Meteorological and Oceanographic Data in ECDIS for Navigation

海洋氣象資料與電子海圖顯示與資訊系統之整合

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Abstract

The incorporation of meteorological and oceanographic information into ECDIS (Electronic Chart Display and Information System) has become an issue of major concern to IMO, IHO and WMO. It is believed that this will make ECDIS a more versatile tool to assist the mariner in decision –making, and in making navigation more efficient and safer as a result. This paper first reviews the essential items (meteorological or oceanographic) which should be included, then proposes data structure, formats, and symbology for the display of these data in ECDIS, according to IHO S57 and S52. This proposed integration has been proved to be highly feasible by preliminary results of the test implementation in a self-developed ECDIS system.

I. Introduction

Electronic chart display and information system (ECDIS) is a navigation information system designed to contribute to safe navigation. ECDIS assists the mariner in route planning and route monitoring by displaying selected information from a system electronic navigational chart database (SENC), information from navigation sensors, and other navigation-related information. With spatial analysis functions, ECDIS can check the preplanned route and predicted path for possible dangers and generate various alarms. SENC means a database resulting from the transformation of the official Electronic Navigational Chart (ENC) by ECDIS, updates to the ENC and other data added by the mariner. The SENC may also contain information from other sources. The content, structure and format of the ENC are specified in IHO (International Hydrographic Organization) S-57 edition 3 including the associated ENC product specification. The presentation (decoding and symbolization) of the SENC on the ECDIS display is specified in IHO S-52, appendix 2 "Colour and Symbol Specification for ECDIS".

In ECDIS glossary, information objects are divided into Chart Objects (unchanging) and Non-chart Objects (variable), the latter named "Marine Information Objects" (MIO). MIOs include all non-cartographic objects that change with time. Since the weather and sea state has significant effect on the safety at sea, the incorporation of meteorological and oceanographic information into ECDIS has become an issue of major concern to IMO (International Maritime Organization), IHO and WMO (World Meteorological Organization). Among these elements, current, tide and tidal stream data are already specified in IHO S57, ed.3.

The meteorological and oceanographic MIOs under discussion include wind, weather, waves, visibility, water temperature and salinity. It is believed that this will make ECDIS a more versatile tool to assist the mariner in decision – making , and in making navigation more efficient and safer as a result. It will also promote cost effectiveness of shipping and better protection of the environment. In the following sections, the essential meteorological and oceanographic items which should be included will be identified. The data structure and formats as well as the symbology for the display of these data in ECDIS, in conformance with the principles of IHO S57 and S52, will be discussed based on test implementation results with a self-developed ECDIS system.

II. Meteorological and Oceanographic Data for Navigation

According to the Joint IMO/IHO/WMO Manual on Maritime Safety Information (MSI, Nov. 1995), meteorological warnings and forcasts for the high seas shall include the following three parts:

Part I : Storm Warnings

(a) Type of warning (gales, storms and tropical cyclones) ;
(b) Date and Time of reference in UTC;
(c) Type of disturbance (e.g. low, hurrican, etc.) with a statement of central pressure in hectopascals;
(d) Location of disturbance in terms of latitude and longitude or with reference to well-known landmarks;
(e) Movement(speed & direction) of disturbance;
(f) Extent of affected area;
(g) Wind speed or force and direction in the affected areas;
(h) Sea and swell conditions in affected area;
(i) Other appropriate information such as future positions of disturbance

Part II: Synopses

The synopses shall have the following content of items:

(a) Date and time of reference in UTC;
(b) Synopsis of major features of the surface weather chart;
(c) Direction and speed of movement of significant pressure systems and tropical disturbances (indicated in compass points and metres per second or knots respectively)

Central pressure and/or intensity, location movement and changes of intensity should be given for each system; significant fronts, high-pressure centers, troughs and ridges should be included whenever this helps to clarify the weather situation.

Part III: Forcasts

The forcasts shall have the following contents of items:

(a) The valid period of forcast;
(b) Name or designation of forcast area;
(c) A description of:
Wind speed of force and direction; Visibility when forcast is less than six nautical miles; Ice accretion, where applicable; Waves;

At present, reception of these information is mandatory under the GMDSS (Global Maritime Distress and Safety System) for all SOLAS class vessels (i.e. over 500t). The maritime safety information is broadcasted via NAVTEX and INMARSAT SafetyNET service.

III. Incorporation of Data into ECDIS

1. Data encoding and presentation

Object classes and attributes for time-varying current, tide and tidal stream data are already specified in IHO S57, ed.3. These data will not be discussed further here. In the theoretical data

models of S57, real world entities are defined as a combination of descriptive and spatial characteristics. The descriptive information and the geometry (the information of shape and location) are defined in terms of feature objects and spatial objects, respectively. There are four types of feature records: geo, meta, collection and cartographic. An object may have attributes and may be related to other objects. In order to facilitate the efficient processing of ENC data, ENC of different compilation scales are categorized into six navigational purposes (intended usage), with the geographic coverage of a given usage split into cells.

Based on IHO S57, the objects and attributes for encoding and updating these information in ECDIS are proposed as listed in Table 1. If the entire surface weather chart (including the station report and isobars) is to be incorporated, large amount of spatial and feature objects will be required to encode the information. These objects are updated(actually replaced)altogether regularly. Therefore, to transfer and update them in an efficient way, it is proposed to group them into a file and replace the whole file for updating. In the case that only the major features of surface weather chart (e.g. high and low pressure centers, significant fronts, such as those available from NAVTEX) are required or available, they may be updated (inserted, modified, or deleted) in an object-based way either automatically or manually. Surface prognosis and analysis can be treated in the same way and differentiated by using an attribute "forcst" indicating the hours of forcast. The time and date of reference can be encoded with "TIMSTA" (time start) attribute, and the valid period can be defined by adding "TIMEND" (time end). "SORIND" can be used to encode the source of the information. Cautionary and explanatory notes can be encoded with "INFORM" or "TXTDSC"(textual description). As for the routine weather and sea bulletin data, which could be provided as area encoded information, the meteorological area and sub-areas should be encoded into SENC of ECDIS. Only the attributes associated with these MET. areas are updated with the transmitted weather information. The numbering of updates as specified in the S57 ENC product spec. is limited to 3 digits, which is definitely not suitable for the frequent update of Met. info. Besides, met. info. could be independent of the navigational usage of ENC base cells. Therefore, there should be a separate product specification for weather data in S57, specifying the file naming, updating, application profiles, and the use of object catalogue for met. data.

2. **Symbolization and Data Presentation**

Meteorological and oceanographic MIO data should follow WMO symbology. For example, surface station report can be plotted in the so called "station model" at the point location of station. This can be easily implemented in S52 presentation library (PL) with a conditional symbolization procedure for ECDIS display. The station symbol is a combination of the symbols for the various attribute classes listed in Table 2, while the symbol of each attribute class depends on the actual attribute value.

3. **Integration and Use of Data**

A. Route Planning and Optimization

For route planning, forecast or predicted data are used. Preplanned routes in ECDIS, which consists of waypoints and leg lines, can be selected or optimized by taking not only own ship parameters, but also wind, wave (swell), current into account. This can

lead to a safer voyage and more accurate ETAs.

B. Route Monitoring

For route monitoring, either real-time (sensor or measured data) or nowcast (forecast data for current time) data are used. From the tropical cyclone and cyclone track, navigable and dangerous semicircle can be identified, so that a suitable evasive action can be taken. From the movement of the storm relative to own ship, the course and speed to be taken to achieve a maximum CPA (closest point of approach) can be calculated. The CPA, as compared with the radius of the storm, indicates the level of threat.

IV. Preliminary Test Results

Some of the proposed objects and symbolizations (See Table 3) have been implemented into an ECDIS system developed on windows NT with Visual C++. Please see Fig.1 for an example screen capture. In this test, complex line styles are designed for cold front and warm front. The color of fronts are chosen to be black to avoid confusion. As for the tropical cyclone, the actual point symbol to be used can be selected according to its geo-location (north or south hemisphere) and strength. Name of the cyclone is encorded as the object name, which can be displayed if required.

V. Conclusion

The incorporation of meteorological and oceanographic information into ECDIS will make it a more versatile tool to make navigation more efficient and safer as a result. The integration proposed in this paper has been preliminarily proved to be highly feasible. However, further investigation and developments are required to gain the maximum benefit from the integration.

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Table 1 Object and attributes for meteorological data

	Object Classes	Geometric Primitive	attributes	Update type
1	Station report	point	wind speed & direction, weather, sky cover, MSL pressure, temperature	file
2	Isobars	line	pressure value	file
3	High pressure	point	central pressure, direction & speed, forcast	file, object
4	Low pressure	point	central pressure, direction & speed, forcast	file,object
5	fronts	line	category: warm, cold, occlusion; direction	file, object
6	Tropical cyclones	point	max. wind speed/ force, radius (force 10 or 7), hemisphere (N or S), direction & speed, forcast	object & attribute
7	Cyclone track*	line	time of arrival at a point, direction & speed	object
8	Alert area**	polygon	category of met.alert, cautionary notes	object
9	area bulletin	polygon	wind, weather, visibility, wave	Attribute

* Collection objects C_AGGR can be used to aggregate all the objects related to a tropical cyclone.

** Collection object C_ASSO can be used to associate the alert area to the tropical cyclones or fronts.

Table 2 Symbology for station report

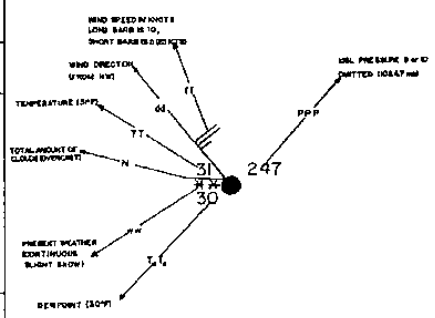
Attribute class	Symbol	
Wind	One wind arrows for each wind speed code Oriented according to the wind direction	Station model : 
Present weather	Weather symbols(synop code ww=00-99)	
Sky cover	clear scattered broken overcast obscured	
MSL pressure	Numeric(same as those used for soundings)	
temperature	Numeric(same as those used for soundings)	

Table 3 Symbology for Meteorological Objects

Object class	Symbol
pressure centers	"H" for high pressure, "L" for low pressure at center, vector for the motion
fronts	Cold fronts  Warm fronts  Stationary  Occluded 
Tropical cyclones	Point symbol: North hemisphere depression storm tropical cyclone South hemisphere depression storm tropical cyclone A solid circle centered at the above point symbol showing the radius can be drawn. For forcast object, dashed lines are used for the circle.
Cyclone track	Plotted with tropical cyclone point symbol connected with solid lines. If required, the ECDIS may mark the positions with date and time.

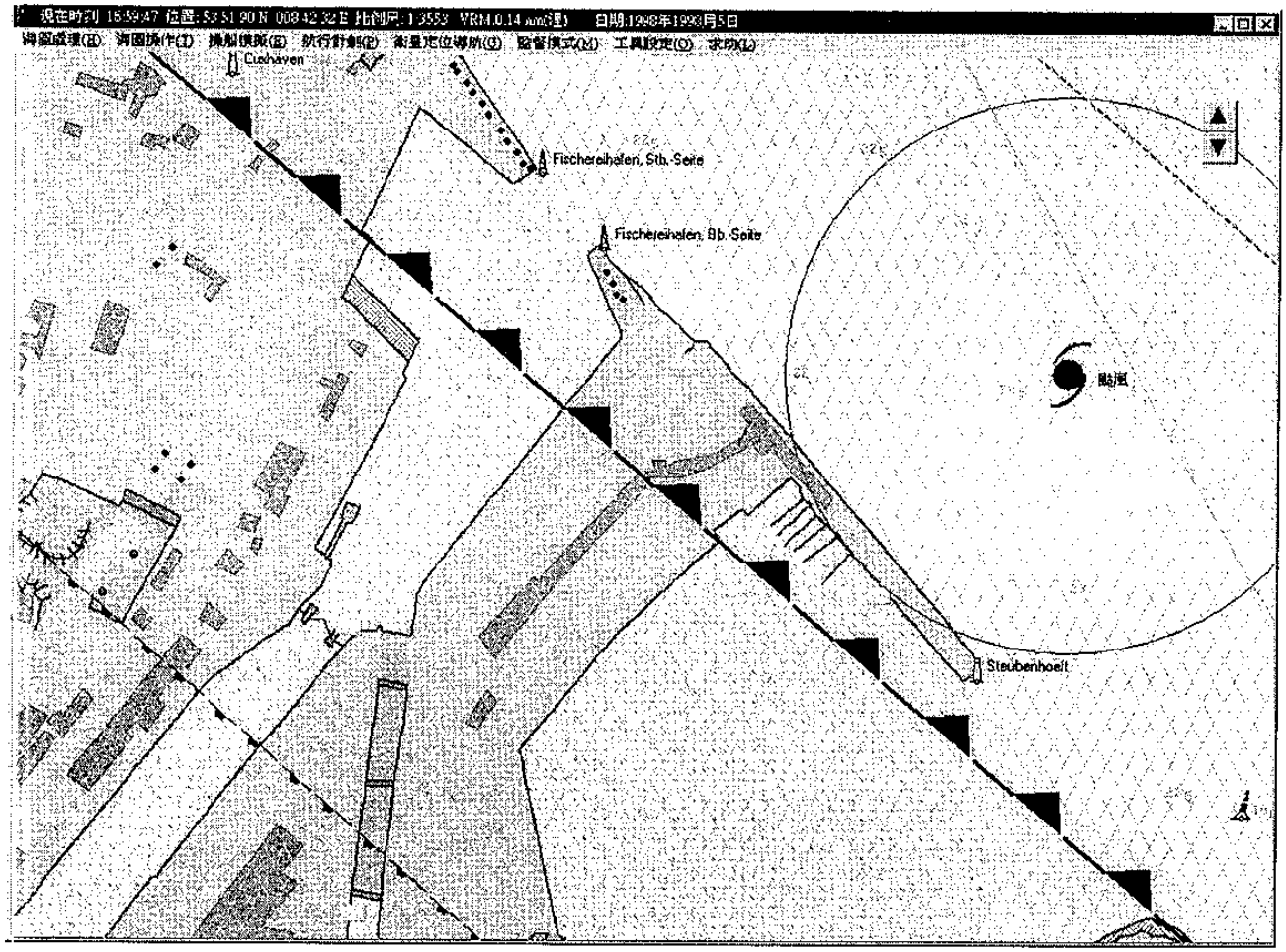


Fig. 1 Screen capture of the test implementation of meteorological data in ECDIS

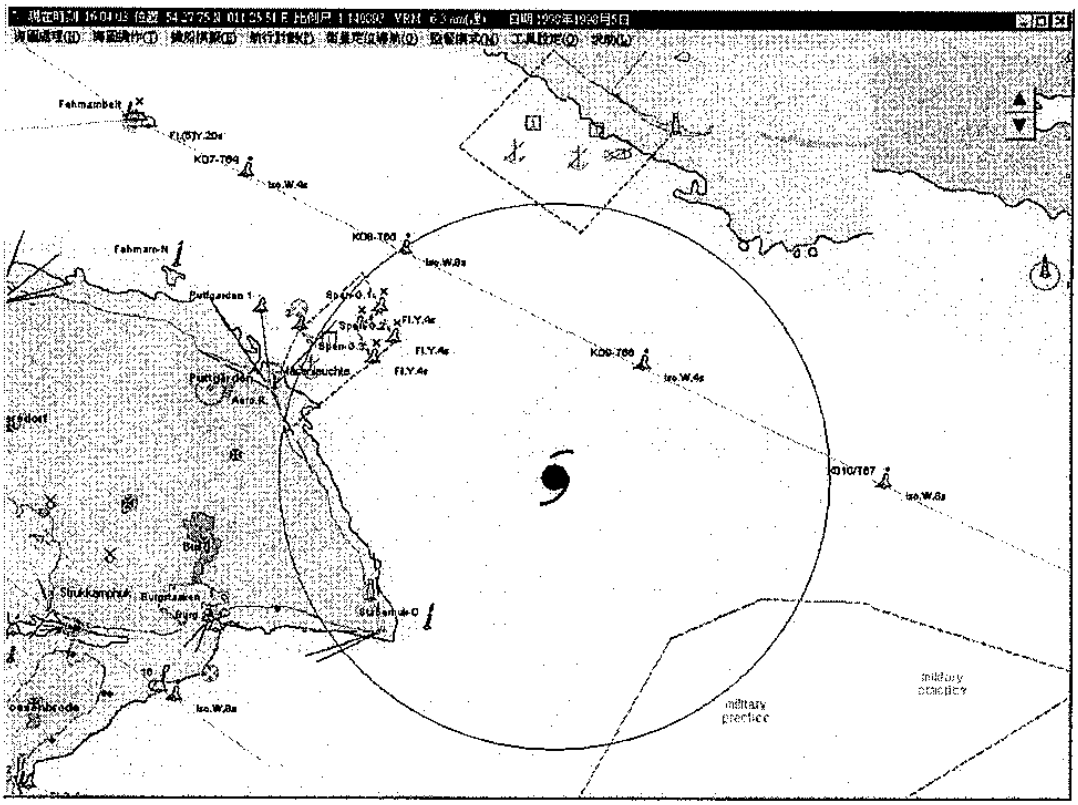


Fig.2 Screen capture of the test implementation in ECDIS (smaller scale)