentation will focus on voyage planning, being the first two phases of the navigation process, across all the disciplines and all segments of the system perspective.

3.3 Voyage Planning Process

The present standard for voyage planning is laid down in the IMO Guide to the Planning and Conduct of passages. This standard discerns the phases of Appraisal, Planning, Execution and Monitoring. Reading this document provides a good impression of the factors to take into consideration. However, the document does not provide a clear picture of the logical structure of the process, the interrelationships of the various aspects to consider, the questions to be answered, and the products resulting from each phase. It is a listing of reminders and things-to-do without logical structure or sequence. Therefore the document does not provide a basis which is sufficient for the development of coherent automated support tools for voyage planning.

Voyage planning is not a straightforward process which leads to the correct answer. It is much more a search through a wide variety of, often time-variant, information in many different publications. The navigator's task is to identify and comprehend the most important aspects to develop his voyage plan. In doing so he is repeatedly revisiting these aspects at an increasing level of detail while at the same time the voyage plan develops.

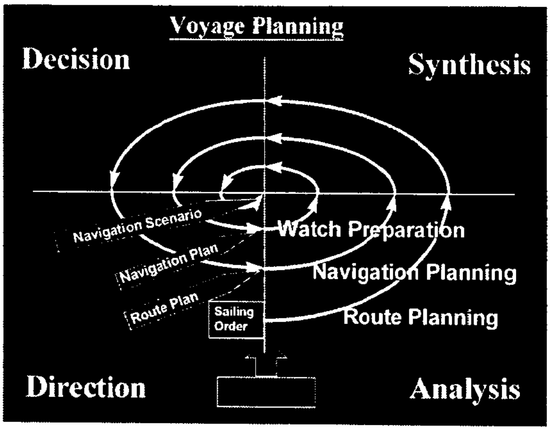

Fig. - 2: Voyage Planning Process

Voyage planning can be seen as an iterative cyclical process, (Fig.-2) as represented by a spiral model, with a standard logical structure and a clearly defined product for every cycle. Each product serves as a directive for the next cycle. The first cycle, *route planning*, is concerned with selecting the best route; the product is the **route plan**, an outline description of the route which is feasible within the constraints provided in the sailing order.

The second cycle, *navigation planning*, is concerned with the question how to navigate the selected route: the precise track to follow, the associated safety margins, track deviation tolerances, the overall time schedule and the navigation procedures for the different phases of the voyage (Fig.2).

The resulting **navigation plan** should provide guidance for every officer of the watch to independently carry out his *watch preparation* resulting in a fully detailed **navigation scenario** for his watch.

Theoretically speaking each cycle as aforementioned consists of the consecutive phases of *analysis*, *synthesis*, *decision*, and *direction* for the next cycle. The analysis-phase starts with the basic issues such as: what is required, within which constraints, which information is required, what does that information indicate. In the synthesis-phase options are generated and considered. Next the plan is finalised in the decision-phase and worked out to the required detail in the direction phase in order to serve as a reference directive for the next phase.

This formal description of the voyage planning process may seem very theoretical to the navigation practitioner. However, the experienced navigator may well recognise the essential ingredients in the procedure he personally developed over the years. This theoretical procedure is not meant to be formally implemented in full detail in the daily navigation practice. It is meant to provide the basis for development of automated tools to support the voyage planning process.

4. VOYAGE PLANNING SUPPORT OUTLINE

The following paragraphs provide an outline description of voyage planning support as envisaged for ECDIS. It is based on the aforementioned analysis. It is not meant to provide a complete picture. It is an extract, just to provide an impression of the required functionality that would result from a proper analysis.

4.1 Cycle-1: Route planning

The aim here is to select the best route fulfilling the mission within the constraints as prescribed. The system requests the ports of departure and arrival to be identified on an overview map, including the basic planning constraints in terms of ETD and ETA, speed characteristics and maximum draught, cargo class. The system searches a predefined route network, to come up with an **outline of feasible route options**. 'Feasible' in this stage indicates that the basic ship's constraints have been verified against the route constraints. Therefore the attributes of each leg of the route network include the basic parameters of that leg, such as distance, maximum allowable draught, speed limitations and prohibited cargo classes. Attributes may also provide references to other limitations that should be brought to the attention of the mariner on presenting the route as a feasible option.
Next the presented route options are verified against a climatologicl and oceanographic database for critical and significant environmental factors as defined by the operator in terms of wind-speed and --direction, seastate, ice, ocean currents. Unfeasible route options (e.g. through ice) are then deleted and significant environmental characteristics are assigned to the remaining route options. The result is an overview of feasible route options with their specific characteristics in terms of distance, time, economy, and environmental factors, providing the necessary information to make an initial route selection. The result is a route defined by Route points and connecting legs, with an associated bandwidth for detailed track planning, together with an initial time-schedule and possibly some pointers urging for more detailed planning, such as tidal time-slots.

4.2 Cycle 2: Navigation planning

The main questions to be answered in this cycle are concerning the definition of navigation track, its subdivision into phases of navigation (e.g. ocean, coastal, confined waters, inshore conditions), the associated safety margins and cross-track tolerances, the associated navigation procedures, and the detailed planning of critical elements of the voyage (e.g. tidal time-slots, critical passages, etc.). Before the course lines are drawn the system should mark areas of unsafe waterspace (within the defined route bandwidth). Then it highlights the vessel traffic data along the route such as TSSs and recommended tracks and routes. With this information the navigator can draw the initial course lines. Next, the system provides an initial subdivision of the track into the standardised phases of navigation. Assigning these phases of navigation automatically assigns specific (standardised) navigation procedures (positioning procedures, manoeuvrability, bridge manning, etc.) to each phase of the route. Then the track is tested for critical points, as defined by the user, based on a combination of criteria such as safe water margin, positioning accuracy, tidal stream and water depth, prompting the navigator to adjust the track or to define additional measures and criteria in a decision point.

Then the system generates associated information regarding traffic management (reporting point, procedures etc.), pilotage (procedures, positions etc.) and communication, based on the fairways and traffic management regions that are passed. The resulting Navigation plan provides all information for every officer of the watch (OOW) to do the planning of his next watch in full detail.

4.3 Cycle-3: Watch preparation

The aim of this cycle is to produce a fully detailed navigation scenario for the next four to six hours.

Upon starting his preparations the OOW will require a geographical overview of the voyage with a small window indicating the area of interest for the hours of his watch. From here the OOW will focus on the area within this window to familiarise with details of the navigation plan for his watch. The system recalculates the planned time schedule in case of any significant deviation from the route or time schedule. This may also involve recalculation of tidal streams UKCs etc.. Now the OOW will need to review the weather situation for his watch. To this purpose the system provides a comprehensive graphical presentation of the weather situation, based on actual data (own sensors), nowcast- and forecast-data, focused on: wind, seastate, visibility and precipitation. The OOW draws conclusion on impact on speed limitations, positioning options and collision avoidance. The next step is for the OOW to plan every course alteration in full detail under the anticipated circumstances of tidal stream, visibility and traffic.

Then the OOW attempts to picture the visual environment in terms of both general and navigation specific characteristics. The system may provide support by detailed pictures, annotated aerial overviews and possibly a video impression. This information may be augmented by a textual description, which is kept to a minimum.

The navigation plan, together with the detailed complementary information can be seen as the detailed navigation scenario in which the track and the associated time schedule are leading for the actions to take, in terms of manoeuvres, radio communication, ship's procedures, navigation procedures and decisions on feasibility.

Once again this description is far from complete, it is just an extract, meant to provide a picture of logical structure derived from analysis of the underlying process, resulting in options and requirements for automated support.

5. CONCLUDING REMARKS

Modelling the process to be supported provides a clear insight into the logical sequence of questions to be answered, with the data available in the specific phase of the process.

This can provide logic and structure into the supporting system, thus inviting the user to follow a structured process, at the same time ensuring that all relevant information is considered. A formal analysis of marine navigation and the processes involved could serve as a reference for manufacturers, data managers, researchers and regulators to provide coherence and purpose into the development of ECDIS as an information system. It could also serve as a reference for the customer to compare and contrast different systems.

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