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ELECTRONIC REFERENCE CHART AND PERFORMANCE STANDARD FOR ELECTRONIC REFERENCE CHART SYSTEM

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1. Introduction

In 1970, some electronic companies in Japan, had developed simple electronic chart systems which displayed only coastlines and ships' positions obtained by Loran C. Although in the 1980s most of the systems were installed on fishing boats, they have spread quickly and are not only used by fishing boats but also by pleasure crafts, as the systems have proved to be most convenient.

As the companies digitized coastlines from the paper chart for their own systems, limited attention was given to standardizing data accuracy, format and media. Consequently a new database for this kind of system which is authorized, standardized and includes more details of chart information has been long awaited.

To meet this situation the Japan Hydrographic Association (JHA) has been engaged, since 1993, in the development of an Electronic Reference Chart (ERC) for the vessels operating in coastal waters. This work has been carried out under the technical guidance of the Hydrographic Department of Japan (JHD) as a 4-year project. Starting in December 1993, the JHA has put on sale ERCs covering certain maritime areas where there is heavy traffic congestion (see Fig. 3).

ERC data are important for navigation and simpler to produce than the ENC (Electronic Navigational Chart). The ERC System (ERCS: hardware and software including display and IC-memory) is simpler and cheaper than the ENC system.

In 1994, the Performance Standard for ERCS (PSE) was prepared in order to show ERCS manufacturers the minimum performance standards for the systems

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from a viewpoint of contributing to safe navigation, for the quick distribution of data and for the navigators to use any type of the system without any anxiety.

This paper reports on the background of ERC, and outlines the method of production, identifies the paper charts that are to be digitized, PSE and future prospects for the system.

2. ERC DATA FORMAT AND MEDIA

In 1991, the ERC data format and media were studied and standardized by the JHA and the SUIYOKAI Group under the guidance of the JHD.

After the unifications JHA as ERC producer/supplier and the ERCS manufacturers have used the same data format and media. The IC-memory card was selected for the ERC media as it can withstand vessels' vibrations or wave shocks during data-loading. Its specifications are as follows:

Type : Flash memory type
Pins : 68
Capacity : 256KB memory

In 1992, the first ERC, as a testbed project in the vicinity of Seto Inland Sea, was released to the SUIYOKAI group members and some other users.

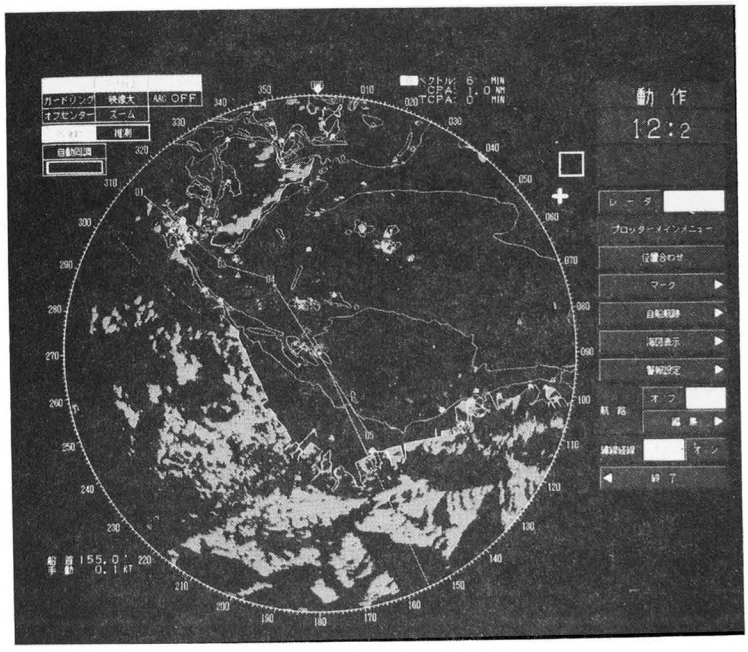


FIG. 1.- The ERC display at the eastern part of Seto Inland Sea in Japan.

3. ERC DISPLAY

Figure 1 shows a typical example of the ERC display. In the Figure (picture taken at the eastern part of Seto Inland Sea in Japan), the ship's positions obtained from GPS are plotted automatically at the centre of the CRT with its tracks and the radar images overlaid.

4. DATA PROCESSING FOR PRODUCTION OF ERC

For the production of ERC, the following steps (1) to (3) of data processing have been carried out by a contracted company, and steps (4) to (5) are processed by the JHA, using its own computers.

(1) Selection of the ERC data from the JHD chart database

The original data of ERC have been supplied from the JHD chart database in which all of the paper chart information is available in digital form. As the JHD data base includes all the data shown on the paper charts, data selection is necessary to form the ERC. The selected data includes :

- Coastlines
- 10- and 20-metre depth contours
- Aids to navigation such as lighthouses and lightbuoys
- Dangers like drying and sunken rocks, fish havens, sunken wrecks, tide-rips, eddies and pipe/cable lines, except the area between coastlines and 10-meter depth contour lines
- Various maritime limits and conspicuous landmarks

The selected data are converted into the ERC data format to produce the ERC data.

(2) The updating of the ERC data

Although the JHD has digitized nautical charts since 1984 to establish a digital data base for paper chart production, no updating had been done so far. For the ERC data it is necessary to arrange that the data be updated.

(3) Data compaction for the ERC

The heavy data density of the JHD's chart database, such as provided for coastlines/contours makes it necessary to reduce the data points for ERC use because of the capacity limitation of the IC-memory card and the loss of time spent in data loading/displaying by the ERCS users. On the other hand, too much data

compaction causes figure distortions on the ERC display. The chosen standard requires that the errors caused by data compaction should not exceed 0.3 mm on the original paper chart.

(4) Integration of the ERC data

In the ERC, there is no requirement to establish borders between each ERC data file digitized from individual chart as long as the current paper chart number can be displayed at the request of navigator. As ERC data are derived from individual paper chart sheets, the integrations of each ERC data are made by the computer and stored on the hard disk as the ERC database.

(5) Division of the ERC database

The ERC database is so large size in memory that the database must be partioned into areas to make the ERC files of smaller memory size e.g. 64KBs (which corresponds to computer graphic memory of most ERCS) to be displayed on the ERCS. An ERC file can record the ERC data of 8,000-9,000 points or paper chart data of 2-3 sheets. (The number of sheets mainly depends on the total length of the coastlines of an adopted chart.)

It is necessary to avoid cases in which boundaries between files are located in the middle of a port or congested maritime traffic areas such as narrow channels, because the navigator would be so busy in such places that he has no time to operate the ERCs to change files. An overlap of charts also needs to be considered. In the case of ERC, the overlapped distance has been taken to be at least five miles in order to provide enough time to change the display.

(6) Production of ERC

As the ERC files have been written in the ASCII format, the files are converted into binary form and stored in the IC-memory card.

Figure 2 shows an example of IC-memory card. The card size is as follows:

Width	: 8.5 cm
Length	: 5.5 cm
Thickness	: 0.3 cm

In an IC-memory card, four related files are normally stored to be used conveniently on continuous voyages.

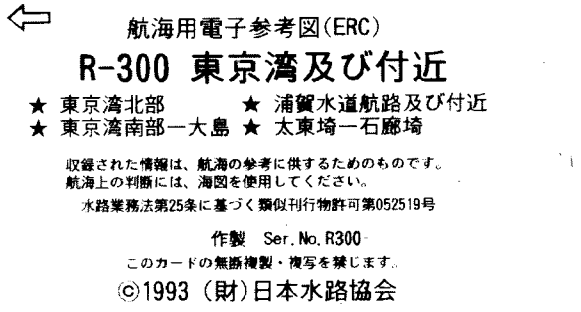


FIG. 2.- Picture of the IC-memory card "Tokyo Bay and Its Approaches".

5. SCALE OF ADOPTED PAPER CHART

The scale range of the paper chart to be incorporated until the end of 1995 is basically 1:50,000 to 1:250,000 when the ERC will have covered all the sea coast of Japan.

In 1996, charts at scales larger than 1/50 000 will be included for the ERC to provide harbour plans (chart) in and around Seto Inland Sea.

6. ERC COVERAGE PLAN

Figure 3 shows the ERC coverage plan in Japanese waters. By the end of fiscal year 1994, ERC will cover the coast of Honshu, Shikoku, Kyushu islands; and in 1995, the coast of Hokkaido island, south-western islands, such as Ryukyu islands and the Southern islands will be completed.

In 1996, as stated already, harbour plans will be included in the ERC.

7. PERFORMANCE STANDARD FOR ERCS (PSE)

The PSE has been studied by the SUIYOKAI Working Group for the first two years, and in 1994, the PSE has also been investigated together with the ERC "colours and symbols", sponsored by JHA and the members consisted of JHD, professors of Tokyo Mercantile Marine University and JHA.

The PSE has been released in June 1994 from JHA and the SUIYOKAI.

ANNEX shows the English version of the PSE.

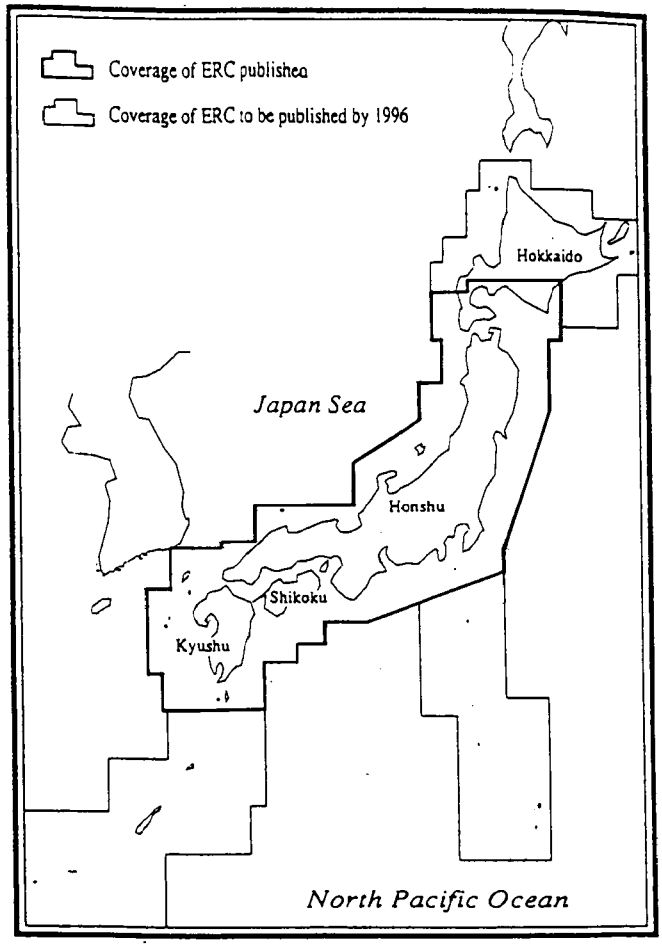


FIG. 3.- The ERC coverage plan in Japanese waters.

8. FUTURE PROSPECTS

(1) The contents of the IC-memory card will be updated once a year.

(2) Since the ERC production of 1994, data improvement has been made. The JHA has developed a way to distinguish coastline and land and colour in the land part on the ERC display by computer.

(3) For small leisure boats, 5-meter contour instead of 20-meter contours and other dangers shallower than the 10-meter contour will be adopted. For fishing boats, a few hundred-meter contours will be included in the ERC.

(4) ERC can be used even by the CAR NAVIGATION SYSTEM which is installed on ships instead of cars. The system including GPS has spread quickly in Japan because of its convenience and low price.

(5) Although the media of ERC, at present time, are only IC-memory card, we might have to prepare another media such as CD-ROMs or floppy disks in the near future.

(6) The JHD has digitized the Japanese paper chart for ENC using DX-90 data format, and this database will be given to the JHA for the new versions of ERC. We are going to prepare some software to convert the DX-90 to the ERC data format.

As the hardware and software is always developed quickly, we have to listen to users' opinions and to watch the circumstances of the world in this field to improve ERC and PSE as much as possible.

ANNEX

PERFORMANCE STANDARD FOR ELECTRONIC REFERENCE CHART SYSTEM

June 1994

1. INTRODUCTION

1.1 The primary function of the ERCS is to contribute to the safety of navigation and to reduce the navigational workload.

1.2 ERCS is not equivalent to the paper charts required by regulation V/20 of the 1974 SOLAS Convention, but it is a system which displays basic information included in the navigational chart, and it should be used with the paper charts.

1.3 ERCS should facilitate simple and reliable updating of the chart information included in the Electronic Reference Chart (ERC).

1.4 ERCS should enable the execution of chart work including route planning currently performed by navigators.

1.5 In addition to the requirements of this performance standard, ERCS should meet IMO Resolution A.694 (17) [General Requirement for Shipborne Radio Equipment forming Part of The Global Maritime Distress and Safety System (GMDSS) and Electronic Navigational Aids].

2. DEFINITION

2.1 ERC means the database issued by the authority of the Hydrographic Department of Japan.

2.2 System Electronic Reference Chart (SERC) means a database resulting from the transformation of the ERC by ERCS for appropriate use, updates to the ERC and other data added by the mariners or the manufacturers.

2.3 Electronic Reference Chart System (ERCS) means a navigational information system which displays selected information from a System Electronic Reference Chart (SERC) to assist the mariner.

2.4 Display Base means the level of SERC information which cannot be removed from the display.

2.5 Standard Display means the level of SERC information that, including the Display Base, should be displayed when ERCS is switched on, and after switched on, ERCS should present the Standard Display at any time by a single operator action.

2.6 Demand Display means the level of SERC information which can be displayed by the mariner's demand other than Standard Display.

2.7 Optional Display means the level of SERC information, other than Standard Display and Demand Display, which is possible to display by the individual ERCS.

3. DISPLAY OF ERC INFORMATION

3.1 ERCS should be capable of displaying all SERC information.

3.2 ERCS should always be capable of displaying the Display Base shown as follows:

(1) coastlines
(2) safety contour of 10m or 20m
(3) traffic routeing systems
(4) isolated dangers
(5) scale or range
(6) orientations

3.3 ERCS should display following Standard Display when the ERCS is switched on, and in case of adding or deleting other information, ERCS should display the Standard Display by a single operator action.

(1) the Display Base
(2) boundaries of fairways
(3) aids to navigation
(4) prohibited and restricted areas
(5) cautionary notes
(6) 10m or 20m contour which is not selected on the Display Base

3.4 ERCS should display the following Demand Display by operator's demand.

(1) ERC information other than the Standard Display
(2) ERC edition data
(3) geodetic datum
(4) names and scales of the original paper charts
(5) chart boundaries

4. PROVISION AND UPDATING OF ERC DATA

4.1 ERC should be issued by the authority of JHD.

4.2 Update of ERC should be executed by exchange of media.

5. ZOOMING

5.1 It should be able to zoom up and down, and to scroll the display.

5.2 Symbols, letters and figures in the ERC should be displayed in the same size in spite of zooming up or down.

6. DISPLAY OF OTHER NAVIGATIONAL INFORMATION

6.1 ERCS should be able to display the following information.

(1) own ship
(2) ownship's track
(3) planned route including waypoints
(4) bearing cursor
(5) distance between any two points on the display
(6) time-labels along own ship's track

6.2 Own Ship's Position

Own ship's positions should appear whenever the display covers that area, and it should be possible to adjust the displayed position of own ship manually.

7. DISPLAY MODE AND GENERATION OF THE NEIGHBOURING AREA

7.1 ERCS should always be able to display in a north-up orientation.

7.2 ERCS should at least be able to provide the true motion mode.

7.3 When true motion mode is in use, reset and generation of the neighbouring area should take place automatically at the pre-set distance from the border of the display, and it should be possible to display the neighbouring area manually at any time.

8. COLOURS AND SYMBOLS

8.1 ERCS should at least meet the requirement of Colours and Symbols of Annex 1.

8.2 The colours and symbols other than those mentioned in Colours and Symbols of Annex 1 should be those described in IHO S-52 APPENDIX 2 and IEC Publication 1174 as possible.

8.3 The size of symbols should at least be 2 mm square.

9. DISPLAY REQUIREMENT

9.1 The effective size of ERCS display should at least be 120 mm x 120 mm.

9.2 The resolution of the display should not be more than 0.5 mm.

10. ROUTE PLANNING, MONITORING AND TRACK RECORDING

10.1 Route Planning

ERCS should be able to carry out route planning, and it should provide at least one clearing line.

10.2 Alarm

ERCS should give audible alarms and visual alarm indications, in the following pre-set conditions.

(1) deviation from the planned route
(2) distance to a waypoint
(3) distance to cross a clearing line
(4) loss of own ship's position

10.3 Track Recording

ERCS should be able to reproduce own ship's track during the previous 15 hours at 3 minutes intervals, with time labels of each hour on the hour.

11. ACCURACY

11.1 The accuracy of all calculations should be independent of the characteristics of the output device and should be consistent with the ERC accuracy.

11.2 Bearings and distances drawn on the display or those measured between features already drawn on the display should have an accuracy no less than that afforded by the resolution of the display.

12. CONNECTIONS WITH OTHER EQUIPMENT

ERCS should not degrade the performance of any equipment providing sensor inputs. Nor should the connection of other equipment degrade the performance of ERCS.

13. PERFORMANCE TEST, MALFUNCTION ALARMS AND INDICATIONS

(to be developed)

14. POWER SUPPLY

Concerning power supply, ERCS should comply with the power supply requirement of IMO Resolution A. 694 (17) [General Requirement for Shipborne Radio Equipment Forming Part of The Global Maritime Distress and Safety System (GMDSS) and Electronic Navigational Aids].

ANNEX 1

COLOURS AND SYMBOLS

Notes. BASE : DISPLAY BASE
STAND : STANDARD DISPLAY
DEMAND : DEMAND DISPLAY
OPTION : OPTIONAL DISPLAY

COASTLINE

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOR	LINE TYPE	BASE	STAND	DEMAND	OPTION
00	Coastline	white	———	O			

LOW WATER LINE

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOR	LINE TYPE	BASE	STAND	DEMAND	OPTION
00	Low water line	white	———	O			

CONTOURS

CODE	CONTENTS		DISPLAY		DISPLAY CONDITIONS			
			COLOR	LINE TYPE	BASE	STAND	DEMAND	OPTION
02	Contours	10m	light blue	———	(O)	(O)		
		20m	light blue	- - - - -	(O)	(O)		

BOUNDARY/AREA

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOR	LINE TYPE	BASE	STAND	DEMAND	OPTION
20	Limiting danger line	red	———	O			
21	Leading line	purple	- - - - -			O	
23	Traffic separation scheme	purple	- - - - -	O			
24	Submarine cable (telephone)	yellow	- - - - -			O	
25	Submarine cable (power)	yellow	- - - - -			O	
26	Submarine pipe line	yellow	- - - - -			O	
31	Restricted area	red	———		O		
38	Prohibited area	red	———		O		
41	Track recommended	purple	- - - - -			O	
61	Wreck showing any portion	red	———	O			
63	Sunken wreckage	red	———	O			
65	Fish havens (group)	red	———			O	
66	Obstructions (group)	red	———	O			
72	Laver beds (group)	yellow	———			O	
75	Conspicuous tanks (group)	light blue	———			O	
77	Conspicuous tanks (group)	light blue	———			O	
83	Anchorage berth	purple	———			O	
97	Paper chart boundary	white	———			O	

AIDS TO NAVIGATION

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOUR	SYMBOL	BASE	STAND	DEMAND	OPTION
01	Lighthouse	red	☆		O		
02	Light	red	○			O	
03	Aeronautical light	red	☆			O	
04	Light beacon	red	☆		O		
05	Port-hand buoy	red	⍋		O		
06	Starboard-hand buoy	red	⍋		O		
09	Porthand-light buoy	red	⍋		O		
10	Starboard-hand light buoy	red	⍋		O		
14	Super buoy	red	⍋		O		
15	Large mooring buoy	red	⌓			O	
17	Large data collecting buoy	red	⍋			O	
18	Fixed beacon	red	⍋		O		
21	North cardinal mark	red	⍋			O	
22	East cardinal mark	red	⍋			O	
23	West cardinal mark	red	⍋			O	
24	South cardinal mark	red	⍋			O	
25	Isolated danger mark	red	⍋		O		
26	Safe water mark	red	⍋			O	
27	Special mark	red	⍋			O	
31	Radio and radar station	red	⊙			O	
48	Buoy (others)	red	⍋			O	
49	Light buoy (others)	red	⍋			O	

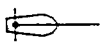
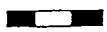
OBSTRUCTIONS/POINTS

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOUR	SYMBOL	BASE	STAND	DEMAND	OPTION
10	Fish haven (confirmed)	red	.			O	
18	Dry rock	red	*	O			
19	Awash rock	red	⁜	O			
20	Sunken rock	red	+	O			
21	Danger (swept)	red	.			O	
22	Submarine volcano	red	.	O			
25	Coral reef	red	.	O			
27	Wreck (showing any portion)	red	.	O			
28	Wreck (masts are visible)	red	.	O			
29	Wreck (dangerous to nav.)	red	.	O			
30	Wreck (depth is known)	red	.		O		
31	Wreck (cleared by drag)	red	.			O	
32	Wreck (depth confirmed)	red	.			O	
34	Foul bottom	red	.		O		
36	Over fall, tide rip	yellow	≈			O	
37	Tidal race	yellow	≈			O	
38	Eddie	yellow	≈			O	
41	Obstruction	red	.	O			
42	Oil exploitation platform	red	.	O			
43	Tower (on the surface)	red	.	O			
46	Fish haven (unsurveyed)	red	.			O	
51	Wave-height meter	red	.			O	

LAND POINTS

CODE	CONTENTS	DISPLAY		DISPLAY CONDITIONS			
		COLOR	SYMBOL	BASE	STAND	DEMAND	OPTION
23	Conspicuous house	light blue	□			O	
29	Tower	light blue	□			O	
31	Chimney	light blue	□			O	
35	Tank	light blue	□			O	
61	Other conspicuous points	light blue	□			O	

OTHER NAVIGATIONAL INFORMATIONS

CONTENTS		DISPLAY		DISPLAY CONDITIONS			
		COLOR	SYMBOL	BASE	STAND	DEMAND	OPTION
Own ship	1. Ship's vector not displayed	white	◎	O			
	2. Ship's feature displayed (vector off)	white		O			
	3. Ship's vector only displayed (vector on)	white					O
	4. Vector and ship's feature displayed	white					O
Cursor		yellow or green					O
VRM, EBL		yellow or green				O	
Event mark		yellow or green					O
Planned route		yellow or green	———			O	
Track line		white	———			O	
North arrow		white		O			
Scale bar (nm)		white		O			
Grid		blue	———			O	
Clear line		red	.....				O
Radar image		green					O