Chapter 2 PROGRESS OF PROJECT and OUTPUTS

2 - 1 (1)-a Collection of Relevant Data and Information, Sorting and Analysis - Work in Japan

The following work items were conducted in Japan before commencing the field work in Cambodia:

1. Arrangement tidal data and others collected by consultant uniquely.
2. Procurement of a Satellite Imagery PLEIADIS 0.5m (refer to Figure 2 – 1) and RapidEye 5m (refer to Figure 2 - 2) for extracting coast lines, dry rocks, potential rock, etc.
3. Creation of the outline explanatory paper of the IHO S-44 and S-57 for the specifications deliberations with MPWT/WD.

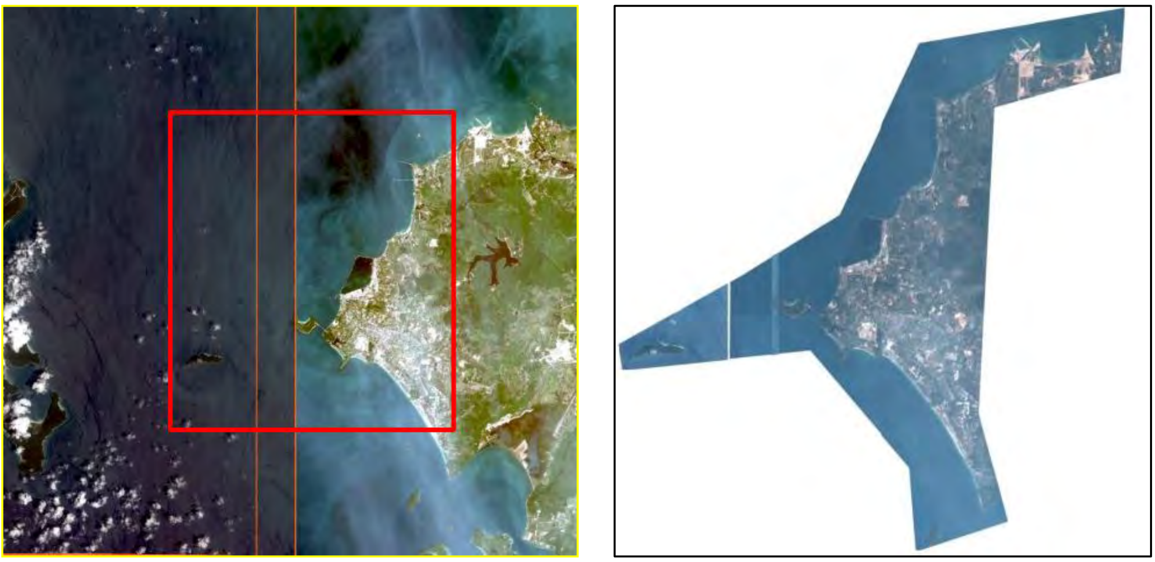


Figure 2 - 1 Satellite Imagery (PLEIADIS)

Purchased the Satellite Imagery PLEIADIS-Sport 6 from AIRBUS Defense and Space with resolution 0.5m taken on December 2012 and March 2013

- PLEIADIS Satellite Image's Property Information

Satellite Name	:	PLEIADES
Acquisition Date	:	2012/12/12 and 2013/3/19
Product Type	:	0.5m Pan-sharpen
Band	:	Colour 4 Band
Resolution	:	0.5m
Geodetic System	:	UTM Zone 48 N (WGS-84)

At the extension project, Planet Lab's Rapid Eye satellite imagery and Digital Globe's WorldView satellite imagery had been purchased. (refer to Figure 2 -2). For the imagery satellite properties information is shown below. For the others interested area also had been purchased from GeoEye and SPOT6, 7 for supplement.

- Rapid Eye Satellite Image's Property Information

Satellite Name	:	Rapid Eye
Acquisition Date	:	2013/1/30 - 2016/1/22
Product Type	:	Ortho Product (3A)
Band	:	5 Band
Resolution	:	5m
Geodetic System	:	UTM Zone 48 N (WGS-84)

- WorldView Satellite Image's Property Information

Satellite Name	:	WorldView2 and WorldView3
Acquisition Date	:	2014/10/27 - 2015/4/21
Product Type	:	Standard (2A)
Band	:	8 Band
Resolution	:	0.4m
Geodetic System	:	UTM Zone 48 N (WGS-84)

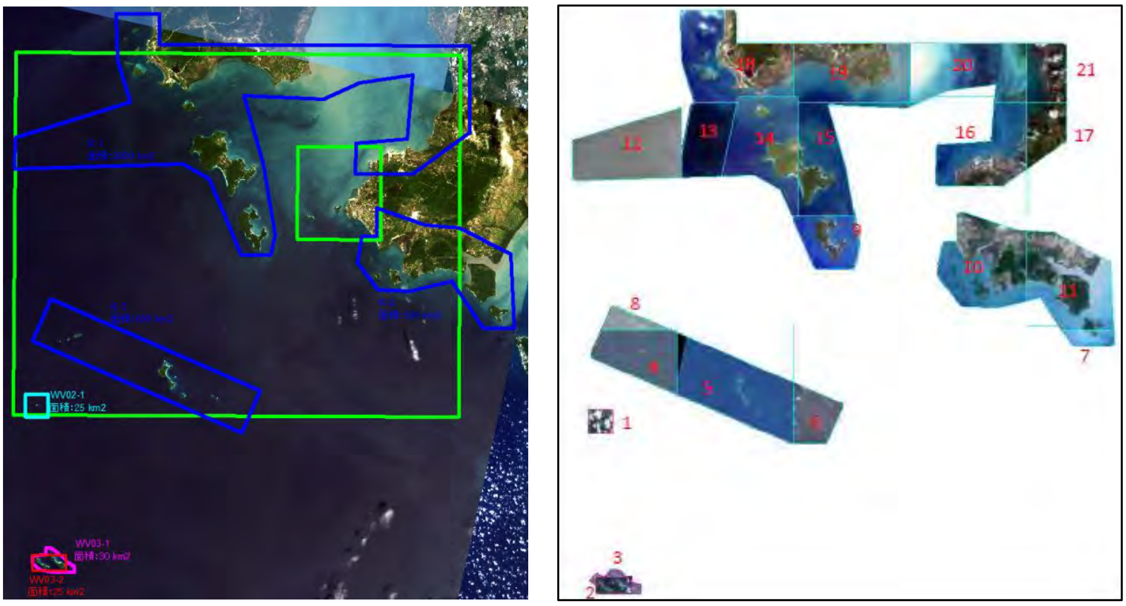


Figure 2 - 2　Satellite Imagery (RapidEye and WorldView)
Left shows the Study Area, inside green frame, Right shows purchased Satellite Imagery

2 - 2 (1)-b Examination of Basic Polices, Process and Method of the Study - Work in Japan

Based on the result of the above, the basic policy of the following implementation, a method, an item, contents, a process, a procedure and an implement schedule of the Study were considered. Moreover, the implementation structure of the study site was considered.

(1) Remodeling the specifications of the Tide station and Tide gauge which use at SHV
(2) Point of installation the transducer of SONIC2020
(3) Point of Digital Hydrographic Survey Data Acquisition and Processing
(4) Point of creating Vector Fair Sheet
(5) Point of compiling C&ENC
(6) The basic policy, the training point, process of technology transfer on counterpart training in Japan and Philippine and the study site.

2 - 3 (1)-c Preliminary Preparation - Work in Japan

The preparation of the following field surveys were started in parallel with the works stated above:

(1) Re-commission of local labor, arrangement of equipment procurement, and satellite image, analysis PLEIADIS0.5m,
(2) Procurement of survey equipment and planning of rigging the equipment,
(3) Perform wet-check of survey equipment subject to purchase by JICA Headquarters on 16th December 2014 at Hota port, Chiba prefecture - refer to Chapter 5.

2 - 4 (4) Consultation of Study Specifications - Work in Cambodia

The study team discussed with the relevant representatives on the specifications for hydrographic survey methodology and the ENC around SHV port to be produced at the 1st Taskforce Meeting and agreed. The part of its result and content was recorded in the Minutes of Meeting.

2 - 5 (5) Collection of Existing References - Work in Cambodia

The study team collected following reference materials available in Cambodian government.

1) National geodetic results (GPS result) around SHV owned by MLMUPC

Network in: Sihanouk Ville **Installation Date:** 1997

SIHA

District: Mittakpheap **Commune:** Mittakpheap **Village:** Mittakpheap
Place: Tao Pi Traffic Circle
Reference Frame: ITRF2005
Project: UTM Zone 48 North Ellipsoid GRS 80

Latitude	N 10° 36' 38.54449"	N (x)	1173318.9281m
Longitude	E 103° 31' 24.63534"	E (y)	338477.8125m
Height (ellip.)	-3.6149m	epoch	2009.56

1/100,000 (5730)

Photo

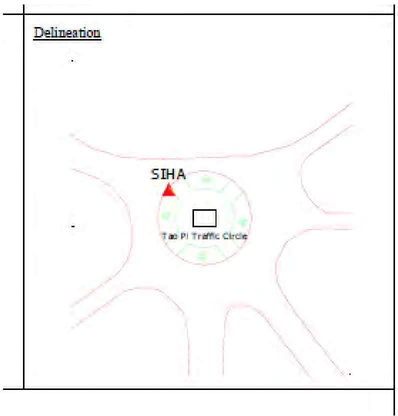


Figure 2 - 3 Example of National Control Point Result near SHV port

2) The result of Bench Mark owned by PAS

PAS-BM	N 10-38-44.91523	UTM48	X=1,176,890.782	National datum level 2.14 m
	E103-30-47.98998		Y= 336,153.193	

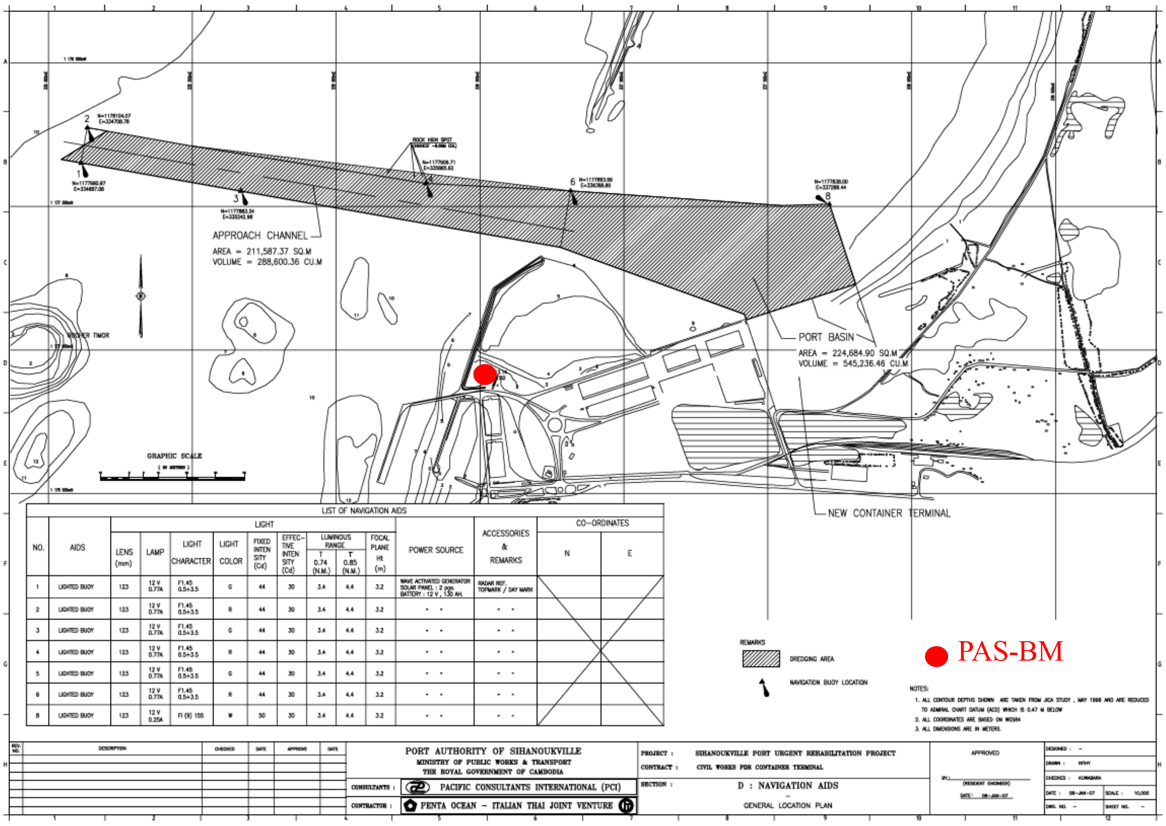


Figure 2 - 4 Results of BM owned by PAS

3) BA Charts around SHV port

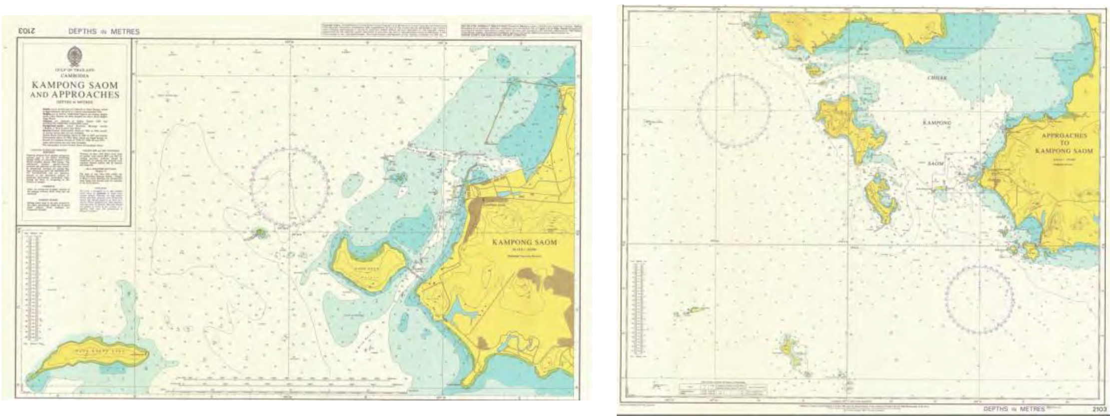


Figure 2 - 5 BA Charts around SHV - No. 2103

4) Tide and Tidal Current Table published by the United Kingdom

CAMBODIA TO VIETNAM

No.	PLACE	Lat. N.	Long. E.	TIME DIFFERENCES (Zone −0700) MHW	LLW	HEIGHT DIFFERENCES (IN METRES) MHHW	MLHW	MHLW	MLLW	M.L. Z_0 m.	
5147	**MIRI**	(see page 144)				**1.6**	△	△	**0.7**		
	Cambodia										
6900	Kaoh Mul	11 25	103 00	−1140	−1100	−0.2	△	△	−0.2	0.99	d
	Chhak Kampong Saom										
6902	Kampong Saom (Sihanoukville) .... F	10 38	103 29	−1215	−1225	−0.3	△	△	0.0	1.07	t
6903	Ream	10 30	103 36	p	p	−0.6	△	△	−0.2	0.80	
	Vietnam										
6906	Ha Tien	10 22	104 28	p	p	−0.5	△	△	−0.2	0.76	
6909	Hon Rai	9 48	104 38	−0725	O	−0.4	△	△	−0.1	0.8	tx
6911	Hon Tho Chau	9 18	103 28	p	p	−1.0	△	△	−0.4	0.5	x
6913	Cua Song Bai Hap (off)	8 39	104 45	−0925	O	−0.4	△	△	−0.4	0.8	tx

Figure 2 - 6 Tide and Tidal Current Table published by UKHO

2 - 6 (6) Collection of Chart Information, Process and Analysis - Works in Japan and Cambodia

2 - 6 - 1 Determination of Chart Datum

Currently, IHO has recommended to adopting internationally the Lowest Astronomical Tide (LAT) as the chart datum. However, there was not an operating permanent tide station in Cambodia, nor was the long-term observation data. In order to determine the LAT in SHV area requires the tidal data of over one year and its data should be managed to observe in a reliable condition. Generally, it is necessary to perform the harmonic analysis based on the data of more than 1 year. Then, after the tidal prediction for 18.6 years using the 60 tidal components derived by the harmonic analysis, the lowest tidal height predicted over the 19 years period becomes the LAT.

Therefore, study team made a harmonic analysis of tide based on the data from November 2013 to October 2014. Then, the tidal prediction result of 19 years based on the 60 harmonic components was carried out to derive the lowest tide level. As a result, the lowest tide level was identified below MSL at 0.99 m predicted on 08:00, 15th July 2022.

On the other hand, Z_0 at KAMPONG SAOM, SHV, was defined at 1.07 m in the Tide Table published by UKHO as shown in Figure 2 - 6 above. Looking at Z_0 of adjacent ports to SHV, they indicated the various ranges such as 1.10 m at Ko Mak, Thailand, 0.99 m at Kaoh Mul near the border with Thailand, 0.80 m in the south of SHV and 0.76 m near the border with Vietnam. However, those ranges did not show big differences with the Z_0 at SHV, or showed rather harmonically in terms of oceanography and topography.

Therefore, study team decided to wait until the confirmation of UKHO opinion, who is subject to issue ENC around SHV, and would determine which Z_0, 0.99 m or 1.07 m, to adopt finally for the datum level in SHV. During the course of discussion made between the study team and UKHO, UKHO made a comment that the Z_0, 0.99 m could be reliable as the LAT in SHV because the Z_0 1.07 m was derived base on the prediction of 9 tidal components induced by the harmonic analysis of short-term tide observation. Finally, the study team decided to adopt the 0.99 m as the datum level below MSL in this project.

Therefore, the study team decided that the DL, Datum Level, above the 0 of gauge should be 0.52 m, which corresponded to the level 0.99 m below the MSL, Mean Sea Level, extracted from the data used for 1 year harmonic analysis. See Detail at Chapter 2 - 6 – 5.

2 - 6 - 2 (6) Control Point and Leveling Survey - Work in Cambodia

In order to fix the coordinates of the digital coastline and land subjects such as navigational objects concerning C & ENC production around SHV, the remarkable Geo-Reference objects near the coastline with open sky that has the elevation were selected in order to extend Geo-Reference (distortion-correction on two-dimension near a sea surface) to the Satellite Imagery, mentioned above at Chapter 2 - 1.

A GNSS survey was carried out based on Cambodian National GPS Network points, and the geodesic coordinates of Geo-Reference points were calculated adequately.

In case, the height of Geo-Reference points and landmarks are required, a direct leveling has been carried out between Benchmark near Pointe Loune (2.140m: based on Ha Tien in Vietnam) in PAS nearby and Geo-Reference point. The measured results of the Geo-Reference points and seamarks are summarized in the Geo-Reference Book. In order to define the difference in elevation between BM and chart datum, the direct leveling has also been performed between BM in PAS and the new BM of the Tide station. Regarding the technology and the technique in these work processes have been also transferred to the C/P through the collaboration work.

(1) Control Point Survey

1) Placing plan of Geo-Reference point

In advance of GNSS observation, the allocating plan of the Geo-Reference points for extracting the coastline of the charting area was performed on the PLEIADIS Satellite Imagery. The adequate points were selected on the PLEIADIS Satellite Imagery that were discernible clearly in open sky like outcropped rock, edge of breakwater near the coastline, etc.,

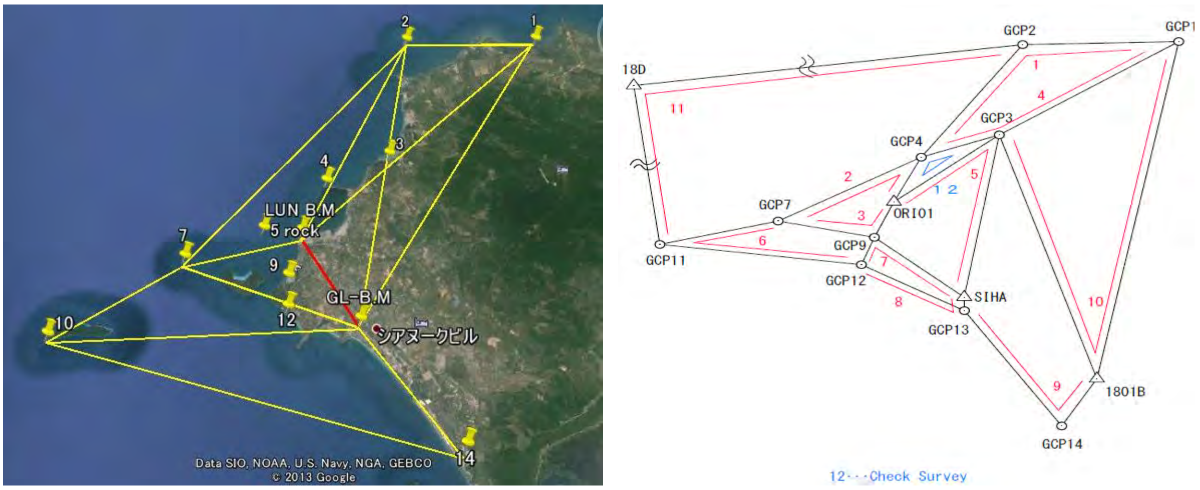


Figure 2 - 7 GNSS Observation Network in SHV

2) GNSS Observation

The GNSS observation has been carried out based on the national reference GPS points by using the GNSS receiver (Leica) with two frequencies. It was carried out between the Main baselines performing the triangle network surveys, adopting long baselines of more than 10km, for more than 2 hours of continuous observation, while the short baseline survey was dependent on its distance. The Table 2 - 1 shows the results of baseline analysis. The accuracy of observation result is satisfied with “overseas survey work regulation” specified by JICA.

```
National GPS Point [No.1801B]  N 10-34-33.86  E 103-34-2.82
Independent pinpointing        N 10-34-33.8   E 103-34-02.8  (2013.10.18)
```


Photo 2 - 1　GNSS Observation at National GPS Point 1801B

Table　2 - 1　Calculation Result of GNSS Observation

Control Point	KP：Known -Point NP：Network -Point	Date of network mathematics of GNSS observation	X	Y	Hight of Ellipsede	Hight of Altitude	Relative Geoid Hight	
18D	N.P	10/22/2013	1184384.714	315084.4297	-1.0452	14.9337	-15.9789	0.0604
1801B	K.P	10/18/2013	1169465.901	343268.1025	-6.8945	7.9537	-14.8482	0.0012
GCP1	N.P	10/22/2013	1188002.674	348103.7685	-11.2691	3.8789	-15.148	0.0264
GCP2	N.P	10/22/2013	1187239.927	341169.9935	-13.2937	2.0117	-15.3054	0.0288
GCP3	N.P	10/22/2013	1181001.166	340201.5589	-13.0329	2.1407	-15.1736	0.0213
GCP4	N.P	10/22/2013	1179526.714	337168.0912	-12.6427	2.5904	-15.2331	0.0231
GCP7	N.P	10/22/2013	1176127.408	331198.1099	-12.4158	2.9167	-15.3325	0.0244
GCP9	N.P	10/22/2013	1175161.149	335538.9392	-11.7426	3.4471	-15.1897	0.0208
GCP11	N.P	10/22/2013	1173156.541	328477.8873	-10.2418	5.0992	-15.3409	0.0254
GCP12	N.P	10/22/2013	1173834.903	335504.9353	-12.5451	2.6181	-15.1633	0.0224
GCP13	N.P	10/22/2013	1172766.754	338227.5569	-12.7432	2.3166	-15.0598	0.0168
GCP14	N.P	10/22/2013	1167465.727	342534.8067	-12.0773	2.7566	-14.8339	0.0213
ORI01	N.P	10/22/2013	1177212.883	336102.0296	-12.3602	2.8558	-15.216	0.0326
SIHA	K.P	10/16/2013	1173318.941	338477.8125	-3.6149	11.4477	-15.0626	2.5363

Note:　It was confirmed that the position of NGP (18D) had moved more than 3m from the position described in the result of NGP by the final baseline analysis

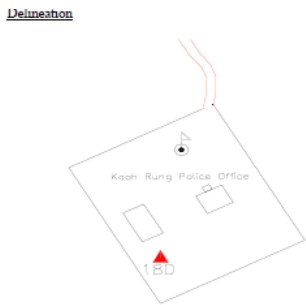
Report by JICA ENC Project Team 20131021

Network in: SHV (Cambodia National GPS Network Control Point 18D)

N 10-42-34.718 E 103-18-33.135 (Existing Result of National GPS Network point)
N 10-42-34.804 E 103-18-33.037 (New result of GNSS Observation in this time)
(Existing 18D station might be moved artificially about 3~4m)

The large drums surrounding warehouse that has been not seen in the photo of the result note of Control point (18D) side would be built several years ago. Then a bulldozer seems to have hooked the base of control point 18D. It turns out the thing at that time, and the inner steel rod of the cubic shape is base of control point is unreserved by missing part of its edge.

In addition, the position of the sketch on 18D differs from the actual condition.



The right side house in Photo is Police Office. The middle house in Photo is the shop and storage place of Police Office The left side house is the building of the warehouse style mentioned above.

Photo 2 - 2 Report on the Fluctuation of National Control Point from C/P

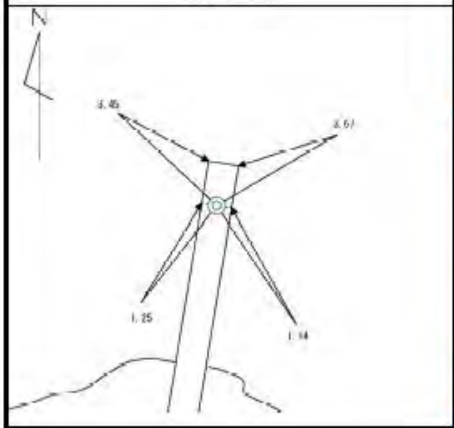
3) Geo-Reference Book

The Geo-Reference Book was created, which includes the coordinates and altitude, a site sketch, a site photo, satellite imagery-scene- picture number, etc., for the modification of distortion of the Satellite Imagery by using GIS software. The Geo-Reference Point Report Book was created carefully enough as the result should influence the accuracy of Geo-Reference work.

DESCRIPTION &RESULT OF GCP-GNSS

Station Name	GCP7	**Geographical Coordinates WGS84**		Latitude	Longitude	Ellipsoidal H. (m)
				10° 38′ 08.80315″ N	103° 27′ 24.67530″ E	-12.4158
Project TM	Origin N 10° 38′ 00″ E 103° 28′ 00″	**Horizontal Coordinates**		Northing (m)	Easting (m)	Altitude/Ground H. (m)
				270.4989	-1073.6699	2.9167
Data	October, .2013	**Eccentric point**	P1			
			P2			

Site Sketch



PLEIADES Image (Scale: approx , 1/10,000)

Site Photo

PLEIADES Image (Scale: approx. 1/1,000)

Remarks:
This result will be created in collaboration with JICA and MPWT/WD in October, 2013.

Acquisition of Satellite Image: 5,December,2012
Satellite Scene No.:DS_PHR1A_201212050345520_SE1_PX_E103N10_0717_05281
Type of Satellite Image: PLEIADES 16Bit 0.5m PAN-SHARPEN(4BANDS)

Figure 2 - 8 Geo-Reference Point Report Book

In Extension Project, for creating coastline for ENC data, geo-reference points were also determined using RapidEye and WorldView satellite imageries (mentioned in Chapter 2 - 1). GNSS observation was carried out at geo-reference point just as same as the survey team did in the Original Project. Figure 2 - 9 shows the geo-reference point and Table 2 - 2 shows the calculation result of GNSS observation.

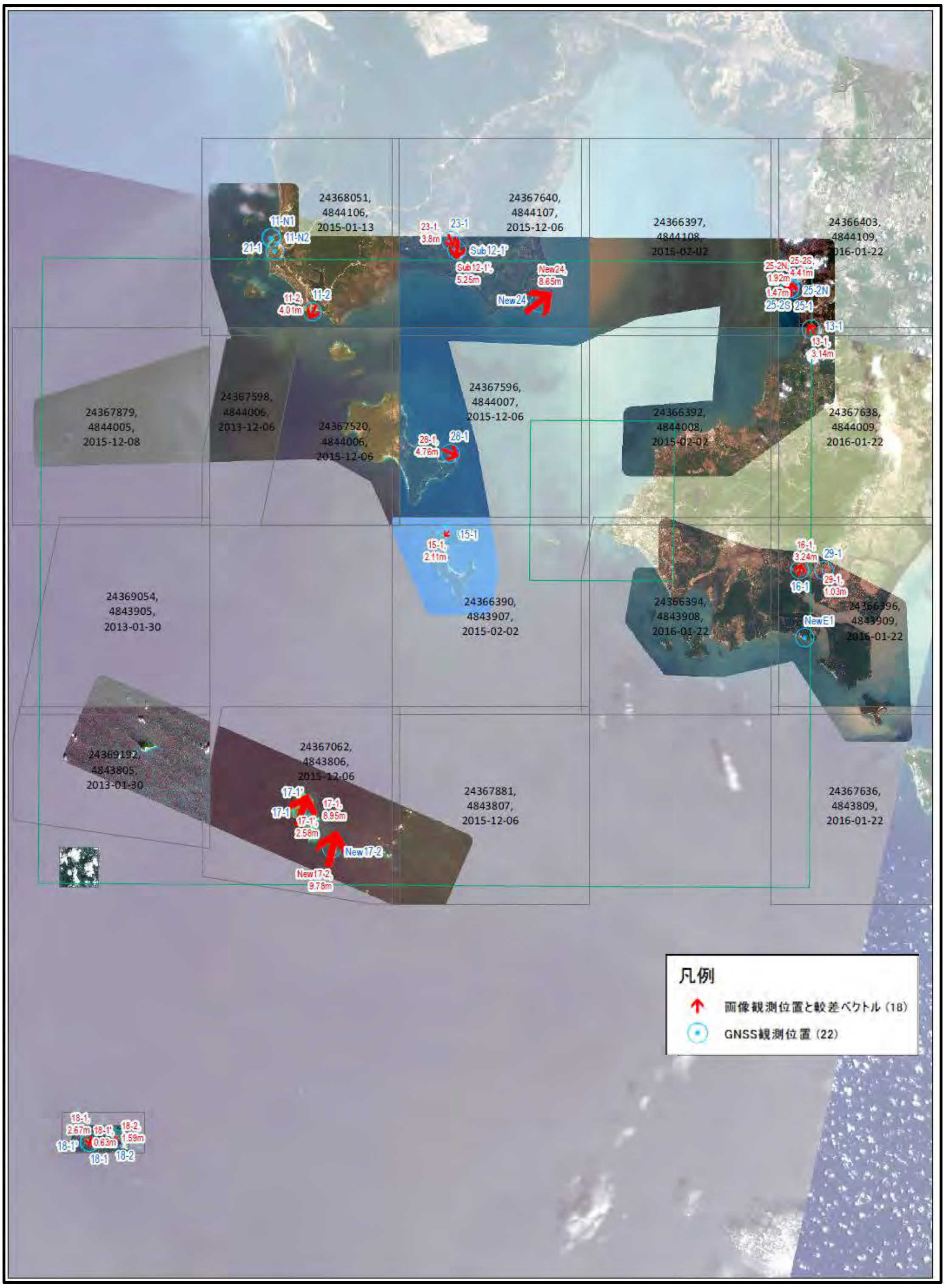


Figure 2 - 9　Geo-Reference Point position map for Extension Project

Table 2 - 2 Calculation Result of GNSS Observation

Name	N	E	POINT_X	POINT_Y	Name	POINT_X	POINT_Y	difference_X	difference_Y	Planimetric difference
11-2	10.872972	103.147333	297,488	1,202,552	11-2	297,489,973	1,202,548,045	1.57	-3.69	4.01
11-N1	10.957472	103.098278	292,183	1,211,933						
11-N2	10.957000	103.099750	292,344	1,211,880						
13-1	10.855806	103.725194	360,657	1,200,328	13-1	360,659,201	1,200,330,381	1.87	2.53	3.14
15-1	10.618694	103.303861	314,448	1,174,325	15-1	314,449,241	1,174,323,513	1.47	-1.52	2.11
16-1	10.580264	103.713319	359,232	1,169,860	16-1	359,231,079	1,169,863,048	-0.76	3.15	3.24
17-1	10.303278	103.139583	296,265	1,139,536	17-1	296,261,998	1,139,544,499	-2.85	8.48	8.95
17-1`	10.303500	103.138611	296,158	1,139,561	17-1`	296,156,085	1,139,562,147	-2.41	0.93	2.58
18-1	9.921547	102.895769	296,282	1,097,469	18-1	269,282,044	1,097,466,087	0.49	-2.63	2.67
18-1`	9.920639	102.895742	269,278	1,097,368	18-1`	269,277,705	1,097,368,847	-0.18	0.61	0.63
18-2	9.925389	102.925333	272,527	1,097,873	18-2	272,526,461	1,097,871,878	-0.64	-1.46	1.59
21-1	10.924139	103.103389	292,731	1,210,233						
23-1	10.955278	103.306528	314,946	1,211,554	23-1	314,944,196	1,211,550,786	-1.39	-3.54	3.80
25-1	10.901222	103.705806	358,559	1,205,360	25-1	358,559,580	1,205,361,097	0.46	1.40	1.47
25-2N	10.903306	103.700056	357,932	1,205,593	25-2N	357,932,991	1,205,594,130	1.39	1.33	1.92
25-2S	10.902389	103.700292	357,957	1,205,491	25-2S	357,957,333	1,205,495,705	0.36	4.39	4.41
28-1	10.711764	103.308333	314,993	1,184,617	28-1	314,989,065	1,184,615,148	-4.35	-1.93	4.76
29-1	10.579708	103.740778	362,236	1,169,786	29-1	362,237,146	1,169,786,245	1.03	0.04	1.03
New17-2	10.258806	103.173417	299,943	1,134,595	New17-2	299,940,957	1,134,604,772	-2.20	9.53	9.78
New24	10.884333	103.409778	326,190	1,203,646	New24	326,182,885	1,203,650,932	-6.89	5.23	8.65
NewE1	10.502250	103.718889	359,806	1,161,230						
Sub12-1`	10.944486	103.314472	315,807	1,210,356	Sub12-1`	315,807,766	1,210,350,510	0.49	-5.23	5.25

RMS	2.36	4.08	4.71
StDev	2.25	3.96	2.66
Average	-0.70	0.98	3.89
Max	-6.89	9.53	9.78

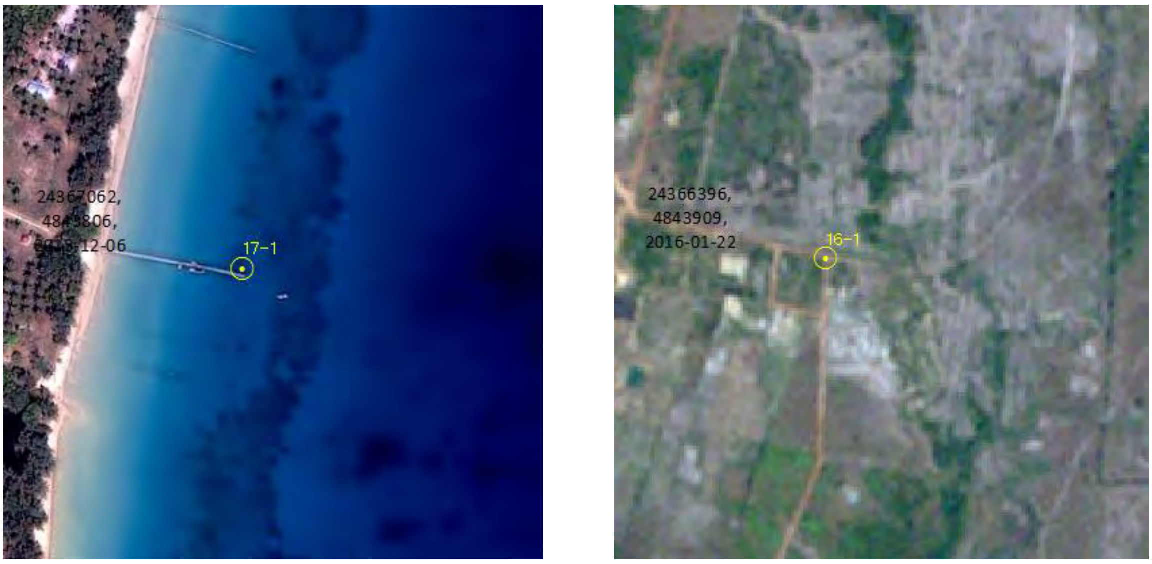


Figure 2 - 10 Geo-Reference Point displayed with Satellite Imagery Background

(2) Leveling Survey

To find the relation between Cambodia's National Vertical datum and SHV Port's mean sea level , Study team did the leveling survey between PAS-BM and renovated PAS Tide Station BM.

Vertical datum in Cambodia is adopted the mean sea level of Ha Tien located in Vietnam and near Cambodia border, and each elevation of BM is connected from this point applying the long distance leveling survey. As a result of leveling survey between PAS-BM and PAS Tide Station BM, the difference of 17 cm was revealed between the Ha Tien and the mean sea level derived from the 1-year observation of tide for the project. (Refer to Figure 2 - 32 and Chapter 3 - 1 - 1)

2 - 6 - 3 (6) Processing of Satellite Imagery/Aerial Photograph Processing - Work in Japan

A lot of ground photographs have been taken over the Geo-Reference points, seamark on ground etc. by GNSS camera in order to improve the efficiency of the digitalizing / editing coastline work on site and in Japan. The Geo-Reference Point Book has been generated consisting of the ground photograph, coordinates with a GNSS camera and a sketch. Although the paper chart is planned at a scale of 1/20,000 the coast line file of ENC near the entrance of SHV port and PAS ground area have been generated accurately, so that it could stand the scale of 1/10,000 by digitizing the coastline from PLEIADIS Satellite Imagery after Geo-Reference processing. Comparing with the PLEIADIS satellite imagery and the present state, the part of coastline changed has been realigned properly and exactly as it was by carrying out a supplemental survey. Following shows the examples of point selection for complement survey.

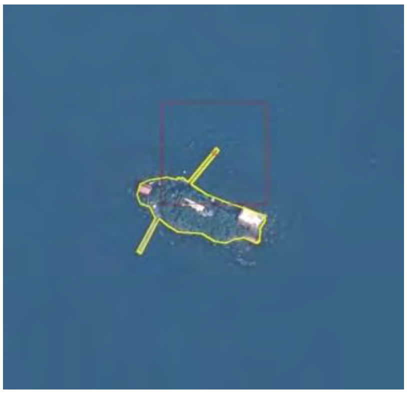
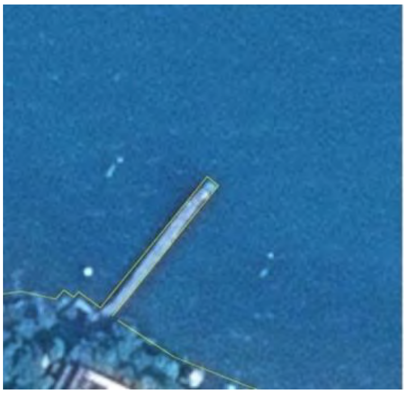
	
GCP7: KAOH DEK KOUL	GCP7 was placed at the edge of the pier
	
GCP11: KAOH KAONG KANG	GCP11was placed 10m east from lighthouse

Figure 2 - 11 Examples of Point Selection for Supplemental Survey

(1) Geo-References Processing

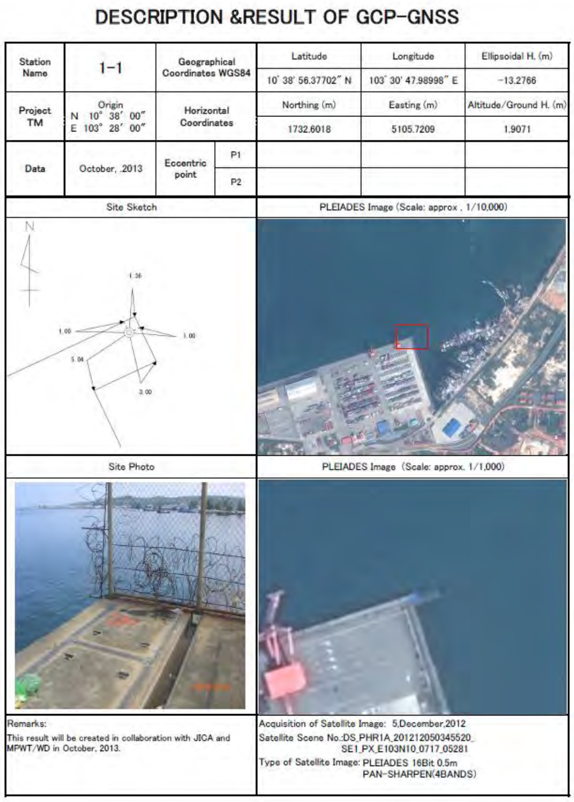
As mentioned above in Chapter 2 - 6 - 2, GNSS observation results at geo-reference points were plotted on the map using the satellite imageries purchased. Then, coastal line and etc. has been drawn based on the satellite imageries processed in accordance with the ENC compilation scale, 1/10,000 in Original Project and/or 1/80,000 in Extension Project.

1) Adjusting Satellite Imagery with Ground Control Point, by Geo-Reference Mapping Processing:

a) To import satellite imagery into AutoCAD MAP 3D (Figure 2 - 12 left)
b) To plot GCP points on to the satellite imagery imported (Figure 2 - 12 right shown in red)

Figure 2 - 12　Geo-Reference Plotting of Satellite Imagery

Following shows an example of description and result of GCP-GNSS, Article Table of Hydrographic Survey (refer to Appendix 3)



DESCRIPTION &RESULT OF GCP-GNSS

Station Name	1-1	Geographical Coordinates WGS84		Latitude	Longitude	Ellipsoidal H. (m)
				10° 38' 56.37702" N	103° 30' 47.98998" E	-13.2766
Project TM	Origin N 10° 38′ 00″ E 103° 28′ 00″	Horizontal Coordinates		Northing (m)	Easting (m)	Altitude/Ground H. (m)
				1732.6018	5105.7209	1.9071
Data	October, .2013	Eccentric point	P1			
			P2			

Site Sketch

PLEIADES Image (Scale: approx . 1/10,000)

Site Photo

PLEIADES Image (Scale: approx. 1/1,000)

Remarks:
This result will be created in collaboration with JICA and MPWT/WD in October, 2013.

Acquisition of Satellite Image: 5,December,2012
Satellite Scene No.:DS_PHR1A_201212050345520_SE1_PX_E103N10_0717_05281
Type of Satellite Image: PLEIADES 16Bit 0.5m PAN-SHARPEN(4BANDS)

Figure 2 - 13　Description and Result of GCP-GNSS, Article Table of Hydrographic Survey

c) The distortion of satellite imagery is corrected by fitting GCP points on the satellite imagery using Rubber sheet command in AutoCAD Map 3D. Therefore the GCP-GNSS points have been chosen such as an edge/rim/corner of wharf, light house etc. where are as same as near the sea surface and possible to observe GNSS observation. (It is put to correct distortion of two-dimensional image, because it is not necessary to do an advanced elevation correction like an Ortho Imagery processing because the purpose is delineating the coastline the work).

Figure 2 - 14 Satellite Imagery before Geo-Reference Processing

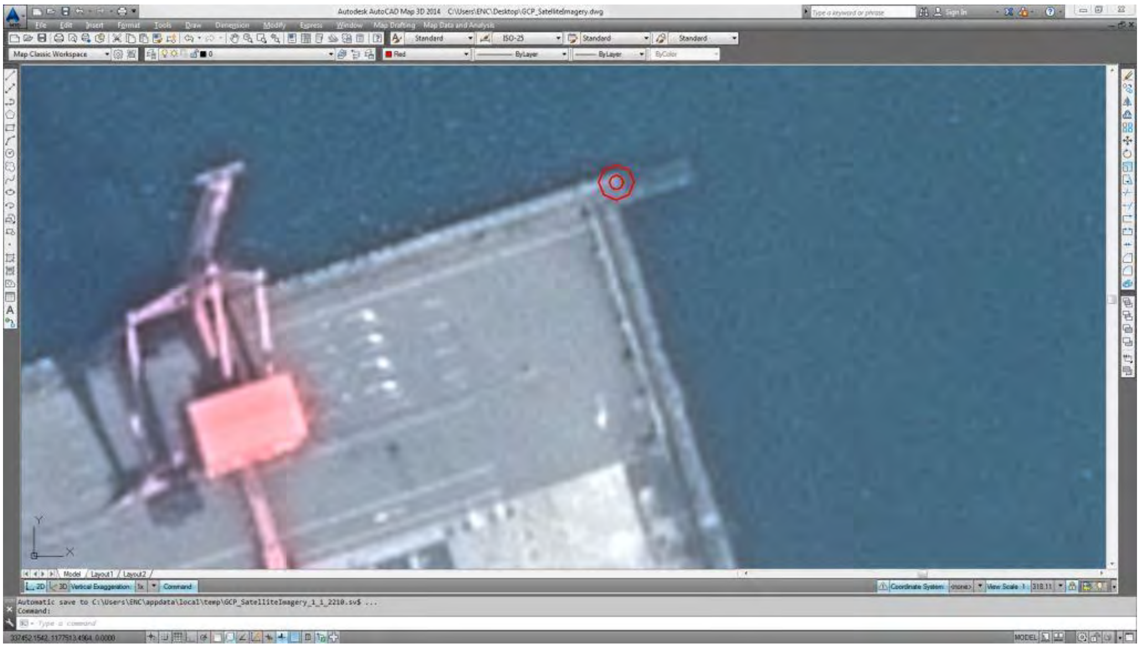


Figure 2 - 15 Satellite Imagery after Geo-Reference Processing

It is clear to find that the GCP is located at the correct location on the satellite imagery.

(2) Extracting of Shoreline Information, Creation of shoreline file:

After the correction of satellite imagery, creation of shoreline information file that contains the attributes of layer structure such as natural shoreline (rock, sand, mud or etc.), artificial shoreline (seawall, pier, stone masonry or etc.) Following shows an example that shows the outline of wharf at PAS extracted.

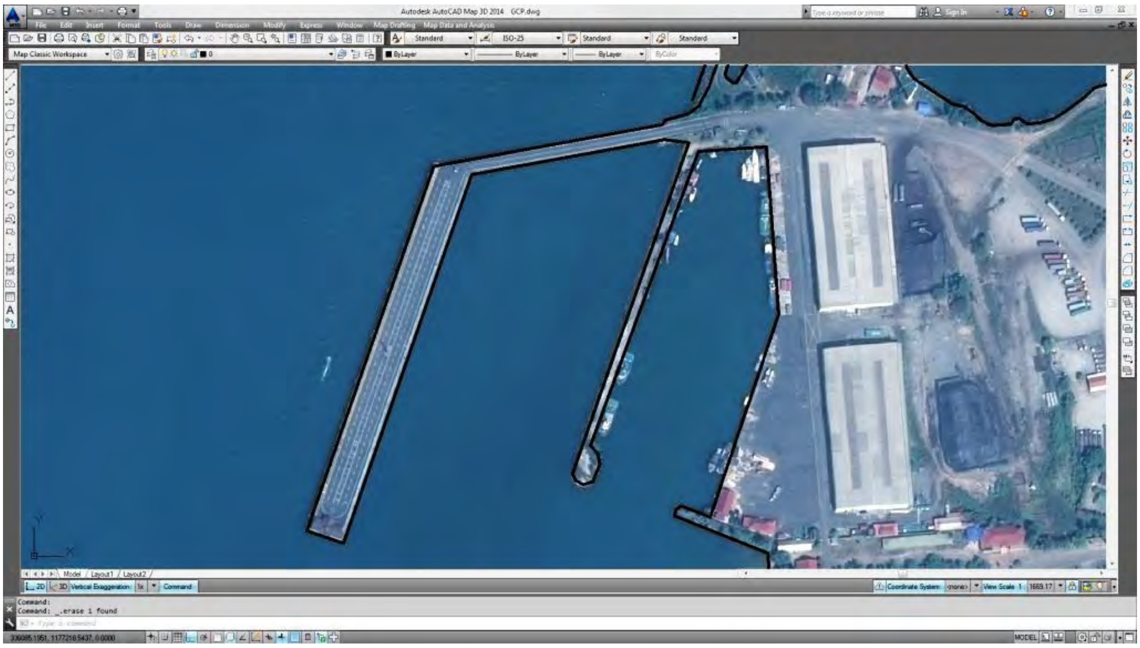


Figure 2 - 16 Imagery Contracted to 1: 10,000

It is appropriate to delineate the shoreline in the corresponding scale navigational chart

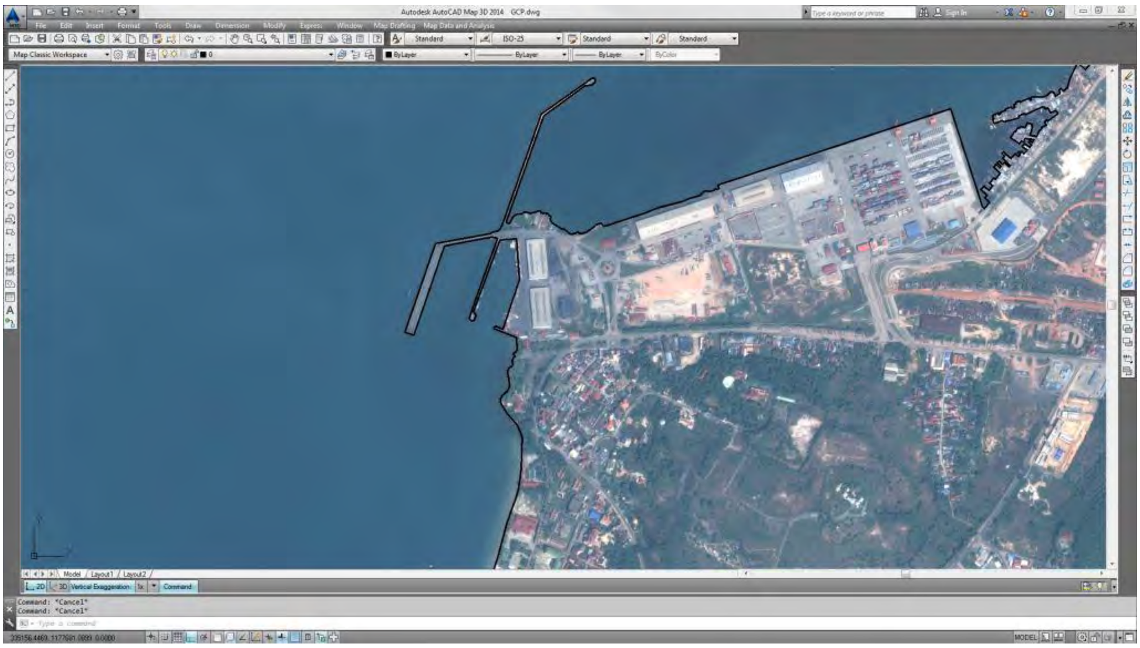


Figure 2 - 17 Shoreline Digitized from the Satellite Imagery of the Shoreline near SHV port

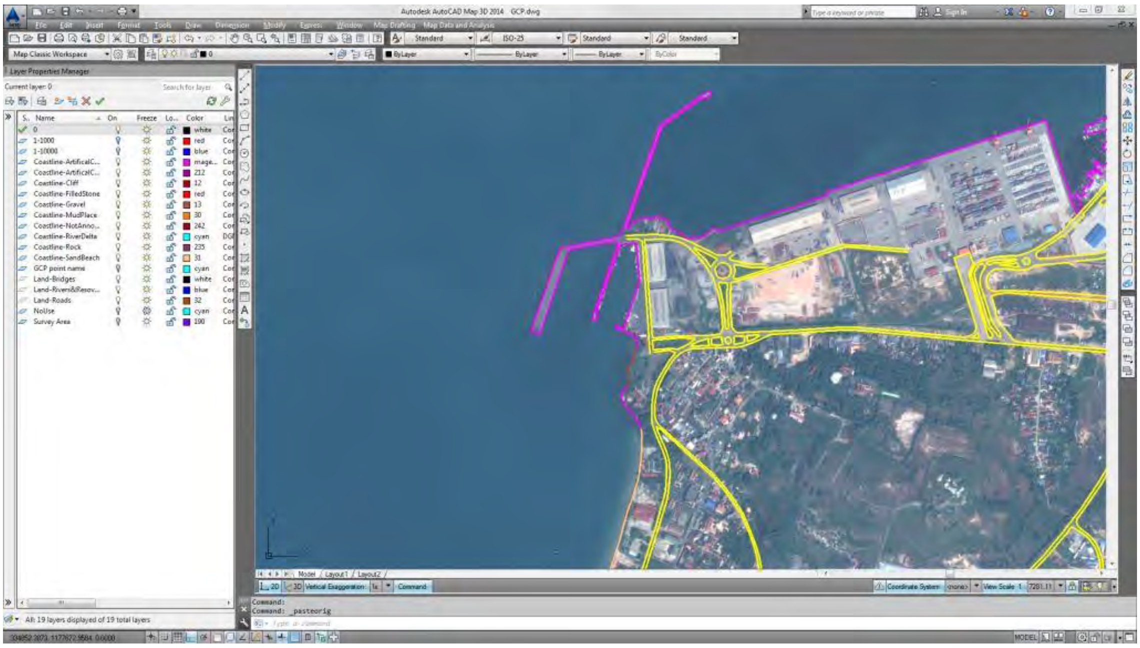


Figure 2 - 18 Shoreline Classified Complying to IHO S-57

The classification includes artificial shoreline in pink, rocky shoreline in red, sandy shoreline in yellowish red and road near the shoreline in yellow. Left panel shows the shoreline file layered in various attributes.

(3) Verification of Satellite Imagery

1) Check with GNSS equipment at HYPACK SURVEY display to confirm accuracy of survey boat position with digitized coastline (Refer to below figure)

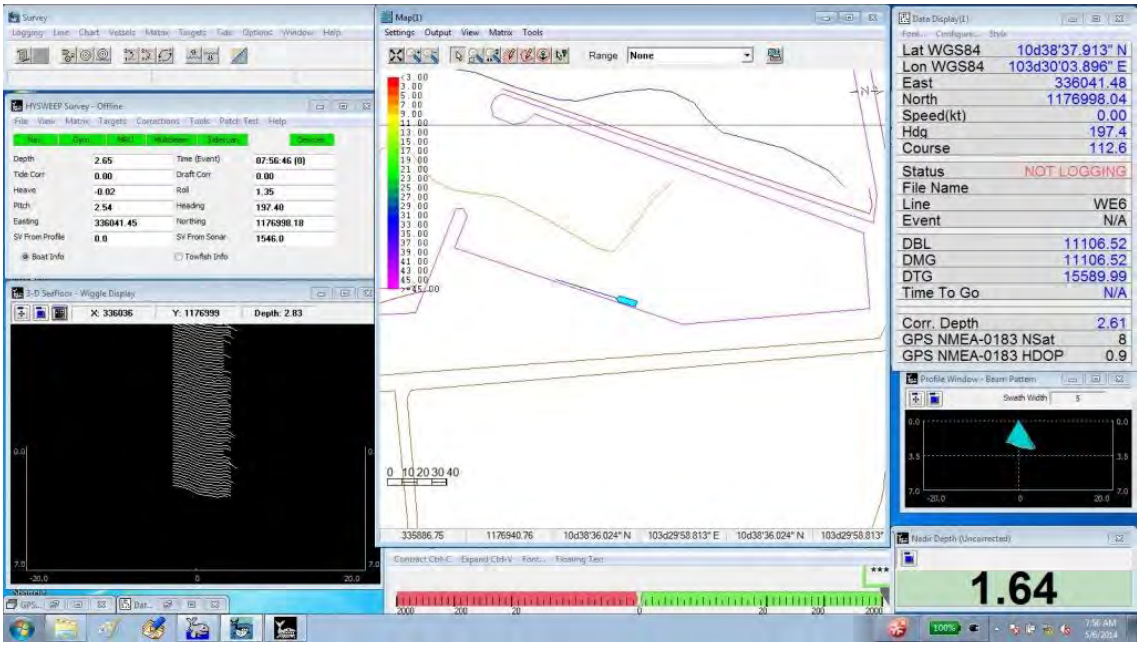


Figure 2 - 19 Confirmation of Location Accuracy of Survey Boat by HYPACK SURVEY

2) In case that the identification of shoreline is difficult, then the study team processed to determine the type of shoreline taking the photo by GNSS digital camera on site.

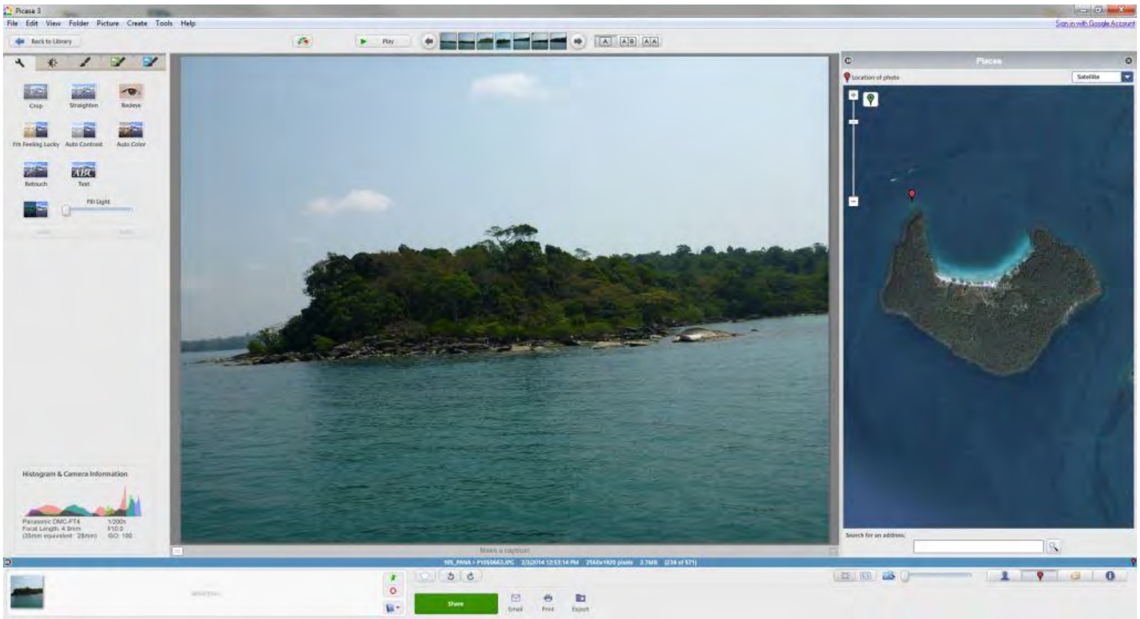


Figure 2 - 20 Confirmation of Type of Shoreline by GNSS Digital Camera on Site
Red point in the right imagery shows the island shot by GNSS Digital camera on the left panel.

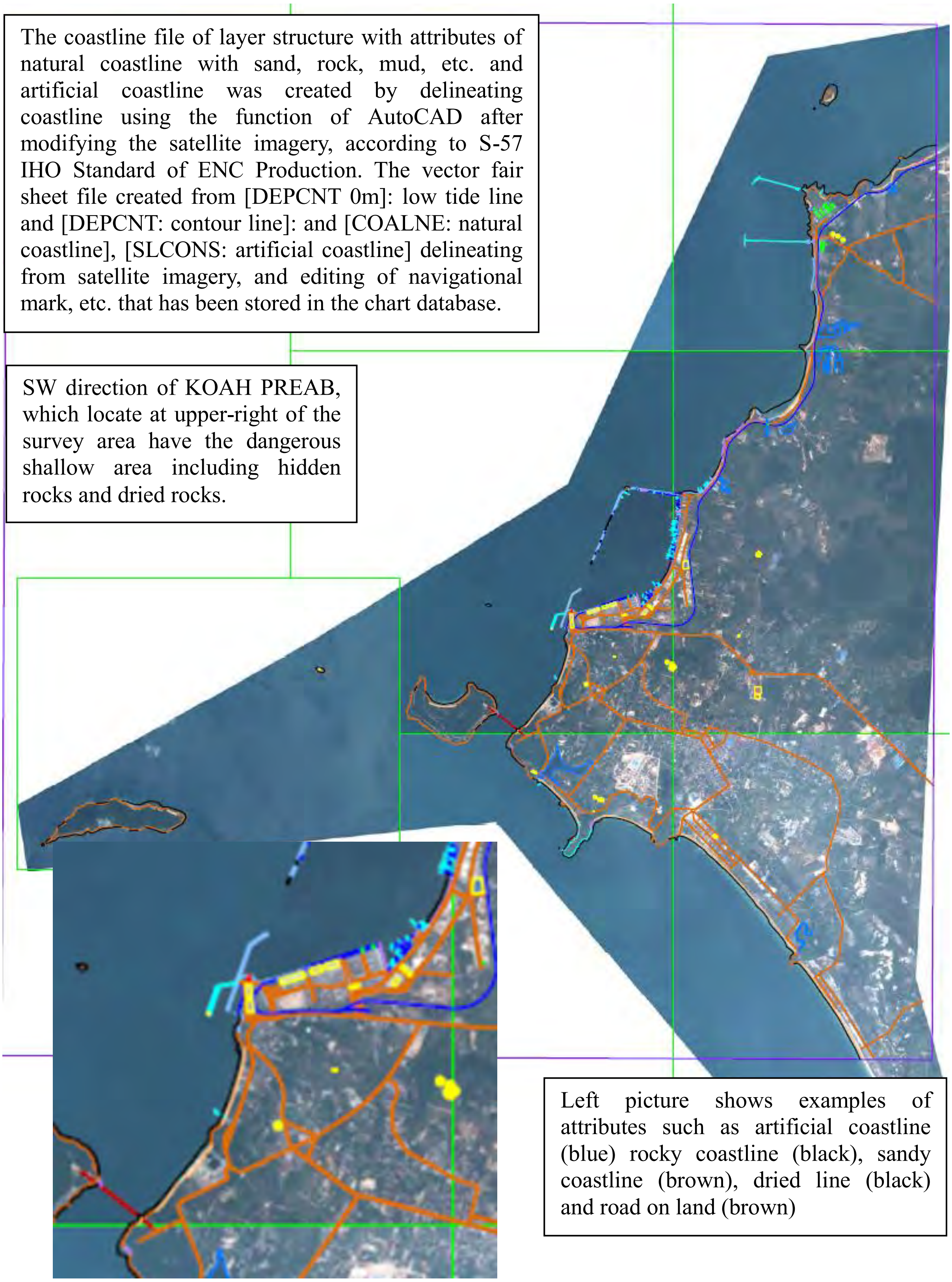


Fig 2 - 21 Colour Coding of Attribute on Types of Coastline

2 - 6 - 4 (6) Acquisition of Digital Hydrographic Survey Data - Work in Cambodia

The multi-beam sounding method is a system which makes the keystone of the modern hydrographic survey, all the data can be recorded and processed in digital format, and it brought the remarkable change on the sounding method, period and preservation of data. In order to acquire the chart information in the study area, the sounding has been conducted by the multi-beam echo sounder complying with the IHO S-44. In order to keep the sounding accuracy, DHSDAS (refer to Figure1 - 2) has been adopted as mentioned in Section 1 - 4 - 1 "Technological Policies" of Chapter 1, and its uncertainties have been minimized as much as possible. Moreover, the transducer of MBES has been rigidly fixed to the gunwale of the survey boat so that the sounding work should be carried out smoothly and properly even on the rough sea and/or at a speed of more than 6 knots. The line spacing has been planned so as to be able to detect an obstacle specified in Classification of survey`s Order (1a) of S-44. The software for DHSDAS is using HYPACK version13 and 14. Besides, the technology transfer, such as "method of stabilizing transducer", "line spacing", "Patch Test for synchronizing signal data between GNSS receiver and motion sensor and transducer", "maintenance of IT equipment", "relating process to the ratio of signal to noise" and others, all of which should be essential for DHSDAS has been carried out on the basis of OJT during the hydrographic survey period to the 8 C/Ps for about 120 days. Regarding the positions at sea, it has turned out that SBAS (Satellite-Based Augmentation System) has not utilized in the study area. However GNSS in use has been verified within ±2m accuracy (95% confidence level)

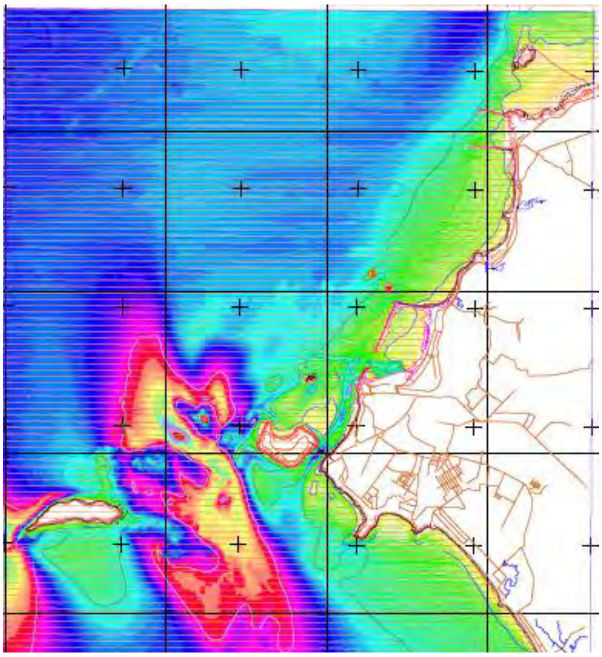


Figure 2 - 22 Quick Report of Colour-coded Depth Map in the Original Project Area

As shown in Figure 2 - 22, colour-coded map; greenish colour represents water depth less than 10m, blue colour represents water depths from 10 to 20 m, pinkish colour represents water depths from 20 to 30m, dark brown represents water depth of more than 40m, shows the completion of MBES hydrographic survey in the area as of May 2014.

Photo 2 - 3 Survey Boats
Left: Multi-Beam Echo Sounding Right: Single Beam Echo Sounding

Regarding the various dangerous areas and the surroundings of Islands drawn in chart, enough sounding data have been acquired to draw the low water lines and the 2m contour line, respectively. The total sounding days and the sounding distance (log) are 65 days and 6,266km, respectively.

Total number of acquired MBES raw data has amounted to more than 170 GB. The supplementary sounding has been carried out for 10 days over the 466km distance in November-December 2014.

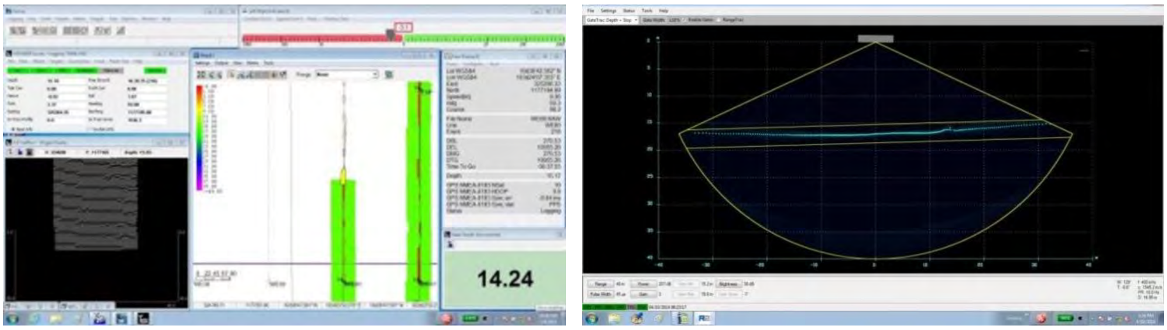


Figure 2 - 23 Navigation Display operated by HYPACK, and Control View of MBES, SONIC 2020

Left view: HYPACK Survey Display for guiding of survey boat and monitoring of hydrographic data (position, depth, roll, pitch, yaw and synchronization of each device, etc.) Right view: Control display of SONIC CONTROL 2000 software for control and setup transducer's parameter such as Power, Gain, Range, Pulse width etc., it needs to adjust depending on the depth and the seafloor classification.

The following photo shows the snapshots of multi-beam sounding. (Operator monitor and Navigation monitor and Data acquisition system)

Transducer of MBES mounted with gunwale

SONIC CONTROL PC(L) and HYPACK SURVEY PC(R)

Operation of DHSDAS using MBES and its peripherals

SBES Survey Operation on Board

SBES Survey Operation on Board

Photo 2 - 4   Operation of DHSDAS on Board

2 - 6 - 5 (6) Oceanographic Observation, Tide and Current - Work in Cambodia

The tide gauge (RMD5225WL-B) of pressure type with atmosphere-correction-function that is possible to observe the tide for more than two years has been installed at the new Tide station in PAS yard. Another type of tide gauge (RT710) has also been installed separately at the same station at first for its verification of proper working. Thereafter, it has been installed at the central part of the study area and observed the tides during the hydrographic survey period. Moreover, the tidal current information, which should be needed as the oceanographic information on C & ENC, has been planned to measure at the narrow channel where the sailing ships are likely to encounter unknown dangers. Besides, the lecture concerning the tidal observation together with the exercise of scale ratio calculation of tidal records compared to the tide pole data observed simultaneously have been conducted on the basis of OJT as mentioned in Chapter 1. The Nearly Lowest Low-Water Level (N.L.L.W.L) corresponding to the Chart Datum has been examined by performing the lectures and trainings concerning the tidal harmonic analysis after obtaining tide data for more than one year.
Following Photo 2 - 5 shows the renovation of Tide station in SHV:

(1) Oceanographic Observation

1) Renovation of Tide Station

			
Before Renovation 10th Oct. 2013	Under Renovation 15th - 18th Oct. 2013	After Renovation 20th Oct. 2013	Installation of Tide Gauge RMD5225 23th Oct. 2013
			
Solar Panel 24th Oct. 2013	Installation of Tide BM	Installation of Tide Pole 29th Oct. 2013	OJT for operating and maintenance of Tide Station

Photo 2 - 5 Renovation of Tide Station in SHV

2) Simultaneously comparative observation of tide

Following Photo 2 - 6 shows the comparative observation between the tide gauge and tide pole:

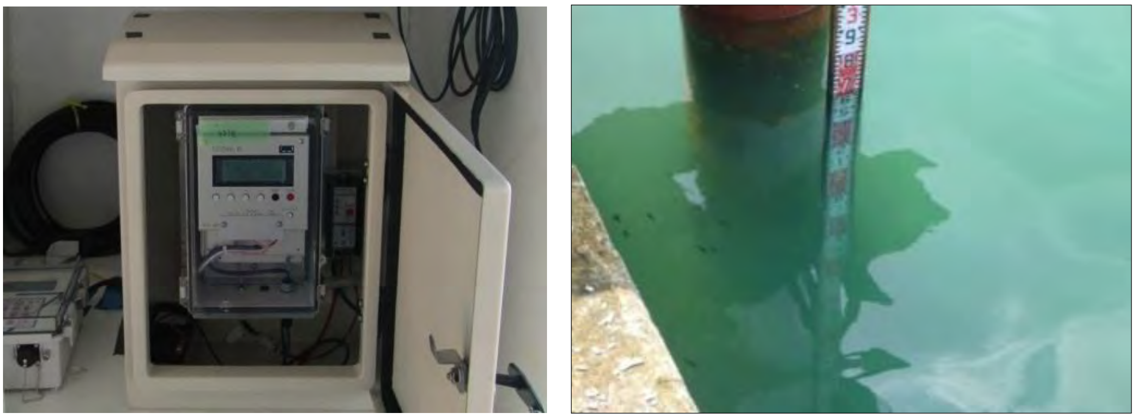


Photo 2 - 6 Simultaneously Comparative Observation of Tide Gauge and Tide Pole

Comparative Observation Records from 10:00, 24th Oct. 2013 to 13:30, 25th Oct. 2013

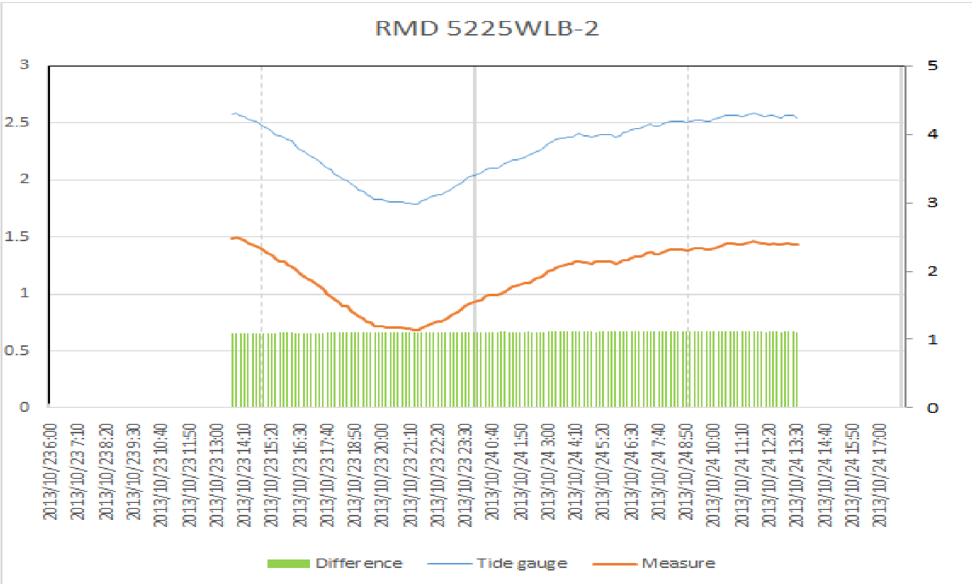


Figure 2 - 24 Comparative Observation of Tide Gauge and Tide Pole graph

The results of comparative observation of tide between the tide gauge and tide pole shows in the following Table 2 - 3. The differences varied from 1.08 m to 1.13 m. The results demonstrate the proper working of tide gauge because the difference was within 5 cm, though the total number of 1.11 m and 1.12 m exceeded more than 50 data.

Table 2 - 3 Comparative of observed value between Tide Gauge and Tide Pole

Difference	Number of Data
1.08m	2
1.09m	18
1.10m	7
1.11m	54
1.12m	51
1.13m	12

Chart Datum was determined by the identification of Nearly Lowest Low Water Level induced by the harmonic analysis, performing the lecture on the tidal process and OJT. Harmonic analysis was carried out by the tide/current expert.

Normally, although the tide curve indicates 2 times of high water and low water per day alternately, a diurnal inequality was prominent in SHV port and showed a single day tide. Following Figures show the mareogram observed by the RMD5225WL-B from 1st November 2013 to 31st October 2014, which coincide with the period of harmonic analysis.

The following Figures show the tidal records of each month from 1st Nov. 2013 to 31st Oct. 2014 in SHV port. Blue curve: observed tide, Green curve: predicted tide, Black curve: smoothing of smoothen tide and Red curve shows deviation between the observed tide and the predicted tide.

Legend of graph

Observed Value — Predicted Value
Smoothened Value — Difference

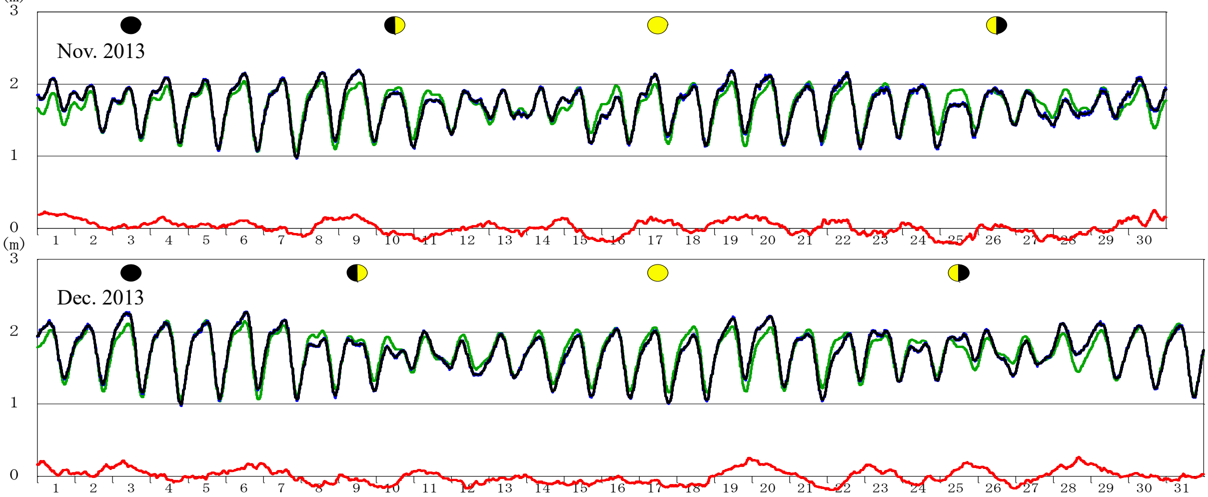
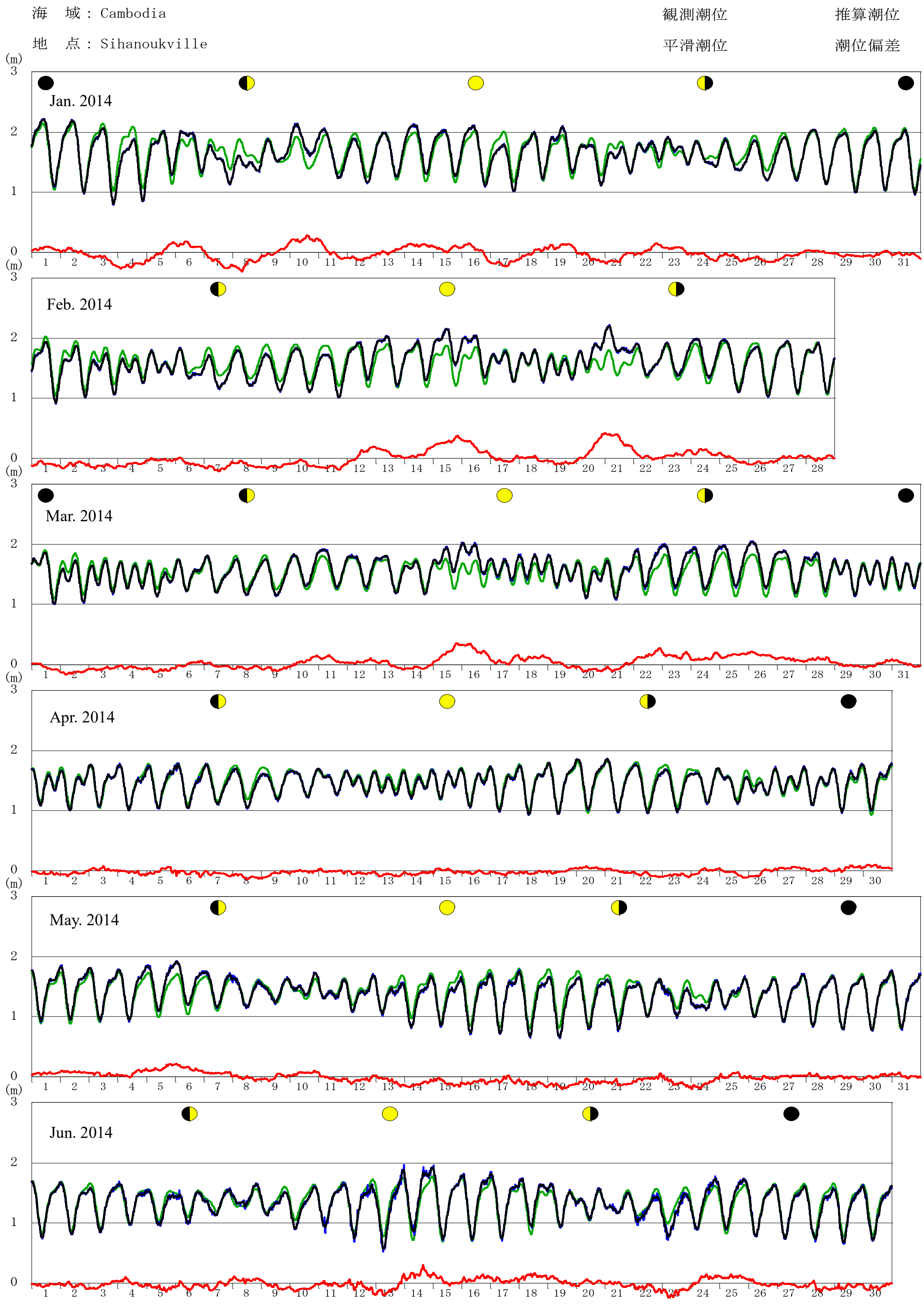


Figure 2 - 25 Tide Curve Observed from November 2013 to December 2013

潮位曲線



潮位曲線

Figure 2 - 26　Tide Curve Observed from January 2014 to June 2014

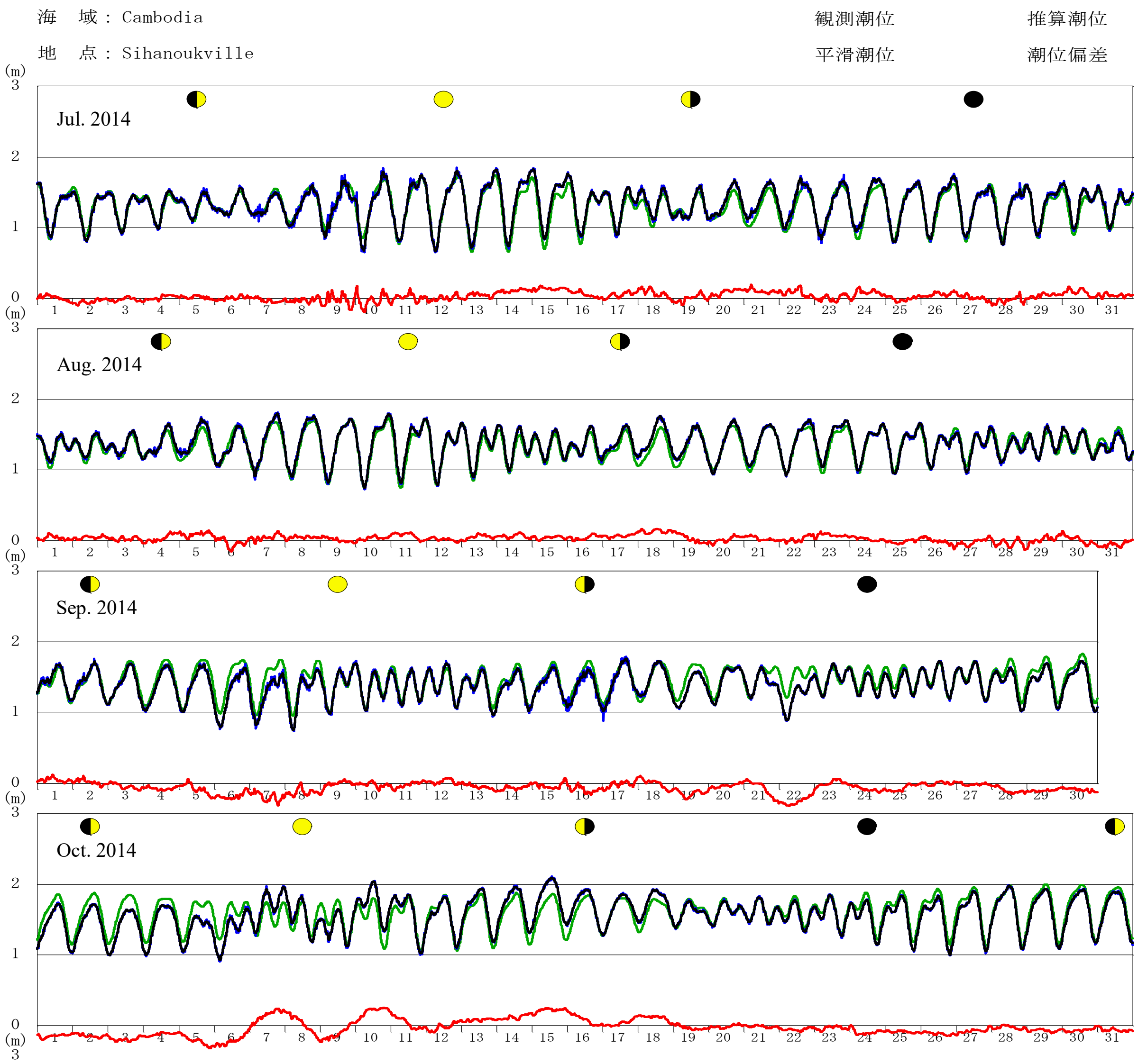


Figure 2 - 27　Tide Curve Observed from July 2014 to October 2014

Generally speaking, tidal range will be large, called Spring Tide, before and after the full moon and new moon. On the other hand, the range will be small, called Neap Tide, before and after the waxing moon and waning moon. Although the diurnal tide is prominent rather than the semi-diurnal tide over the SHV area, tide range during the Neap Tide period of waxing and waning tends to larger than the Spring Tide period of full moon and new moon, as the tidal ranges of Vernal Equinox in March and of Autumnal Equinox in September were examined, respectively.

3) Harmonic Analysis of Tide

The harmonic analysis of tide has been performed by using the above tidal data (Creating tidal data at every hour by smoothing every ten-minute data) of one year from 1st Nov. 2013 to 2nd Nov. 2014. The result is as following procedures were taken:

a) Every hourly data was aligned, giving smoothing technique on every 10-minute interval data, for computation. Mean value of 7 data of 10-minute interval data, 30 minutes before and after every hour, has been adopted for the computation.
b) Harmonic analysis of 1 year, from 1st Nov. 2013 to 2nd Nov. 2014, has been computed.
c) Following Table shows the 60 tidal components derived by the harmonic analysis of tide for 1 year. Daily maximum and minimum tides were extracted from the predicted hourly data based on the harmonic analysis. Prediction of tide for the same period of observation was carried out and examined its difference with each other on the diagram above. Further, tidal curve, or mareogram, representing 4 seasons has been produced based on the 6 main tidal components. (See detail in Appendix 4)

Table 2 - 4 Result of Harmonic Analysis of Tide for 1 Year including 60 Tidal Components

***** ANALYSIS OF TIDAL HARMONIC CONSTANTS *****

AREA	;	Cambodia
STATION	;	Sihanoukville
TIME ZONE	;	-7.0
LATITUDE	;	10 38 35 E
LONGITUDE	;	103 30 3 N
DURATION	;	NOV. 1, 2013 - NOV. 2, 2014
CENTRAL DAY	;	MAY 3, 2014
METHOD OF ANALYSIS	;	LEAST SQUARE METHOD

SYMBOLS	H (CM)	K (DEG.)	G (DEG.)	SYMBOLS	H (CM)	K (DEG.)	G (DEG.)
SA	19.52	276.7	277.0	KJ2	0.19	185.8	193.2
SSA	3.99	99.9	100.5	M2	11.41	351.2	347.1
MM	1.79	286.1	289.9	2SM2	0.29	259.1	269.2
MSF	1.13	266.9	274.0	OP2	0.82	70.7	66.0
MF	2.22	265.8	273.4	MKS2	0.87	48.3	44.7
S1	0.47	312.0	313.5	N2	2.45	341.0	333.1
K1	24.94	120.9	122.7	NU2	0.29	20.7	13.3
P1	7.48	122.3	123.5	MU2	0.64	342.3	331.1
PI1	0.40	148.7	149.6	2N2	0.49	303.9	292.2
PSI1	0.10	193.9	196.0	MNS2	0.32	287.7	272.7
PHI1	0.43	116.6	119.0	OQ2	0.36	142.9	127.3
M1	0.92	106.6	104.5	SK3	0.27	286.8	291.6
THETA1	0.24	164.8	169.9	MK3	0.86	249.9	247.6
J1	1.31	166.2	171.8	SO3	0.66	274.8	271.9
CAI1	0.05	242.3	240.8	M3	0.11	0.6	354.4
O1	18.82	87.2	81.3	MO3	0.59	211.3	201.2
MP1	0.66	171.5	166.2	S4	0.04	231.2	237.2
SO1	0.89	307.6	316.5	SK4	0.11	225.7	232.3
OO1	1.90	136.8	146.3	MS4	0.34	212.4	211.3
RHO1	0.97	79.3	70.1	MK4	0.12	134.7	134.2
Q1	3.92	70.3	60.6	SN4	0.14	232.2	227.3
SIGMA1	0.60	112.1	99.1	M4	0.42	159.5	151.3
2Q1	0.53	58.1	44.5	MN4	0.21	132.8	120.7
S2	5.58	36.4	39.4	2SM6	0.07	235.5	237.4
T2	0.11	183.9	186.6	MSK6	0.08	68.4	70.9
R2	0.18	343.1	346.3	2MS6	0.23	119.3	114.1
K2	2.33	350.3	353.9	2MK6	0.02	111.1	106.5
L2	0.64	313.0	312.7	MSN6	0.13	91.5	82.5
LAMDA2	0.18	317.8	317.0	M6	0.17	109.4	97.1
MSN2	0.25	170.5	177.3	2MN6	0.10	92.3	76.2
				SO	1.510	(METER)	

Table 2 - 5 Yearly Frequency Distribution of Residuals between the Observed and the Predicted

***** FREQUENCY DISTRIBUTION *****

-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
0.0	0.3	0.7	2.0	6.0	13.1	20.1	22.2	17.1	9.9	5.1	2.1	0.7	0.4	0.2	0.2

NUMBER OF DATA = 8808 MEAN OF DEVIATION = -0.44 STANDARD DEVIATION = 9.53

The following Table 2 - 5 shows the frequency distribution of residuals through the year between the observed and the predicted.

Following Table 2 - 6 shows the example of monthly data smoothed of November 2013 for the computation of Harmonic Analysis:

Table 2 - 6 Smoothed Monthly Data of November 2014 for Harmonic Analysis

DAY \ HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MEAN
1	185	182	179	179	182	185	191	197	203	207	208	205	198	189	180	171	165	163	165	171	178	184	187	189	185.1
2	188	186	182	180	178	179	184	190	195	197	197	197	191	180	166	151	140	135	134	140	149	158	166	173	172.3
3	178	178	177	176	175	175	178	185	190	193	194	193	189	181	168	153	138	129	126	131	143	154	164	174	168.4
4	182	188	190	189	189	191	193	198	203	207	208	208	204	195	181	165	148	131	121	119	125	138	152	162	174.5
5	172	179	185	187	185	186	188	190	194	200	205	206	205	201	190	173	156	136	120	110	112	121	136	151	170.3
6	162	173	183	190	193	193	196	198	200	205	210	213	215	212	205	191	173	154	134	118	109	111	121	135	174.8
7	147	159	167	177	184	185	187	190	191	193	199	205	206	207	202	191	173	156	137	118	105	99	102	112	166.3
8	127	137	149	161	172	178	182	187	194	197	202	207	212	215	216	214	205	189	173	154	138	126	122	128	174.4
9	139	154	165	176	188	197	202	205	208	212	213	215	217	219	217	213	207	196	182	164	148	134	124	121	184.0
10	125	134	144	153	162	170	177	182	183	185	187	187	187	187	188	187	184	179	170	159	146	133	122	115	164.4
11	113	117	127	138	147	155	164	172	176	177	178	178	177	176	178	177	177	175	172	167	159	150	141	135	159.4
12	131	133	140	151	159	168	178	187	191	190	188	186	181	179	177	175	175	177	178	177	171	167	164	160	170.1
13	155	152	155	160	167	173	181	186	190	192	190	184	176	167	160	155	153	157	159	162	158	156	158	157	166.8
14	154	155	157	160	165	172	180	188	192	195	194	188	178	167	160	154	149	152	159	165	172	175	179	181	170.5
15	180	179	177	175	176	179	183	187	188	191	193	187	175	161	145	133	121	118	121	126	133	141	146	153	161.2
16	157	157	155	154	156	159	164	170	176	181	182	180	174	165	152	138	126	118	119	126	137	150	165	176	155.7
17	182	186	186	186	186	190	197	203	209	211	213	211	203	193	177	158	143	133	129	131	138	148	155	165	176.4
18	176	181	184	184	180	182	183	185	188	192	196	197	195	187	173	156	140	124	115	117	124	135	149	162	166.9
19	174	181	189	192	193	194	198	200	204	212	217	218	215	210	197	182	165	151	138	132	133	140	149	163	181.1
20	173	183	192	199	197	197	202	205	206	209	209	211	210	206	197	186	169	150	132	123	117	119	127	135	177.2
21	147	155	163	171	177	180	183	186	190	192	195	198	197	193	191	185	171	157	142	130	121	126	137	143	167.9
22	155	166	178	188	192	195	197	200	202	203	208	210	214	214	205	192	178	165	147	130	118	113	117	127	175.6
23	137	145	156	165	173	179	184	186	185	187	192	192	190	192	193	190	183	172	155	142	132	127	127	137	167.5
24	148	157	167	179	185	190	190	191	192	190	193	196	198	197	194	189	181	167	155	141	126	116	112	115	169.5
25	120	130	140	150	159	165	170	170	171	172	171	170	170	171	173	173	171	169	161	154	138	130	130	135	156.8
26	142	153	163	172	179	184	187	189	189	190	193	193	191	189	188	189	186	181	176	168	161	152	145	144	175.2
27	143	148	155	164	171	180	187	190	188	187	185	181	175	169	163	159	157	156	156	157	154	151	147	144	165.3
28	143	145	152	155	161	169	175	177	178	177	174	168	164	161	158	156	155	159	159	159	159	159	160	160	161.8
29	161	164	170	172	177	181	187	190	189	190	186	179	173	164	158	156	154	157	167	171	172	179	180	185	173.4
30	187	185	188	195	198	203	207	207	207	203	198	192	186	177	170	167	165	164	164	167	173	177	183	191	185.6
																									170.6

Following Table 2 - 7 shows the Daily Maximum and Minimum Tides from 1st Nov. 2013 to 2nd Nov.2014:

Table 2 - 7 Daily Maximum and Minimum Tides from 1st November 2013 to 2nd November 2014

	11		12		1/'		2		3		4		5		6		7		8		9		10		11	
DAY	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW
1	208	163	213	136	221	110	193	92	186	102	168	109	180	94	169	76	163	87	150	111	168	118	172	104	188	116
2	197	134	208	128	218	100	187	103	173	105	167	101	183	96	166	83	150	82	152	118	171	112	172	104	190	135
3	194	126	226	116	206	81	174	107	172	119	176	107	181	95	162	85	149	92	155	117	169	111	164	100		
4	208	119	212	100	186	86	166	126	171	127	176	101	180	95	165	98	152	99	165	116	166	103	170	101		
5	206	110	213	106	201	129	180	141	168	114	174	105	186	111	153	98	151	110	171	122	168	101	154	105		
6	215	109	227	121	201	134	183	133	174	123	176	105	192	121	152	101	157	118	162	107	163	80	165	92		
7	207	99	215	107	178	114	171	117	181	120	176	111	174	116	156	113	149	118	179	91	153	83	196	132		
8	216	122	190	111	160	126	180	121	175	116	170	105	164	117	165	129	158	102	175	91	160	76	193	120		
9	219	121	190	118	187	149	174	113	175	115	164	118	164	123	151	114	167	88	172	84	168	99	164	112		
10	188	115	179	122	213	162	183	111	184	132	169	123	173	136	159	91	177	69	178	75	170	103	204	134		
11	178	113	200	149	204	124	172	102	191	129	169	127	161	131	165	93	174	82	175	82	161	110	185	103		
12	191	131	187	140	188	117	192	132	180	129	165	125	169	110	161	73	181	69	172	80	170	107	182	111		
13	192	152	195	136	199	126	203	122	181	119	164	127	160	105	189	58	181	73	166	90	161	96	193	119		
14	195	149	193	118	211	131	195	131	171	118	167	121	167	84	191	87	181	74	163	99	161	103	196	132		
15	193	118	194	111	203	128	215	157	196	154	168	121	165	87	192	73	182	85	157	112	164	112	209	138		
16	182	118	203	109	210	112	204	135	201	152	170	107	170	74	178	73	176	90	162	114	160	106	192	131		
17	213	129	200	102	179	103	177	128	179	142	173	100	173	73	182	76	157	90	164	117	176	103	186	128		
18	197	115	195	105	199	123	181	128	183	144	174	94	175	68	172	96	156	111	176	119	172	124	192	147		
19	218	132	219	135	209	133	171	132	181	131	180	96	165	66	164	95	158	113	163	115	158	107	176	139		
20	211	117	221	124	178	112	199	149	170	111	185	102	165	81	156	106	165	113	171	95	165	111	176	141		
21	198	121	196	106	175	132	220	176	172	110	185	99	160	79	150	117	165	112	164	106	164	121	181	144		
22	214	113	196	132	184	152	190	139	195	129	176	97	163	101	143	102	169	99	170	93	151	89	176	134		
23	193	127	201	131	191	146	192	138	199	130	168	99	149	100	147	76	166	85	170	105	169	123	185	127		
24	198	112	183	133	185	142	198	134	194	126	170	113	160	112	174	90	169	95	165	100	163	122	177	115		
25	173	120	196	142	188	136	197	111	198	131	167	113	165	115	172	91	165	80	165	95	161	122	184	107		
26	193	142	202	139	185	120	186	104	204	128	170	127	162	100	162	78	172	84	165	102	172	120	183	100		
27	190	143	187	144	191	120	194	109	188	120	172	129	170	93	161	74	167	87	160	97	172	116	190	106		
28	178	143	211	168	204	113	191	110	185	123	169	110	167	85	157	73	158	77	159	111	162	103	198	108		
29	190	154	212	136	198	101			175	115	176	98	166	80	160	67	160	90	162	115	169	105	193	109		
30	207	164	208	121	201	105			173	129	177	100	175	79	161	72	163	98	160	115	173	102	192	117		
31			208	110	203	98			178	128			176	81			157	99	153	115			189	119		
HIGHEST	219		227		221		220		204		185		192		192		182		179		176		209			
LOWEST		99		100		81		92		102		94		66		58		69		75		76		92		

4) Tidal Current Measurement

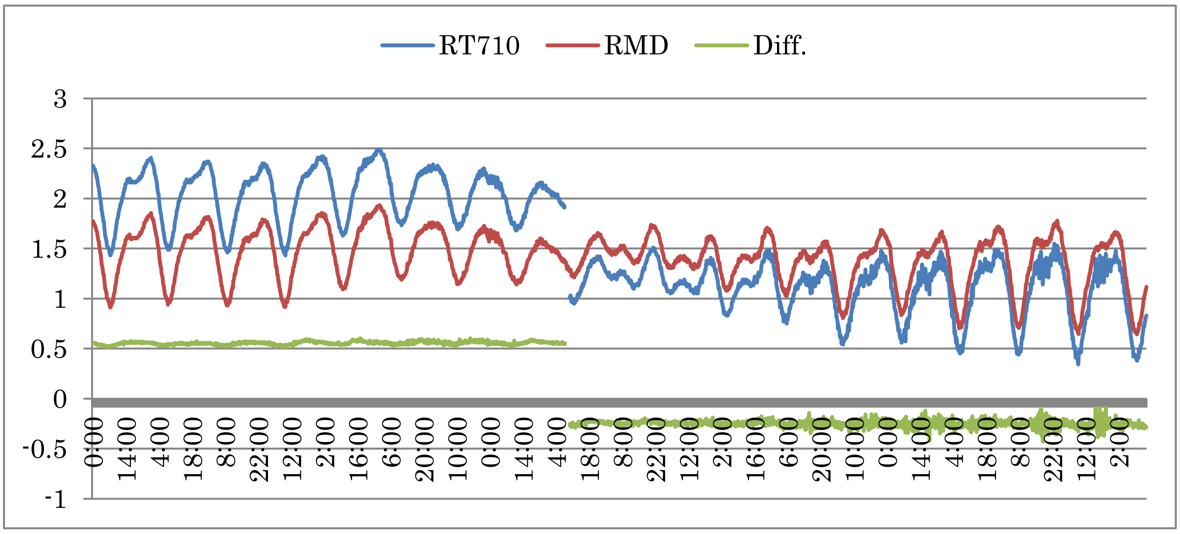


Figure 2 - 28 Comparison between RT710 and RMD, and its Differences

The Figure 2 - 28 above shows the comparison observed between by RT710 and RMD, and its differences from 1st May to 18th May 2014. Both Tide gauges were installed at the Tide station inside the PAS until 9th May. Study team transferred RT710 to KAOH DEK KOUL, the central part of study area, on 9th May to confirm the tidal difference and the time lag in the study area. However, the 0 of gauges was naturally changed, there were no big differences in terms of tidal differences and time lags, probably due to similar latitudes.

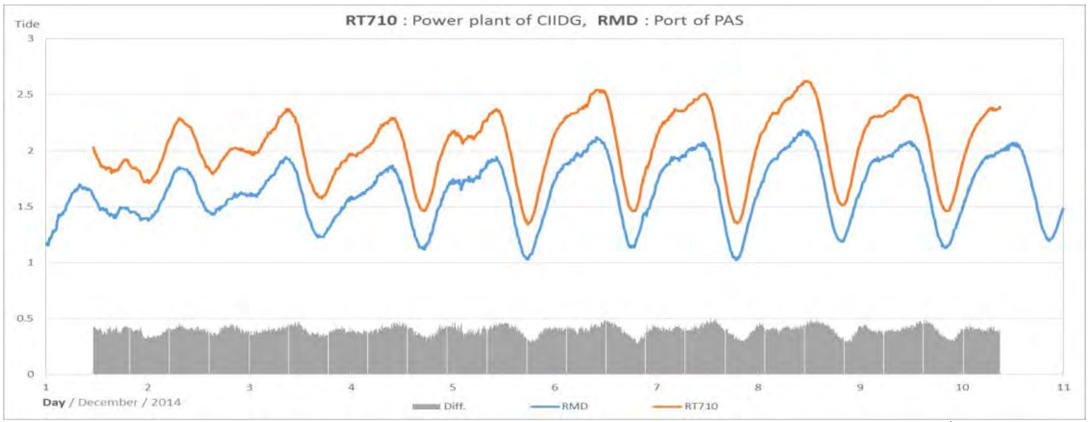


Figure 2 - 29 Tidal Comparison between RT710 and RMD from 1st Dec. to 10th Dec. 2014

Figure 2 - 29 above shows the mareograms observed by RT710 and RMD from 1st Dec. to 10th Dec. 2014. Similarly, RT710 has been transferred to the pier of power station, CILDG, in the northernmost location of the study area of the original project on 1st Dec. 2014. As a result, it was confirmed that the time lag will be able to ignore though, there happened rather a predominant tidal differences that cannot be neglected.

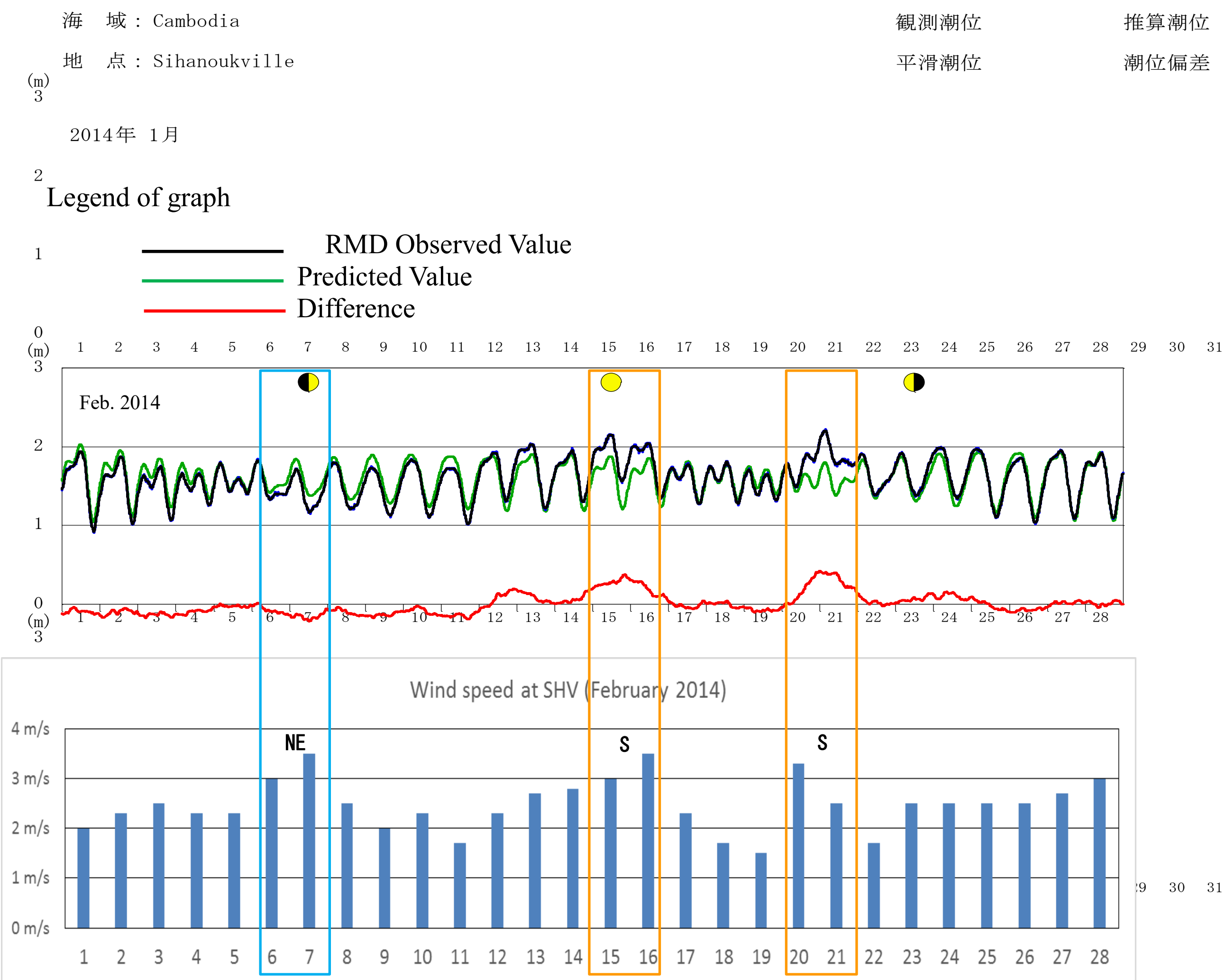


Figure 2 - 30 Tide Comparison between RMD and Predicted Value from 1st Feb. to 28th Feb. 2014

Looking at the tidal differences between the predicted tides and the observed tides in February and March, there happen peculiar phenomena that the tidal differences become larger to 45 cm in maximum between the predicted and the observed in mid-February, before and after 20th Feb. and mid-March. There were not any records of atmospheric pressure fluctuation of 45hPa during the same period. Then the study team gave a consideration on the weather-induced effects and the team examined and focused on the weather condition of wind direction and speed in February and March, given by the SHV weather observatory. Then the team found that the strong south wind was predominant for several days continuously during the said period, appearances of big differences between the predicted and the observed.

Therefore, necessary counter measures should be taken against the damages due to extreme high tide along the coast of SHV when the strong south wind is predominant during the spring tide. On the other hand, sailing vessels in and around SHV should pay great attention on the water depth fluctuation during the NE monsoon period that dominates the strong north wind.

At the beginning of tide observation, tide data collected was not enough to determine the MSL, Mean Sea Level, in SHV and also the 4 major tidal components to determine Z_0 that can be deduced the temporal Chart Datum Level, i.e. MSL - Z_0 = Temporal CDL.

Accordingly, tide correction was carried out using the MSL and 4 major tidal components defined in the Tide and Tidal Current Table published by UKHO at the 1st Phase of the project. Then at the 2nd Phase of the project, tide correction was carried out using the temporal Chart Datum Level, NLLW, derived from the tide data observed, but not enough to calculate the LAT, Lowest Astronomical Tide. Figure 2 - 31 shows the temporary determined tide relations in the 1st Phase and the 2nd Phase of the project.

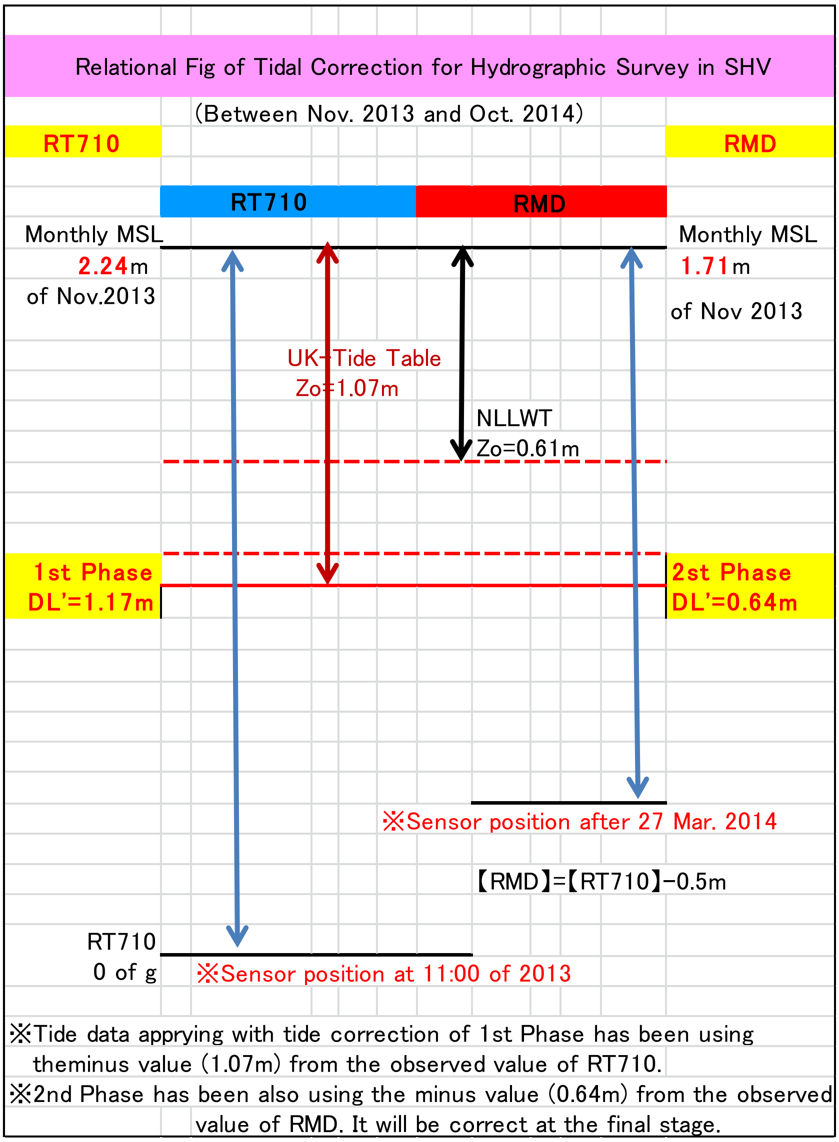


Figure 2 - 31 Temporary Relational Figure of Tidal Correction Relation

Finally, tide data observed from November 2013 to October 2014 for 1 year was processed by the harmonic analysis to extract the 60 tidal components and Mean Sea Level. Then, 60 tidal components were used to predict the tide for 19 years, which is the longest lunar cycle, and examined to identify the lowest tide level, which should be the LAT, Lowest Astronomical Tide.

Figure 2 - 32 shows the final tidal relation and the Chart Datum Level for tide correction to the depth of water.

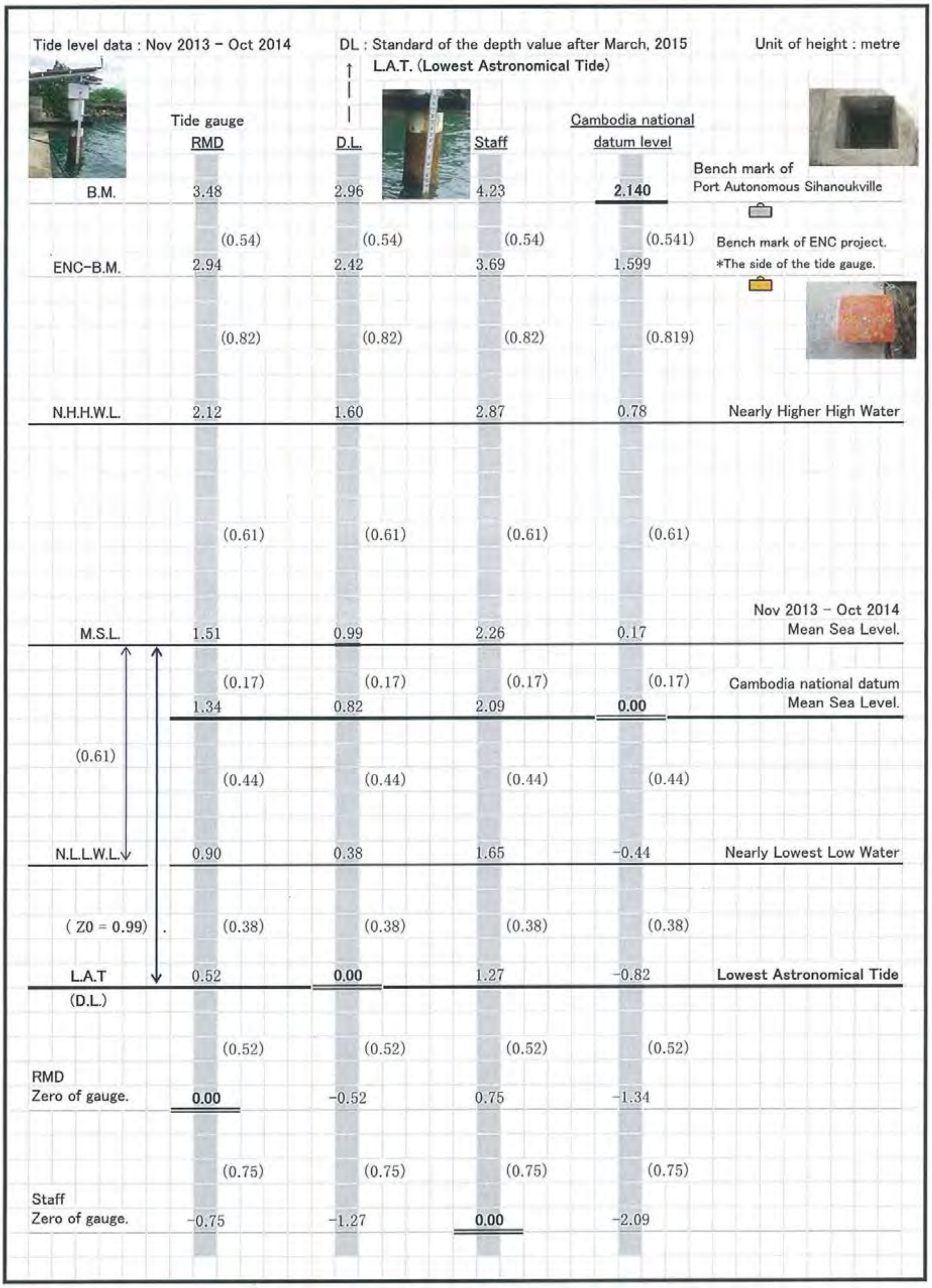


Figure 2 - 32 Final figure of Relation of Height and datum level

(2) ADCP Current Measurement

26th Nov. 2014 when the ebb tide is prominent, current measurement was carried out using ADCP, Acoustic Doppler Current Profiler (SONTEK ADP500), provided by JICA.(refer to Chapter 5) Measurement was carried out by the ADCP looking downward to the bottom from the sensor being side-mounted and sailed along the pre-fixed lines at a sailing speed of 2 to 3 knots. The results are shown in green arrow lines. The southward current (190°-220°) of 3 knots in average was measured at 1 m below the surface between KAOH POAH and KAOH DEK KOUL, and old south channel. The depth cell size has been set at 1m each. The current measurement was conducted only between KAOH PUOS and KAOH DEK KOUL and old south channel because the appearance of strong currents is very limited period along with the constraint of the shooting speed due to the strong downstream current at the Ebb Tide.

The second current measurement was carried out in order to measure the Flood Tide Current at the next Spring tide on 8th Dec. 2014. As the Flood Tide appears at night at this time of the year in SHV, the current measurement was carried out from 20:00 to 22:30. The line transect methodology has been adopted for the current measurement by ADCP looking downwards, and the shooting lines were fixed starting from the SHV port to the offshore. However the boat proceeded to the KAOH DEK KOUL and KAOH KAONG KANG, the measurement was cancelled on the way to the completion of the measurement due to the issue of signal reception together with a limitation of time. The Doppler current meter used for current measurement was new one to the study team though, study team managed to operate the system referring to the operational manual and duly acquired the current data as shown below:

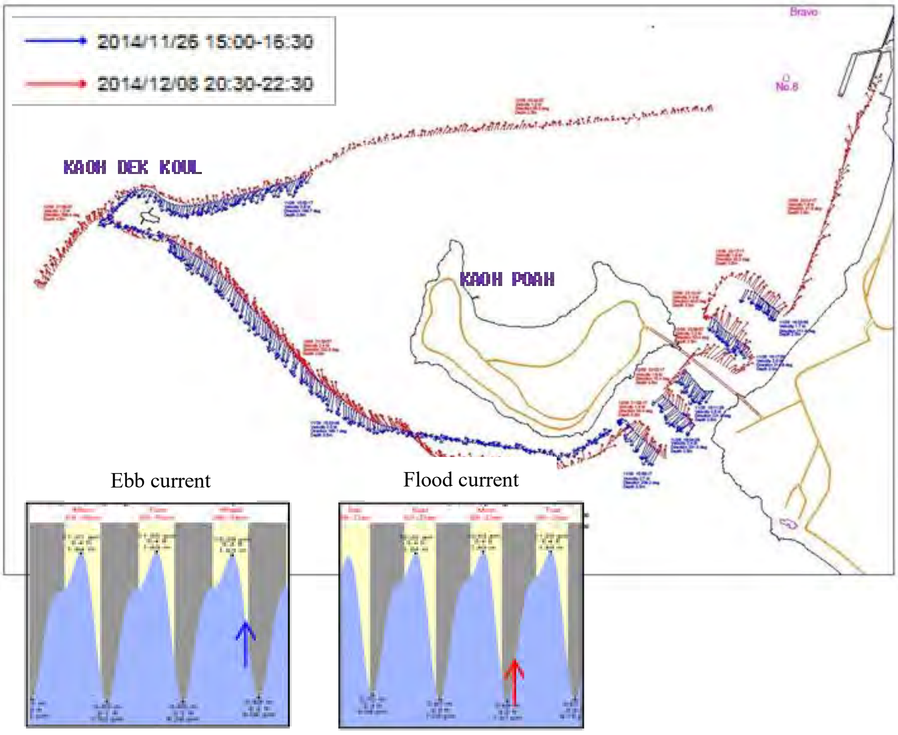


Figure 2 - 33 Results of ADCP Line Transect Current Profiling:
Blue arrows indicate ebb current and Red arrows indicate flood current.

The blue arrow on the above figure 2 - 33 shows the Ebb Current and the Red arrow shows the Flood Current. Looking at the Ebb Current and the Flood Current, the Ebb Currents have been stronger than the Flood Currents between KAOH DEK KOUL and KAOH POAH. However, it is almost the same at south channel. The reason of its difference of twice current velocity measured around KAOH DEK KOUL may be the first and the second measurement times in the strong current zone. Or, it may have been affected by the effect of island and sea bed condition enclosing the Study area. Anyway, it is considered no problem as long as the tidal current information described in charts is concerned.

2 - 6 - 6　(6) Digital Hydrographic Survey Data Processing　- Work in Cambodia and Japan

The Digital Hydrographic Survey Data Processing System (DHSDPS) has been consisted of the Personal Computer (PC) having capability of keeping the large capacity of interim data and HYPACK for the data acquisition too. The DTM database has been created by doing matrix process, deleting of noise data, giving of tidal correction, correction of sound velocity, correction of transducer posture (Yaw, Roll, Pitch: Motion of survey boat) for the MBES sounding data.

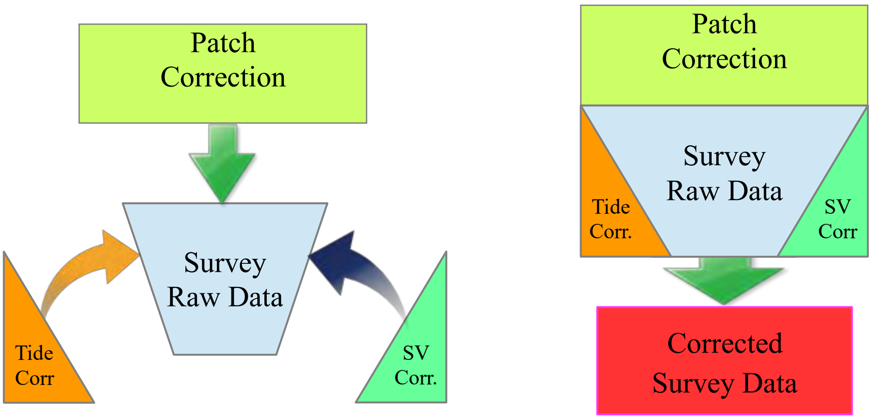


Figure 2 - 34　Survey Raw Data and the relationship of Correction Files

Technology transfer on the process of DHSDPS was carried out to the 4 C/Ps for about 100 days on the basis of OJT. Further, please refer to section 3 - 1 - 5 as the study tem entrusted actual data processing of more than half of the quantity.

(1) Correction Files:

Raw data acquired by DHSDAS should be provided for various corrections to get the corrected depth data as follows:

1) Tidal Correction File

1	Cambodia ENC tide convert table								
2	Convert to HYPACK format		MSL-Z0 1.51-0.99		HYPACK Tidal format Single Day format		HYPACK Tidal format Multi-Day format		
3	Date	Observed Sea surface	Datum Level (DL)	Height of Tide	hh:mm	Correction Tidal Level	Date DD/MM/YYYY	hh:mm	Correction Tidal Level
6916	2016/5/1 0:00	1.62	0.52	1.10	00:00	-1.10	01/05/2016	00:00	-1.10
6917	2016/5/1 0:10	1.61	0.52	1.09	00:10	-1.09	01/05/2016	00:10	-1.09
6918	2016/5/1 0:20	1.61	0.52	1.09	00:20	-1.09	01/05/2016	00:20	-1.09
6919	2016/5/1 0:30	1.61	0.52	1.09	00:30	-1.09	01/05/2016	00:30	-1.09
6920	2016/5/1 0:40	1.60	0.52	1.08	00:40	-1.08	01/05/2016	00:40	-1.08
6921	2016/5/1 0:50	1.58	0.52	1.06	00:50	-1.06	01/05/2016	00:50	-1.06
6922	2016/5/1 1:00	1.60	0.52	1.08	01:00	-1.08	01/05/2016	01:00	-1.08
6923	2016/5/1 1:10	1.61	0.52	1.09	01:10	-1.09	01/05/2016	01:10	-1.09
6924	2016/5/1 1:20	1.63	0.52	1.11	01:20	-1.11	01/05/2016	01:20	-1.11

Figure 2 - 35　Example of Tide Correction File conversion table

Tidal data level observed from Tide gauge 0 position. Charted Depth that based on DL (LAT) needed to process from Observed Depth and tidal correction file.

Charted Depth = Observed Depth - (Observed Tidal data - 0.52m)

Tidal data based on DL = Observed Tidal data - 0.52m

(Figure 2 - 36 shown Tidal level and Charted data relation)

Tidal Correction File, Use table to create (Refer to Figure 2 - 35) to convert to use at HYPACK for data processing.

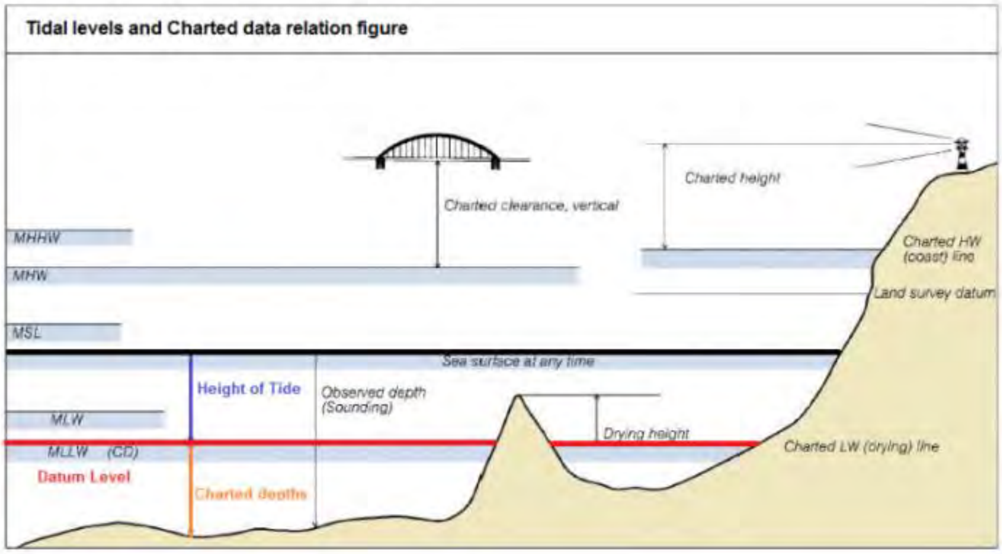


Figure 2 - 36 Tidal level and charted data relation figure

2) SVP Correction File

Sound velocity profile shall be fluctuating depending on the water temperature, salinity and pressure. In the hydrographic survey requires taking the sound velocity profile data from the surface to the deepest depth at each area. In order to create the sound velocity file that correct every depth acquired from hydrographic survey, measurement of sound velocity should be performed everyday (shown in Figure 2 - 37).

By using Sound Velocity Correction File, HYPACK processed Observed data to Corrected data.


Cambodia0505.vel - メモ帳
ファイル(F) 編集(E) 書式(O) 表示(V) ヘルプ(H)
FTP NEW 2
1.00 1547.58
2.00 1546.83
3.00 1546.35
4.00 1546.17
5.00 1546.10
6.00 1546.07
7.00 1546.06
8.00 1546.06
9.00 1546.06
10.00 1546.08
11.00 1546.09
12.00 1546.10

Figure 2 - 37 Sound Velocity Correction File

3) PATCH Test Correction File

PATCH Test verifies not only the posture of sounding transducer together with ‘Roll’, ‘Pitch’ and ‘Yaw’ but also the heading direction derived by the GNSS receiver. However, some bias on the 3 dimensional parameters will be produced between the initial measurements at the time of rigging and the operational time. Therefore, necessary correction should be given on the MBES data acquisition system by PATCH Test identifying the respective bias of each parameter. Thus, the MBES data shall be corrected by the correction files based on the PATCH Test.

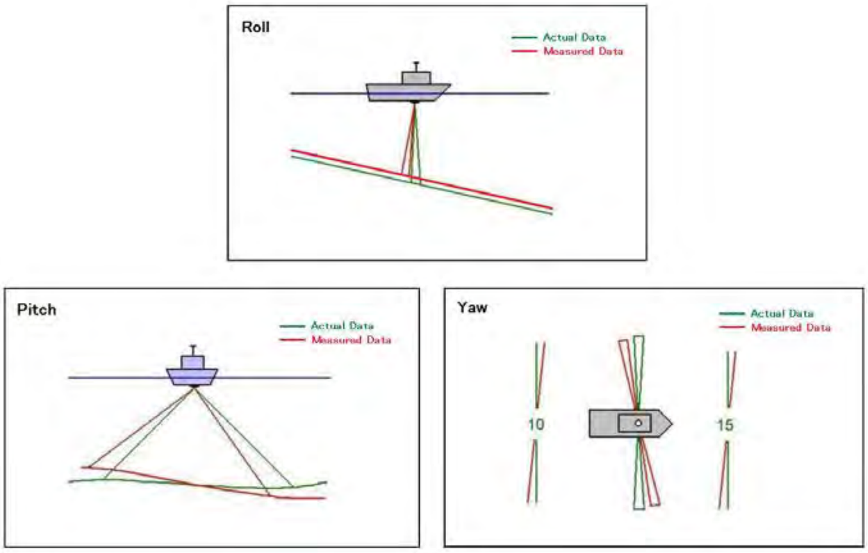


Figure 2 - 38 Boat Motion, “Roll”, “Pitch” and “Yaw”

Figure 2 - 39 shows the difference between the same cross section Before-After the application of Patch Correction. Without Patch correction, topology will not match together depending on the survey direction. However, after the application of Patch result, each survey line data matches together reasonably.

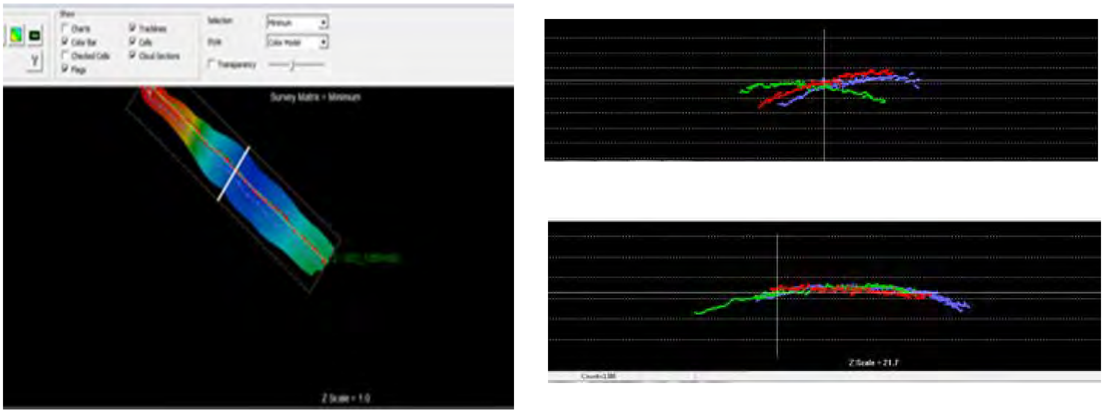


Figure 2 - 39 Cross section Before-After Applying Patch Correction

(2) Line Survey Based Data Processing Procedures

1: Automatic noise filtering used to delete noise near the sea bottom.
2: Interactive noise reduction and elimination of false data by using the ‘HYSWEEP EDITOR’ ion, which is the most time consuming process among other processes,
3: As the identification of real bottom from the false data and/or noise is very difficult for the beginners, study team made sample sheets of noise data by the screen shot for the C/Ps.
4: Important information for Navigational Chart; flag shall be given on any items considered to be hazardous to the navigational vessel such as extreme shallow reef and/or protruding object above the bottom, outcropped rock, fishing reef, Extraneous Object(EO) and etc.

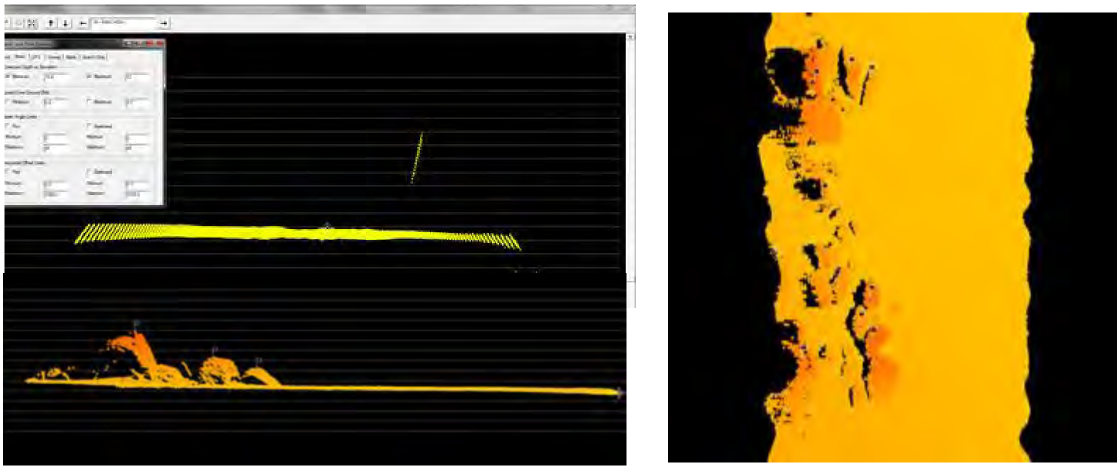


Figure 2 - 40 Left view shows the cross section of rocky reef and Right view shows from top view

(3) Area Based Data Processing Procedures

Similar to the noise reduction on each survey line, automatic noise filtering was made on to the area data divided. Then, the interactive noise reduction processes were made whether the data is maintained in its accuracy, and the individual data is connected in harmony with the data of adjacent lines and cross lines that have belted data.

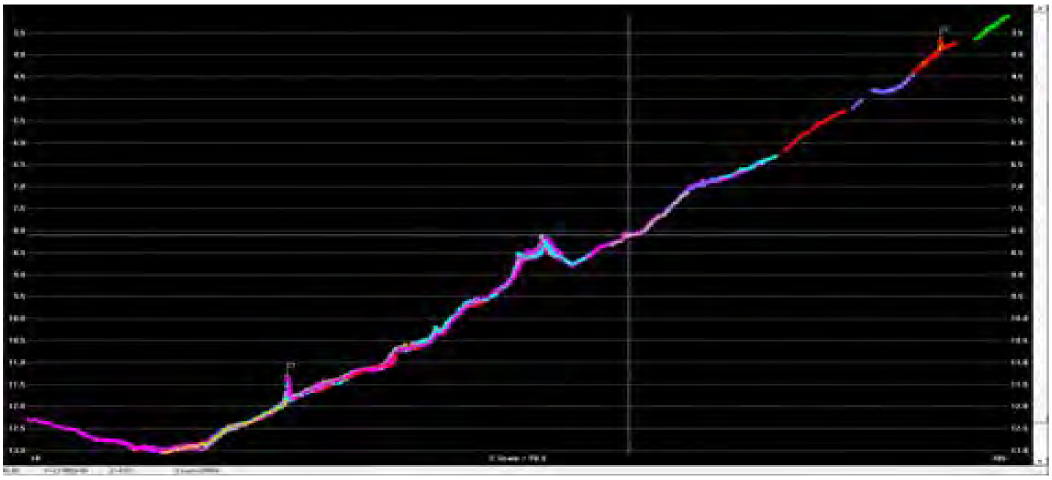


Figure 2 - 41 Area Based Profile Processed

Based on the individual area divided, any survey lines were selected to verify the relevance of depth data at the area where the bottom was seemed to be unnatural configuration.

(4) Data Processing Management

1) BLOCK DATA PROCESSING

During data processing, data obtained on different dates should be well managed to parcel out for the noise deletion to all the trainees and the study team member. Accordingly, the management sheet (file) for data processing was created as shown in the following Block, as technology transfer. Study team asked C/Ps to manage and control the data processing based on the Block sheet by them. Each Block was divided into 500 m x 500 m in order for HYPACK to process the enormous data.

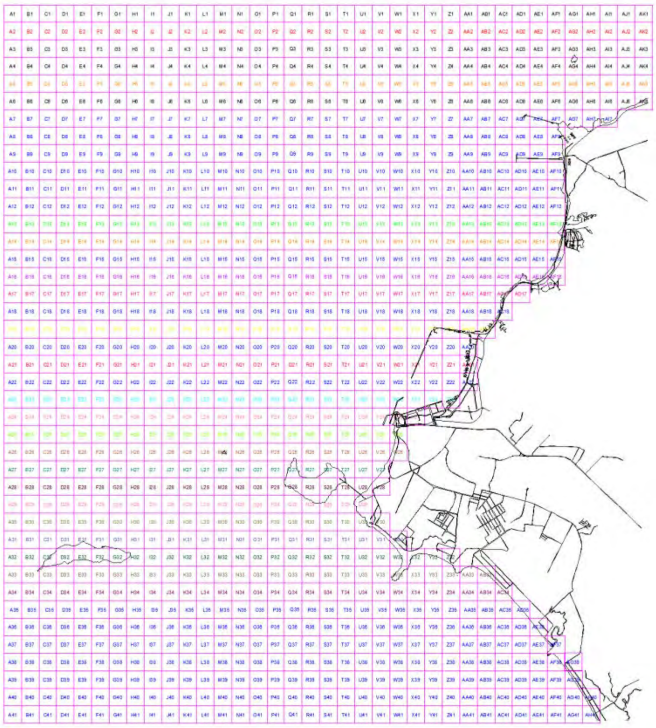


Figure 2 - 42   Blocks divided over the Project Area

Table 2 - 8   Data Processing Process Sheet Sample

Data Processing Process Sheet

Survey Date	#	TRC File	File Name	Phrase 1				Phrase 2				Processing Info		Check Date	Remarks
				Tide Correction	SV Correction	Equipment Offset	Patch Correction	HS2	HS2x	MTX	TIF	Processed Date	Processor		
	1		003_0857.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	2		002_0904.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	3		001_0911.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	4		011_0920.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	5		012_0940.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	6		013_0951.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	7		014_1002.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	8		015_1039.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	9		016_1046.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	10		017_1054.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	11		017_1130.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	12		018_1139.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	13		018_1146.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	14		019_1158.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
26. May. 2016	15	TRC_05262016	022_1226.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	16		023_1227.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	17		022_1248.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	18		024_1302.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	19		028_1324.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	20		031_1341.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	21		030_1349.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	22		032_1354.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	23		033_1404.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		
	24		034_1417.RAW	Tide_05262016_Edit_New	Vel_05262016_edit	ok	ok	ok	ok	ok	ok	June 1, 2016	Smey		

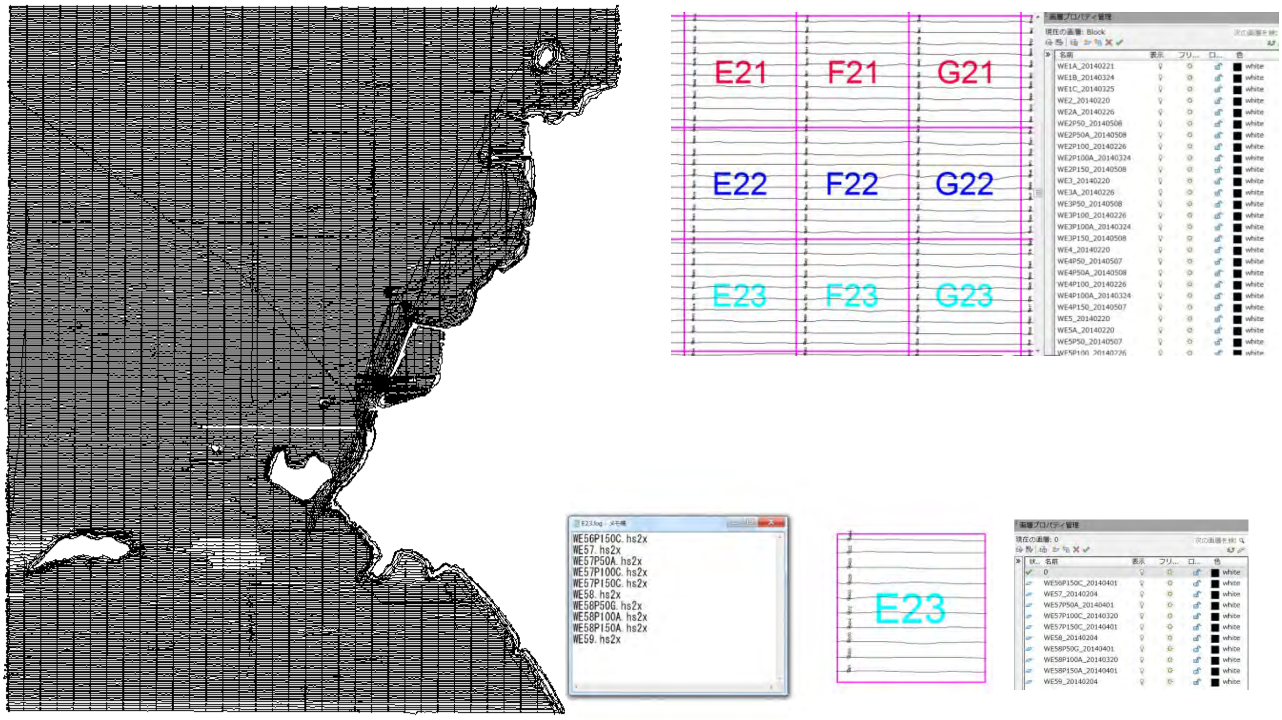


Figure 2 - 43　Example of Survey Line Log contained in Each Block

The depth data in each Block will be classified into the correct depth and false data automatic by means of trim function of AutoCAD. However, the false data still remains in the log file of each Block.

2) Examination of Depth data based with IHO S-44

The depth data processed should be examined whether the data complies with the IHO S-44. IHO S-44 requires that more than 95 % Confidence level of sample data processed should be less than the value of TVU, Total Vertical Uncertainty, which is dependent upon the classification of survey area. The areas surveyed in this project are corresponding to the order 1a and 1b, of which limit of TVU should be less than the value derived from the following equation:

$$\text{TVU Limit} = \sqrt{(0.5+(0.013\times \text{Depth})^2)}$$

In this project, the mean value was selected within the 5 m mesh after the manual editing of depths data, and it's being positioned in its cell center. And, it's compared with the depths of adjacent survey line as well as cross line.

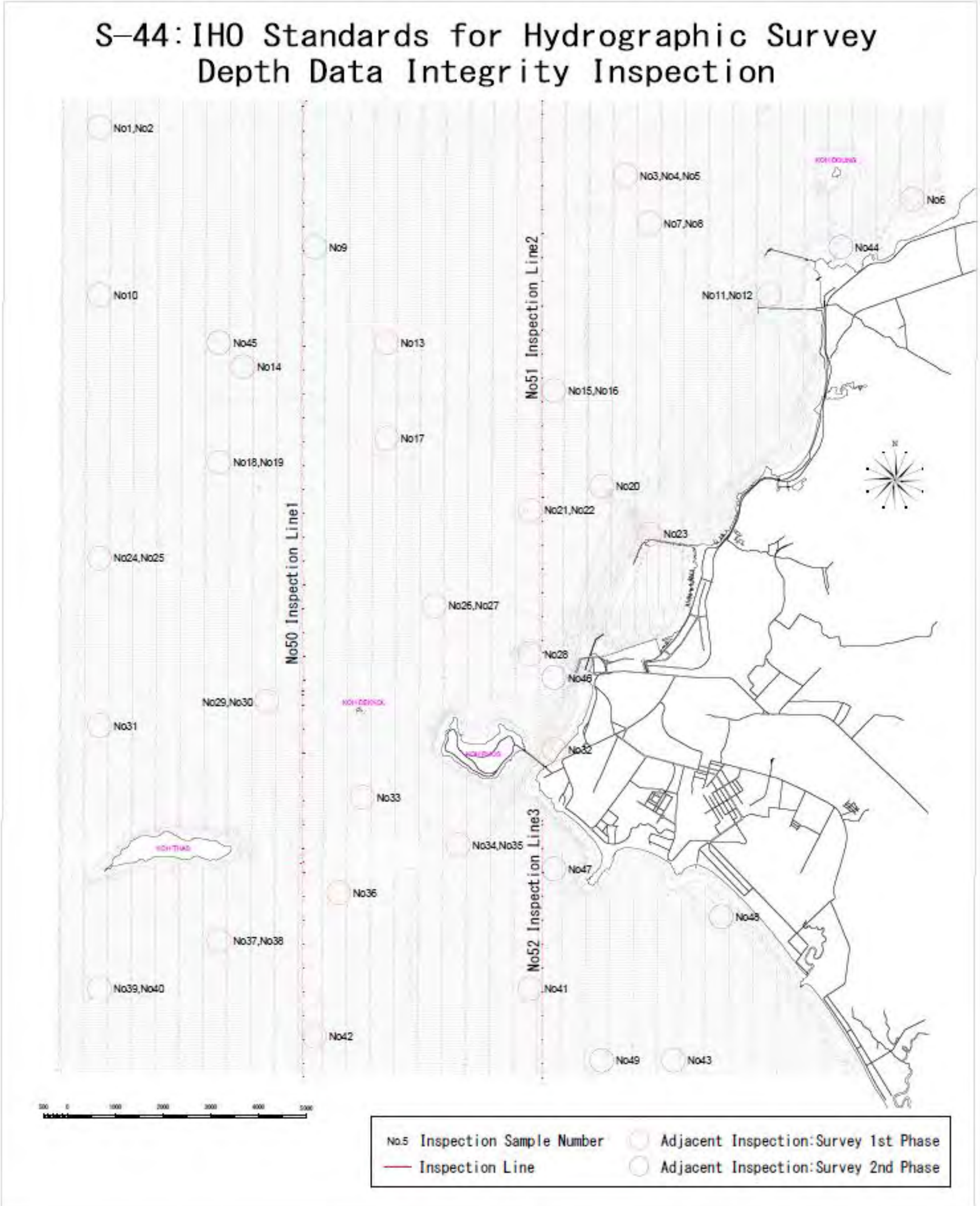


Figure 2 - 44 Positions selected for Adjacent Lines Inspection and Cross Line Inspection

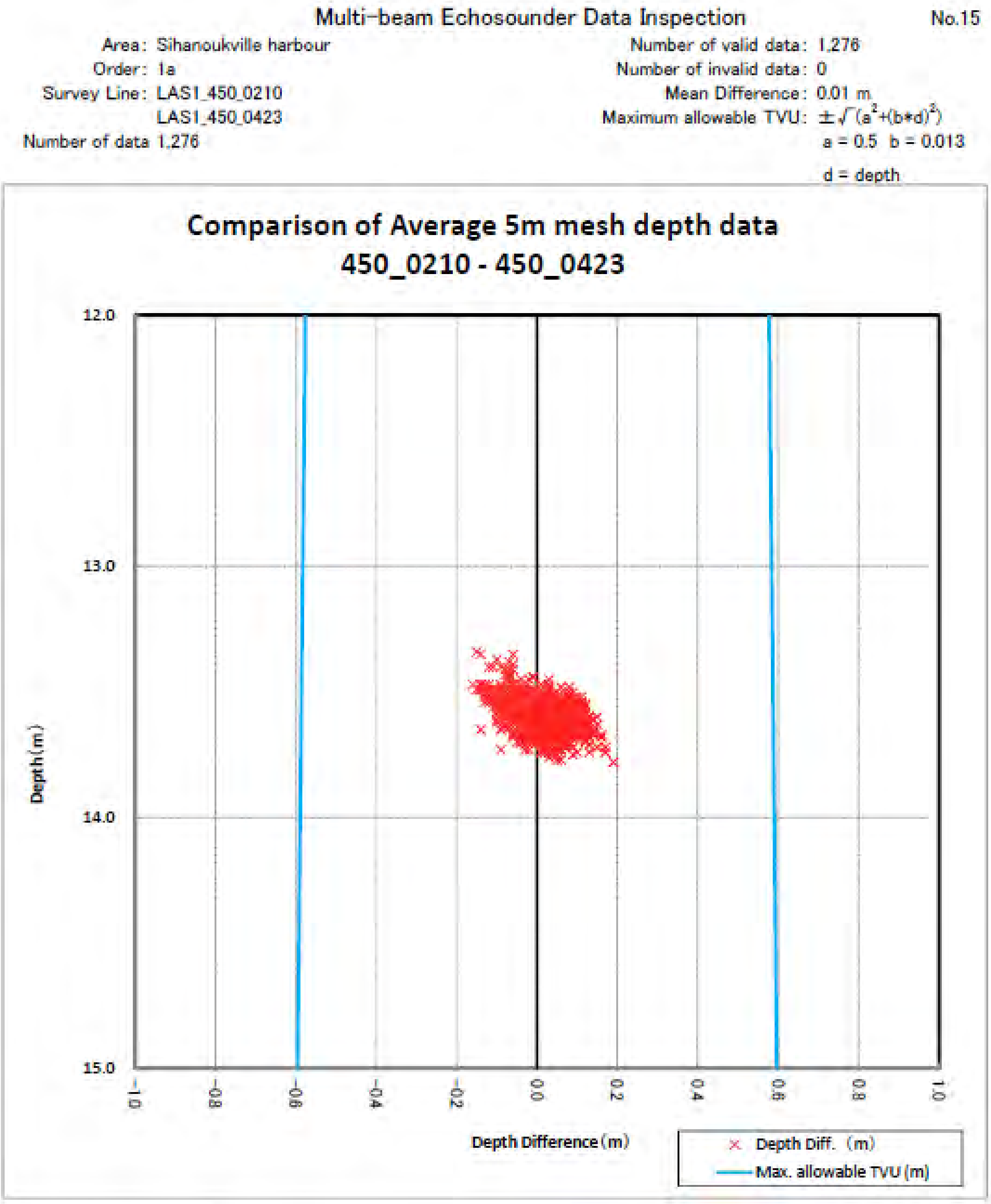


Figure 2 - 45 Inspection Results in the Original Project

Blue colour indicates the limit line of TVU compared at No. 15 inspection point between the survey lines of LAS1_450_0210 and LAS1_450_0423.

During the Extension Project, inspection of depth data was carried in the same manner. However, the depths of crossing point were inspected, as the adjacent lines were absent in the Extension Project

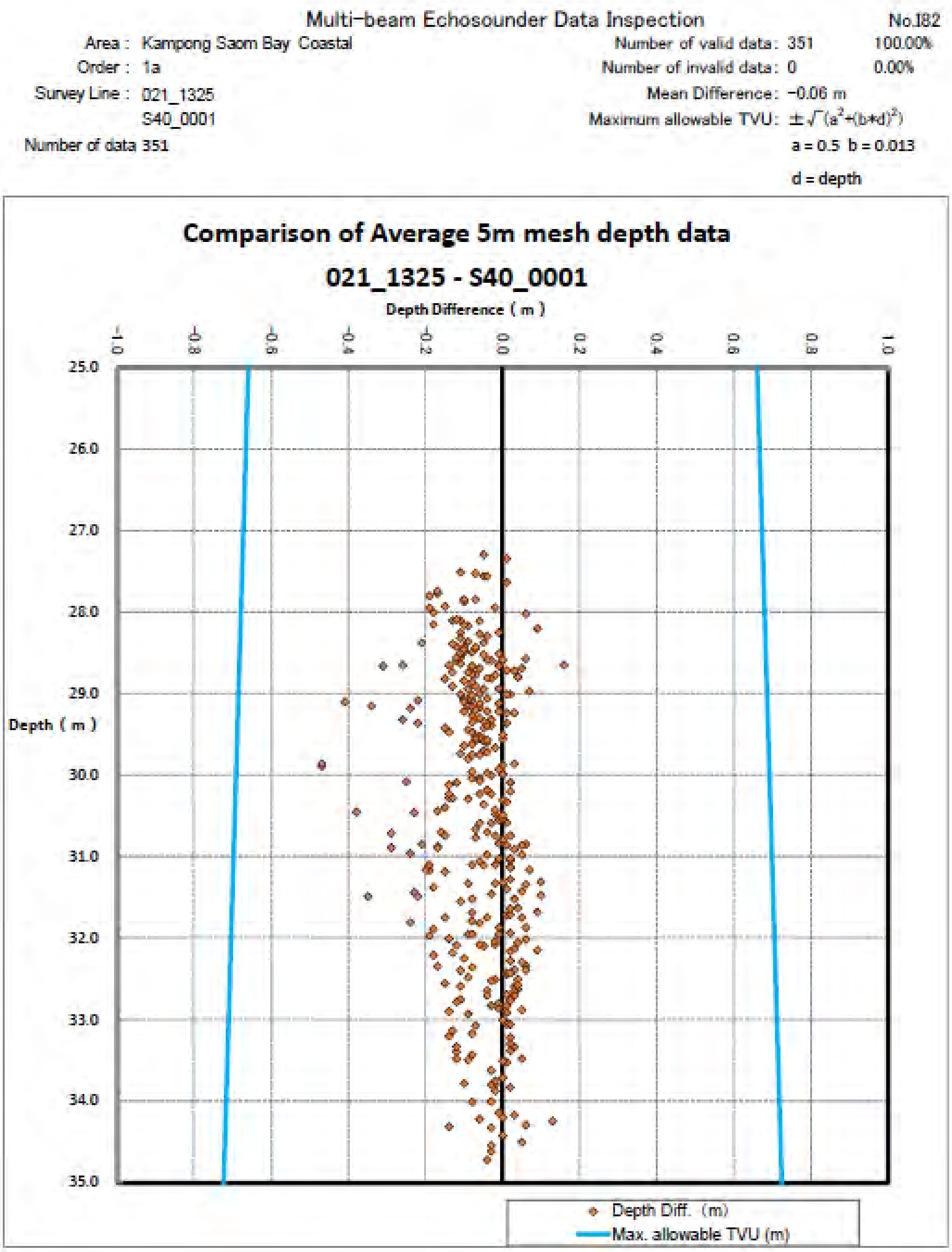


Figure 2 - 46　Inspection Results in the Extension Project

Figure 2 - 46 shows Inspection Result. For Extension Project, there is no any inspected depth sounding exceeding the limit of TVU, which meant the inspected depth sounding accuracy was acceptable.

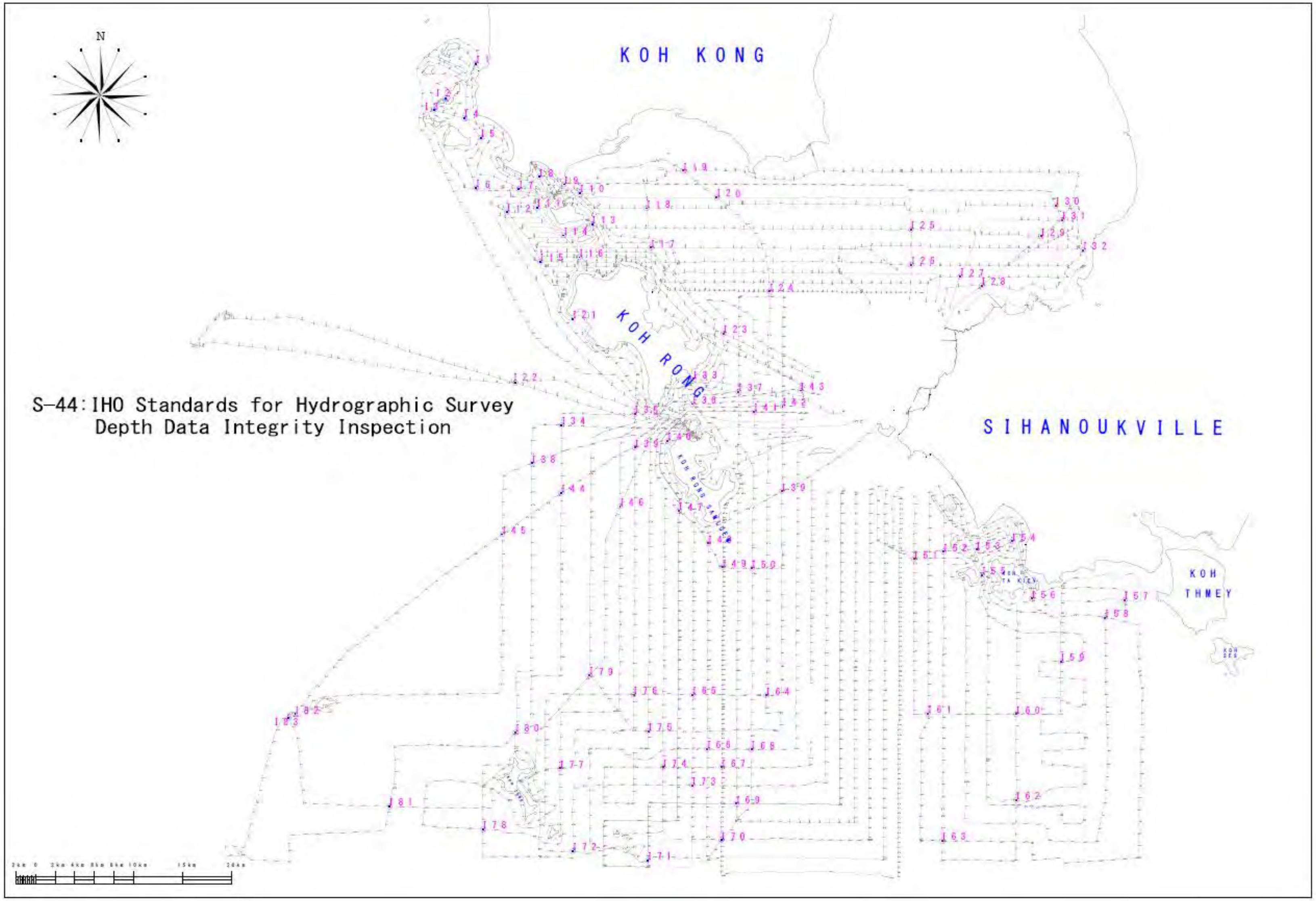


Figure 2 - 47 Crossing Points Selected for Depths Inspection in the Extension Project

(5) Conversion Process of Chart Datum from NLLW to LAT

At the beginning of this project, study team had designed to tentatively apply the NLLW, Nearly Lowest Low Water, as the datum level for tidal correction, based on the Z_0 derived from the sum of 4 major tidal components, which was computed from the data observed at SHV Tide station.

However, we should use the LAT, Lowest Astronomical Tide, as the chart datum, instead of NLLW, to meet the recommendation by IHO and the requirement on publications defined by UKHO.

Therefore, study team observed tide for 1 year continuously, and derived 60 tidal components from the harmonic analysis of tide for 1 year. Finally, the datum level of 0.99 m below the MSL, Z_0, was determined as the lowest tide based on the tidal prediction of 19 years. Refer to Chapter 2 - 6 - 1

Accordingly, the depths of water already acquired had to be rectified to be shallower by 0.38 m than the original water depth. For example, water depth of 11.57 m should be rectified to 11.19 m based on the datum level as LAT. As a result, all the water depths of XYZ files had been rectified to shallower by 0.38 m using Z_0 shift parameter of HYPACK automatically.

Concretely, by using “XYZUtil.exe” in HYPACK. To add offset to old datum level data to final datum level (LAT).

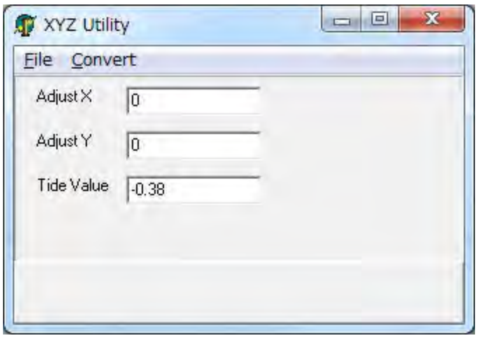


Figure 2 - 48 XYZUtil to set offset from old datum level convert to new datum level (LAT)

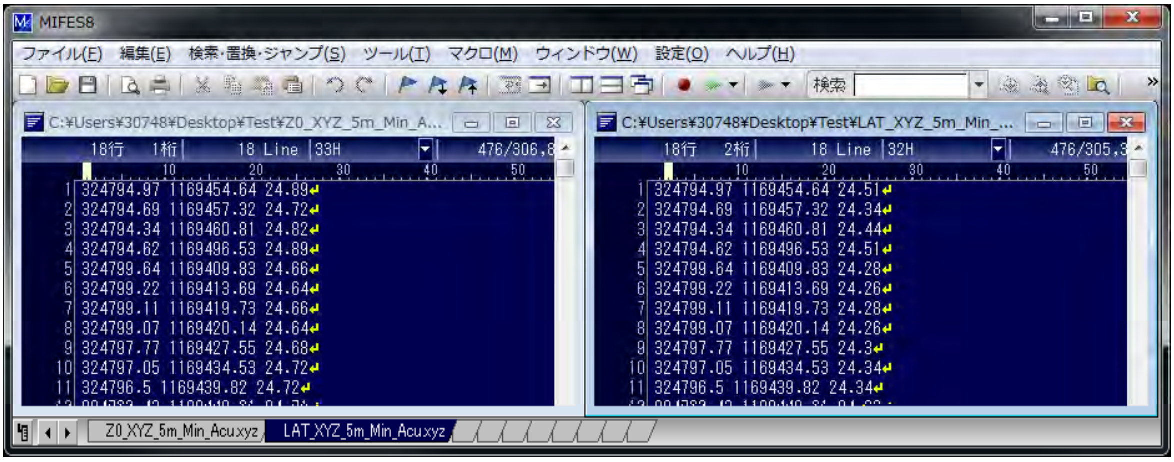


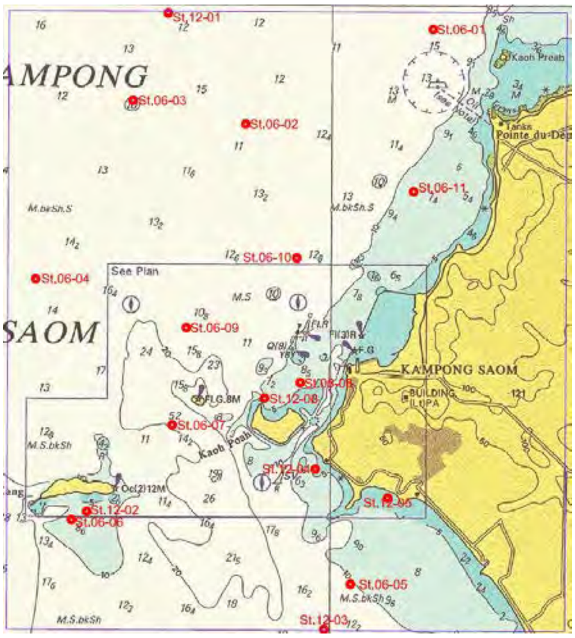
Figure 2 - 49 Comparison between before and after offset shifted

Figure 2 - 49 Left shows NLLW Charted Depth that based on NLLW datum level and Right shows Final Charted Depth based on LAT after conversion process

(6) Process of Bottom Material Identification Data

1) "Bottom Classification File" has been created from the Bottom Classification Book Identified / recorded by field Judgment at the place of bottom classification.

2) Bottom samples collected were provided for analysis by MPWT laboratory and determined its bottom material referring to the triangular block diagram for bottom classification based on the particle analysis shown as follows:



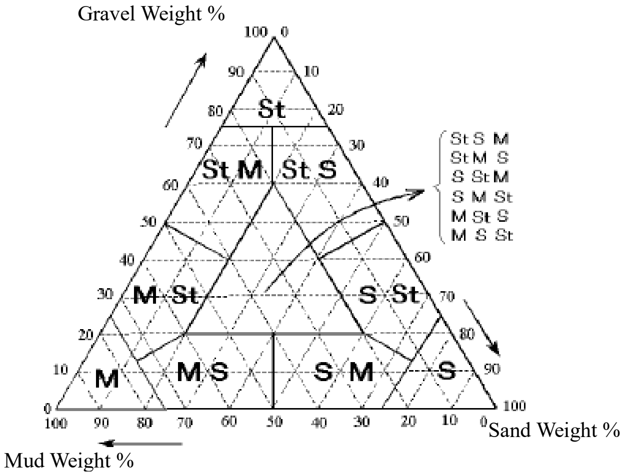


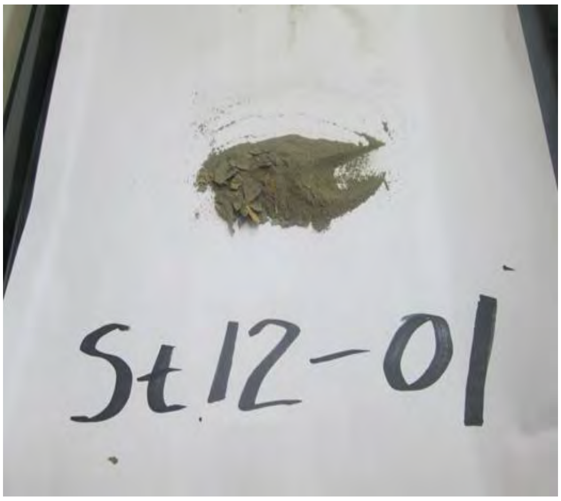
Figure 2 - 50 Location for Bottom Material Identification

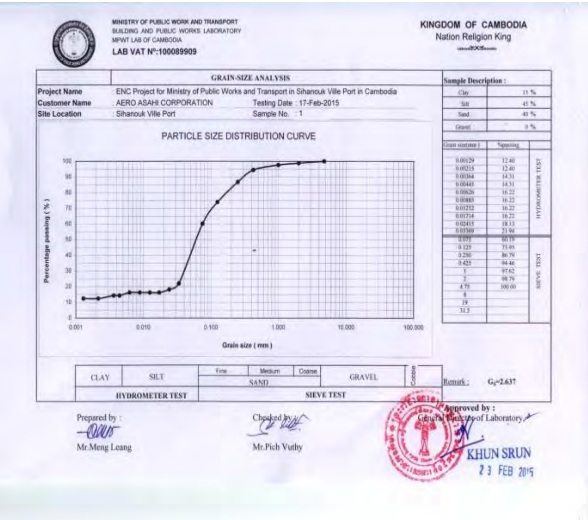
Table 2 - 9 Bottom Material Type and Particle Size

BOTTOM MATERIAL TYPE		**SYMBOL**		**PARTICLE SIZE (mm)**
CLAY		M	Cy	<0.002
SILT			Si	0.002 to 0.063
SAND	Very Fine Sand	S	fS	0.0625 to 0.125
	Fine Sand			0.125 to 0.25
	Medium Fine Sand		mS	0.25 to 0.5
	Coarse Sand		cS	0.5 to 1.0
	Very Coarse Sand			1.0 to 2.0
GRAVEL	Small Size Gravel	St	G	2.0 to 4.0
	Medium Size Gravel Pebble		P	4.0 to 64.0
	Large Size Gravel Cobble		Cb	64.0 to 256.0
ROCK		R	R	>256.0

Followings Photo 2 - 7 show the example of bottom sampling; details are shown at Appendix 6:

St 1 2 - 01	Date:	2014.12.15





MINISTRY OF PUBLIC WORK AND TRANSPORT
BUILDING AND PUBLIC WORKS LABORATORY
MPWT LAB OF CAMBODIA
LAB VAT N°:100089909

KINGDOM OF CAMBODIA
Nation Religion King

GRAIN-SIZE ANALYSIS

Project Name : ENC Project for Ministry of Public Works and Transport in Sihanouk Ville Port in Cambodia
Customer Name : AERO ASAHI CORPORATION Testing Date : 17-Feb-2015
Site Location : Sihanouk Ville Port Sample No. : 1

Sample Description :

Clay	15 %
Silt	45 %
Sand	40 %
Gravel	0 %

Grain size (mm)	%passing	
0.00129	12.40	HYDROMETER TEST
0.00215	12.40	
0.00364	14.31	
0.00443	14.31	
0.00626	16.22	
0.00883	16.22	
0.01252	16.22	
0.01714	16.22	
0.02415	18.13	
0.03369	21.94	
0.075	60.19	SIEVE TEST
0.125	73.95	
0.250	86.79	
0.425	94.46	
1	97.62	
2	98.79	
4.75	100.00	
8		
19		
31.5		

Remark : G_s=2.637

Prepared by : Mr.Meng Leang
Checked by : Mr.Pich Vuthy
Approved by : General Director of Laboratory
KHUN SRUN
23 FEB 2015

Grain Size Analysis

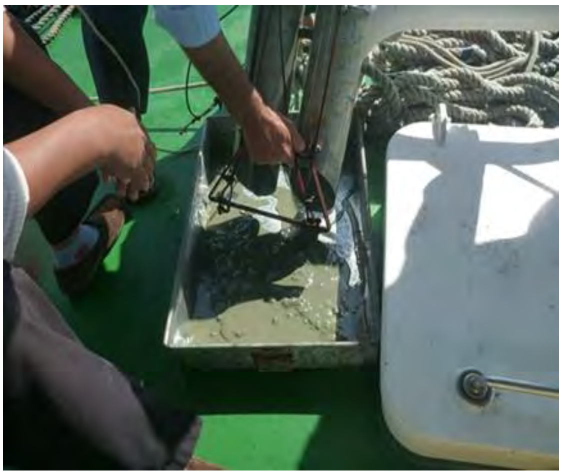


Photo 2 - 7 Example of Bottom Sampling

Table 2 - 10 Log Book for Bottom Material Identification

Sampling Location	Date	Positioning	Lat.	Long.	Method	G.S.A	Bottom Classification Sediment Type	ID
St 6-01	2014/06/02	GNSS	10°44' 42"	103°31' 00"	Dredge	-	Sand, Silt, Clay	4,3,2
St 6-02	2014/06/02	GNSS	10°43' 00"	103°28' 15"	Dredge	-	Silt, Sand, Clay	3,4,2
St 6-03	2014/06/02	GNSS	10°43' 25"	103°26' 14"	Dredge	-	Silt, Sand, Clay	3,4,2
St 6-04	2014/06/02	GNSS	10°40' 14"	103°24' 30"	Dredge	-	Sand, Silt	4,3
St 6-05	2014/06/03	GNSS	10°34' 50"	103°30' 10"	Dredge	-	Sand, Silt	4,3
St 6-06	2014/06/03	GNSS	10°35' 57"	103°25' 09"	Dredge	-	Silt, Sand, Clay	3,4,2
St 6-07	2014/06/03	GNSS	10°37' 39"	103°26' 57"	Lead	-	Sand, Shell	4,17
St 6-08	2014/06/03	GNSS	10°38' 24"	103°29' 15"	Dredge	-	Sand, Silt, Shell	4,3,17
St 6-09	2014/06/03	GNSS	10°39' 22"	103°27' 12"	Dredge	-	Sand, Silt, Shell	4,3,17
St 6-10	2014/06/03	GNSS	10°40' 37"	103°29' 10"	Dredge	-	Sand, Silt, Shell	4,3,17
St 6-11	2014/06/03	GNSS	10°41' 48"	103°31' 15"	Dredge	-	Sand, Silt	4,3
St 12- 01	2014/12/15	GNSS	10°44' 58"	103°26' 51"	Dredge	@	Silt, Sand, Clay	3,4,2
St 12-02	2014/12/15	GNSS	10°36' 06"	103°25' 26"	Dredge	@	Silt, Sand, Clay	3,4,2
St 12-03	2014/12/15	GNSS	10°34' 01"	103°29' 41"	Dredge	-	Sand, Silt, Shell	4,3,17
St 12-04	2014/12/15	GNSS	10°36' 52"	103°29' 31"	Dredge	@	Sand, Silt, Clay	4,3,2
St 12-05	2014/12/16	GNSS	10°36' 22"	103°30' 49"	Dredge	@	Sand, Silt, Clay	4,3,2
St 12-06	2014/12/16	GNSS	10°38' 06"	103°28' 46"	Dredge	@	Sand, Clay, Silt	4,2,3

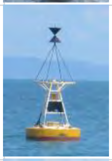
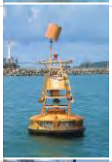
Note: G.S.A stands for Grain Size Analysis, ID is the bottom type of material coded in S-57.

Photo 2 - 8 Bottom Material Identification Work by Lead and Bottom Sampling

(7) Measurement of Navigational Aids

Positions of 30 Navigational Aids in the Study area were measured /investigated including its features such as shape, colour, purpose, characteristic light, and etc. of buoys, in order to input into attribute column of ENC. The following table shows only 9 Navigational Aids installed along the passage to PAS.

Table 2 - 11 Navigational Aids installed along the passage to SHV Port

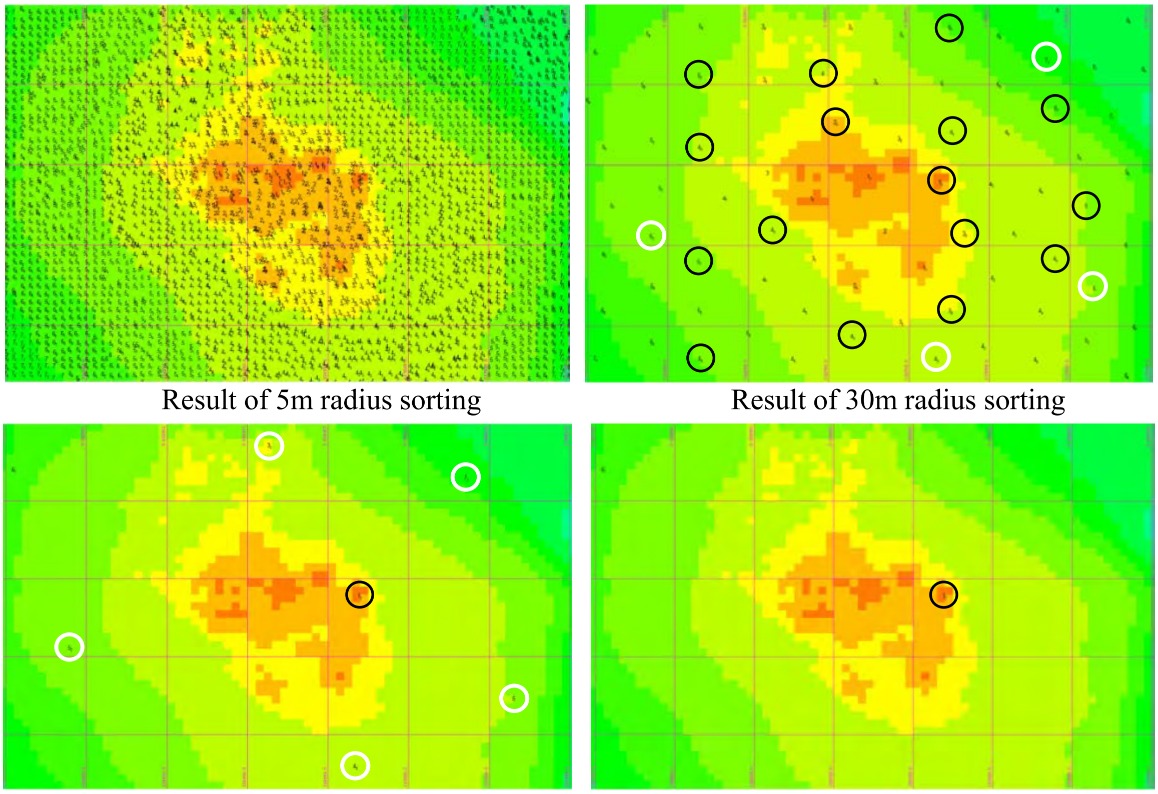
ID	Photograph	種類	LON	LAT	OBJECT-1	Category-1	OBJNAM (Name)	BOYSHP (Buoy_shape)
0	A	A	0	0	A	A	A	A
1		浮標、安全水域標識 Buoy, safe water.	103.4815097	10.60452846	BOYSAW	Buoy, safe water	SV	Pillar
2		浮標、方位標識 Buoy, Cardinal,West	103.4836964	10.65117139	BOYCAR	Buoy, cardinal	A	Pillar
3		浮標、方位標識 Buoy, cardinal,East	103.4957532	10.64827956	BOYCAR	Buoy, cardinal	B	Pillar
4		浮標、側面標識 Buoy, lateral, port	103.4888956	10.65375785	BOYLAT	Buoy, lateral	2	Pillar
5		浮標、側面標識 Buoy, lateral,Starboard	103.4936642	10.65175928	BOYLAT	Buoy, lateral	3	Pillar
6		浮標、側面標識 Buoy, lateral, port	103.5001639	10.65209995	BOYLAT	Buoy, lateral	4	Pillar
7		浮標、側面標識 Buoy, lateral, port	103.5043682	10.65184108	BOYLAT	Buoy, lateral	6	Pillar
8		浮標、方位標識 Buoy, Cardinal,West	103.512649	10.6515277	BOYCAR	Buoy, cardinal	7	Pillar
9		浮標、側面標識 Buoy, lateral, port	103.4948627	10.643723	BOYLAT	Buoy, lateral	8	Pillar

(8) Production of XYZ File

The shallowest depths in each 5 m mesh were selected by means the sorting function out of a large quantity of depth data. As a result, study team produced “SOUNDG_5m”. Depend on Vector Fair Sheet Scale, Charted Depth Sounding properly density (interval) will be different. Can doing [DEPTH SOUNDING SORT] by HYPACK SORT 64bit.

1) DEPTH SOUNDING SORTING

When each block data processing had been finished, it will get the representative data by creating from minimum value within mesh 5 m of XYZ file (Easting, Northing, Depth) in the actual position of XY coordinate because in chart it need to the actual position not the representative position (as mesh or grid). By using HYPACK SORT 64 bit which is designed to extract the minimum value with following approximate distance between sounding depth point. Below 4 figures shows a critical shallow area and the comparison between 4 results by difference radius interval sorting of 5m, 30m, 100m and 200m consequently using HYPACK Sort 64. A lot of depth selected 5m radius sorting can be seen that becomes one depth finally by 200m radius sorting. (Refer to below Figure 2 - 51)



Result of 5m radius sorting | Result of 30m radius sorting

Result of 100m radius sorting | Result of 200m radius sorting.

Figure 2 - 51 Sample of the sort process result with 5m, 30m, 100m and 200m

As an example of sorting, the result of 30m sorting was used for checking of the Fair Sheet of 1/10,000, which was to be created out of the 100m radius sorting. With the same manner of sorting, the depth sorted out of 100 m radius would be used to inspect the ENC/Paper Chart of 1/20,000, which was to be created out of the 200 m radius sorting.

2) DATA SORTING INSPECTION

Correction of water depth should be made for meeting the requirements and be needed to reconfirm the minimum depth, which was considered to be important for navigational charting.

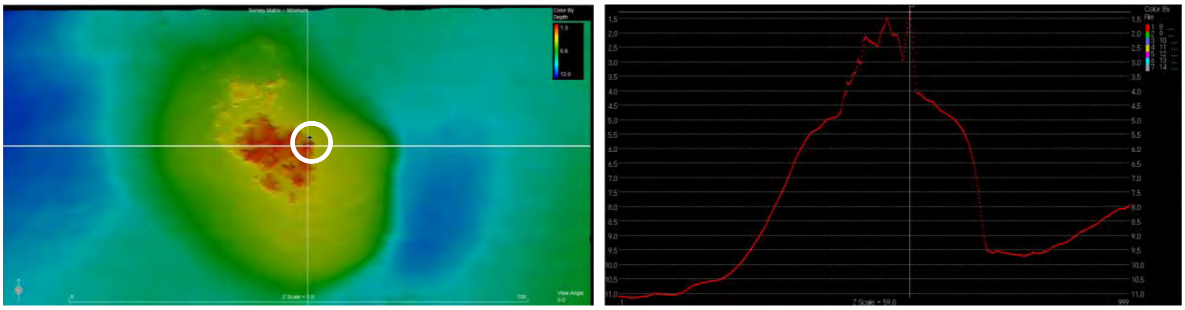


Figure 2 - 52　Example of Confirmation of Sorting Result

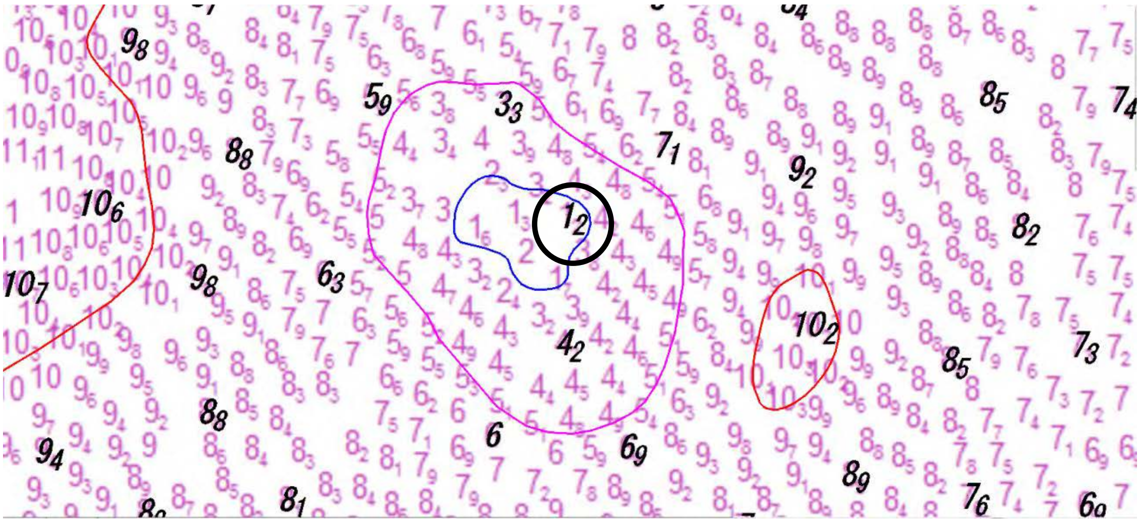


Figure 2 - 53　Comparison between the Results of Sorting and the Raw Data

In the left, white circle indicates the shallowest depth in the above area, while the right screen shows the sectional diagram of around white circle on the left, which can be seen that the shallowest depth is selected. It corresponds to the location of water depth 1.2 m as shown below: Shallowest depth 1.2 m was extracted out of the depths surrounded referring to the area in white circle in the Figure 2 - 52 above.

C/Ps performed these processes, production of depth map and the inspection of depth of water.

(9) GENERATION OF CONTOUR LINE

To prepare for depth contour for ENC production, we use the HYPACK TIN 64, which can create the Triangular Irregular Network (TIN) between points of sounding depths. By connecting with the same depths continuously, one can create the contour line as needed. In ENC, it requires only 0m (low tide line), 2 m, 5 m, 10 m, 20 m, 30 m and 50 m except 0 m contour line. Contour line file for ENC containing 2 m, 5 m, 10 m, 20 m and 30 m, excluding 0 m contour, should be generated by the function of HYPACK TIN64, creating contour lines of every 1 m automatically, and then extracting only of the 2 m, 5 m, 10 m, 20 m, and 30 m contour lines. Low-water line file shall be separately generated referring to the satellite imagery and the depths of 5 m mesh near the shoreline, and make the file based on the delineation of low-water line by AutoCAD. Following Figure 2 - 54 shows the contour lines of every meter together with the magenta colour-coded contours of 2 m, 5 m, 10 m, 20 m, and 30 m.

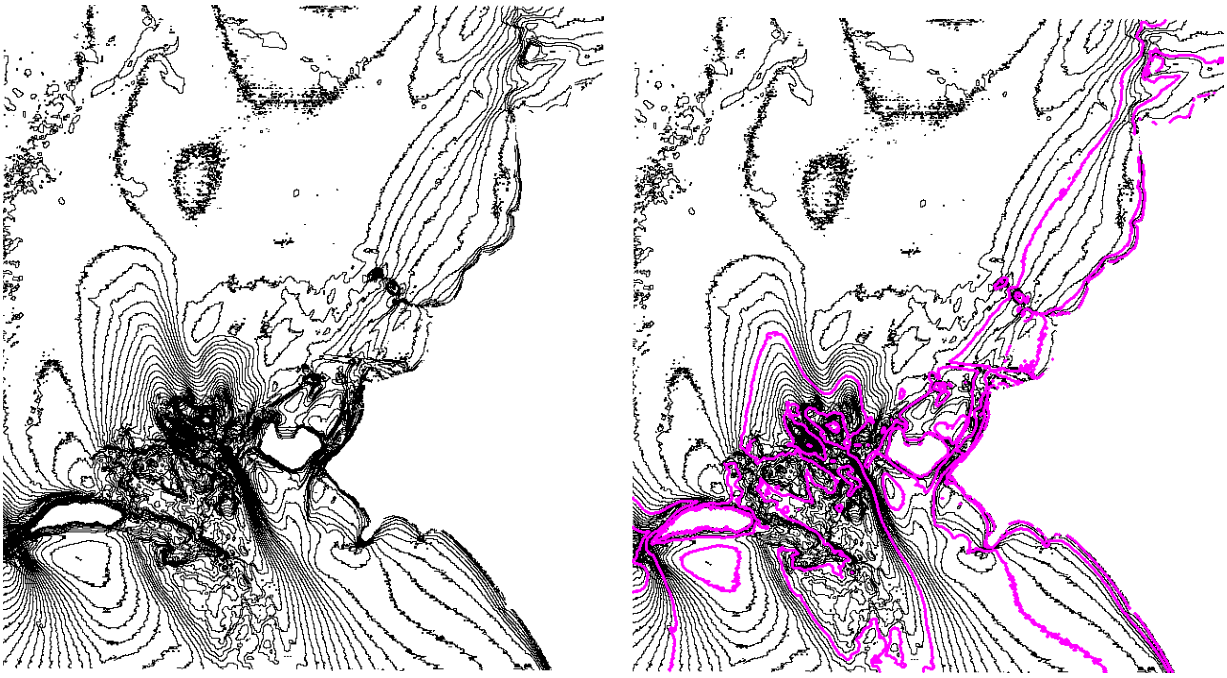


Figure 2 - 54 Contour Map

Looking at the contour lines generated automatically, dotted portions of depths and indented lines are evident in some area. This exactly shows the actual depths of data processed faithfully. However, this will be appropriate for researcher and/or surveyor to analyze the bathymetric features though, it will not be suitable to use it for navigational purpose.

Therefore, within the range of not significantly affecting the relationships of depths data depicted in the Chart, smoothing technique will be adopted together with the special technique called “Generalization” for the shallow portion. Following Figure 2 - 55 shows the contour line automatically generated in black and the contour line manually corrected in other colours, respectively.

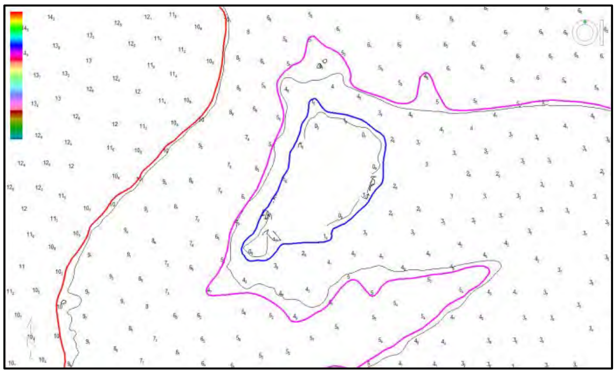


Figure 2 - 55   Generalized Contour Line Sample

(10) CREATION OF DRAFT VECTOR FAIR SHEET

Vector Electronic Smooth Sheet was produced by means of FME function integrating all the files, i.e. “Contour Line File”, “Depth File”, “SOUND_0m, Shoreline File”, “Navigational Aids File”; including various attributes, “Bottom Material File” and “Land Information File”, comprised of ENC basic data. Following Figure 2 - 56 shows one part of the example of Draft Vector Fair Sheet near SHV port.

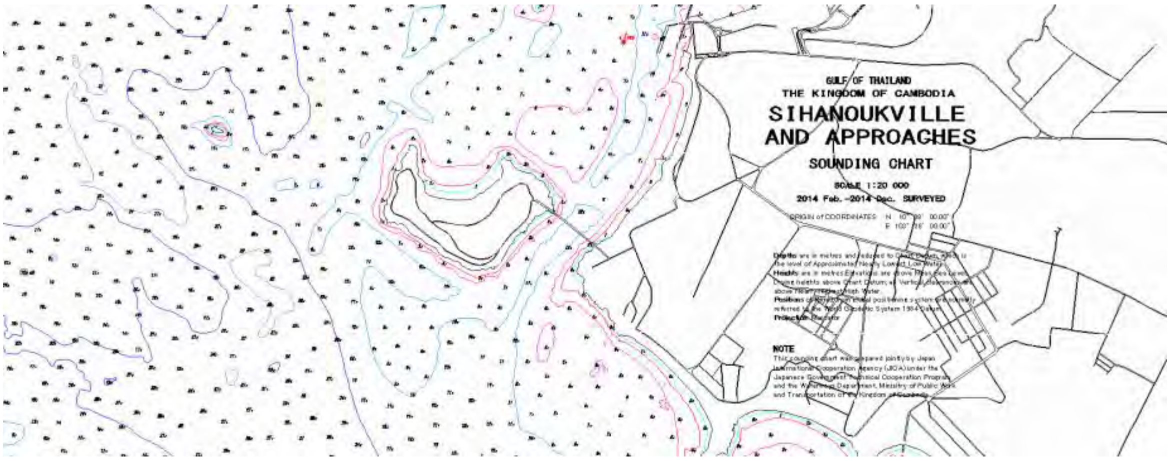


Figure 2 - 56   Example of Draft Vector Fair Sheet near SHV port

Several data processed in the above have joined together and given the overlapping processes to produce the draft vector fair sheet in the CAD. This draft vector fair sheet is the basic data for ENC production, and there are some advantages to import or convert to the next step and easy to modify by CAD.

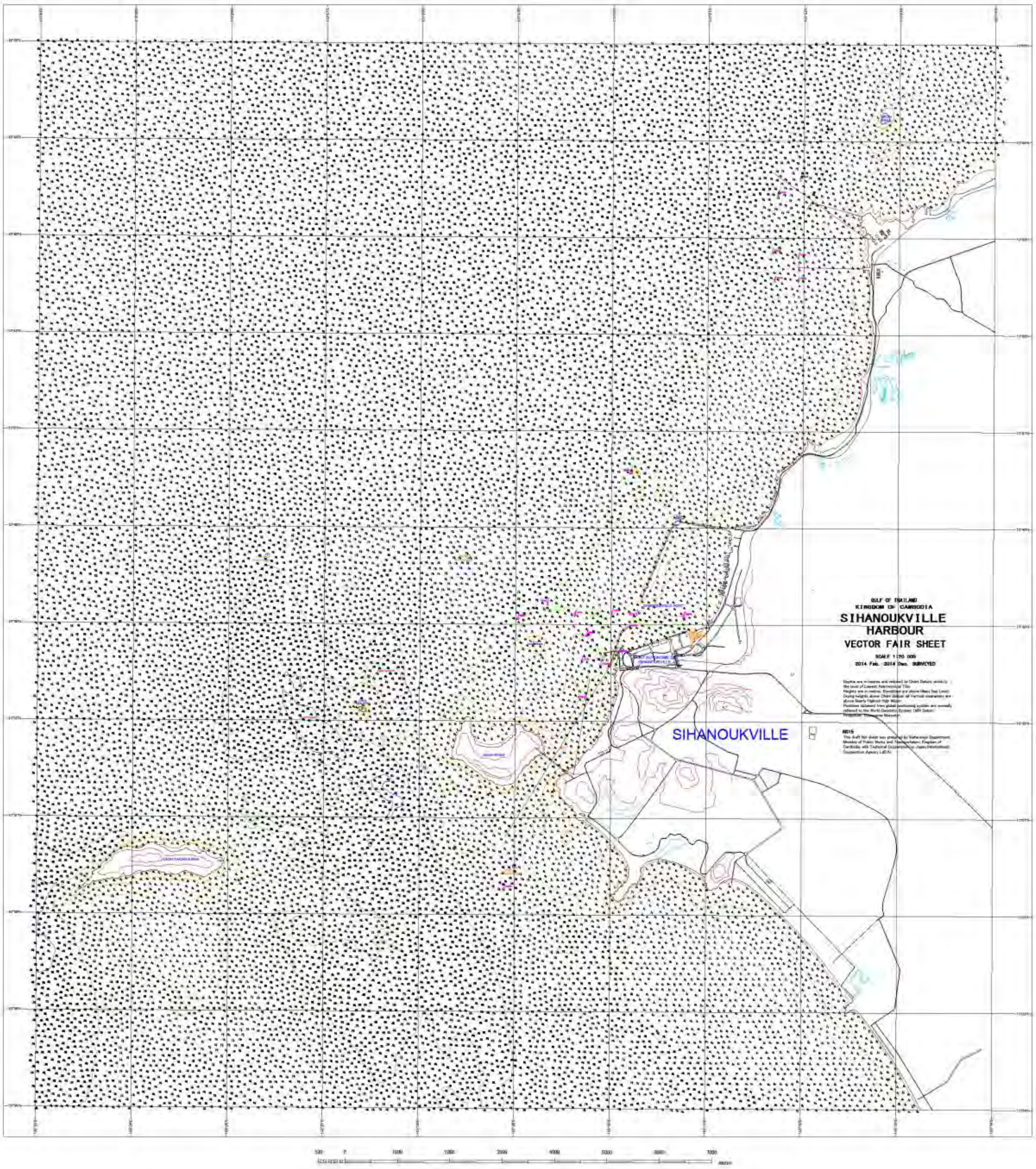


Figure 2 - 57 Draft Vector Fair Sheet in the Original Project Area, at a scale of 1/20,000

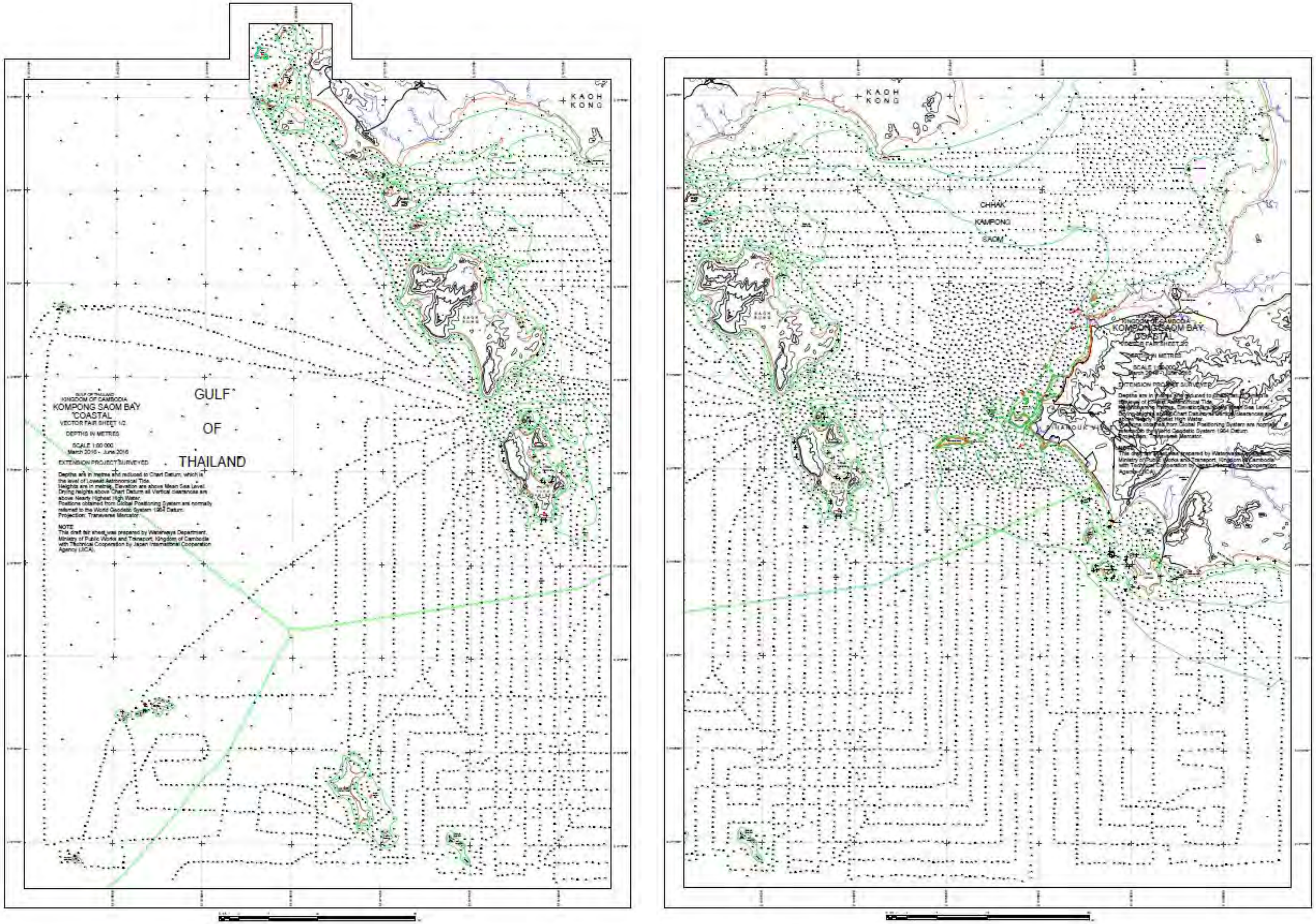


Figure 2 - 58 Draft Vector Fair Sheet in the Extension Project Area, at a scale of 1/80,000

2 - 7 (7) **Production of Chart and ENC**

2 - 7 - 1 (7) Production of Chart and ENC

Processed Survey data from DHSDPS such a Depth Sounding [SOUNDG], Low tide line [DEPCNT_0m], Depth Contour [DEPCNT] and Data that derived from Satellite Imagery such a Natural coastline [COALNE], Artificial Coastline [SLCONS] and collected data Navigational Aid etc. collect into Vector fair sheet in Vector data format file as database of ENC.

This database is the original source for producing ENC production. As shown in Figure 2 - 59 ENC Production Flowchart, By using Safe Software Inc's FME (Feature Manipulation Engine) to convert data to S-57 format. With ENC Designer, ENC Optimizer and ENC Analyzer software from SevenCs GmbH to edit and manage ENC data cell. ENC Cartographer will edit and maintenance component of the ENC Tools suite produce paper chart as output.

[ENC PRODUCTION]

The SevenCs GmbH's provides the software tool package to creating, editing, checking, optimizing ENC data and printing to paper chart, all of which are included in the following software list.

- ENC Designer

Geo-Reference ENC producing software having functions of digitizing and editing, creating and editing Feature Object, making S-57 conversion set, creating Electronic Notice to Mariners (ENC update) and Geo-reference on Raster data

- ENC Optimizer

Optimizing ENC data by having function cutting unnecessary points, Clustering of Depth Object, investing with SCAMIN function and optimizing vector points,

- ENC Analyzer

Checking error of ENC Data based on S-58 standard

- ENC Referencer

Mapping Raster Image (Scanned Chart) to Geo-Reference to digitize in ENC Designer.

- ENC Manager

Manage (create new edition, update edition) ENC cell data to convert in form of database and export ENC cell data to ENC Media.

- ENC Cartographer

Converting and Producing Paper Chart from ENC data

- FME

Conversion function for every format used in topographic information (Ex; SHAPE, DWG format) to S-57 format

- FME S-57 Writer

Plug-in of FME Desktop for automatic conversion to advanced set S-57 format

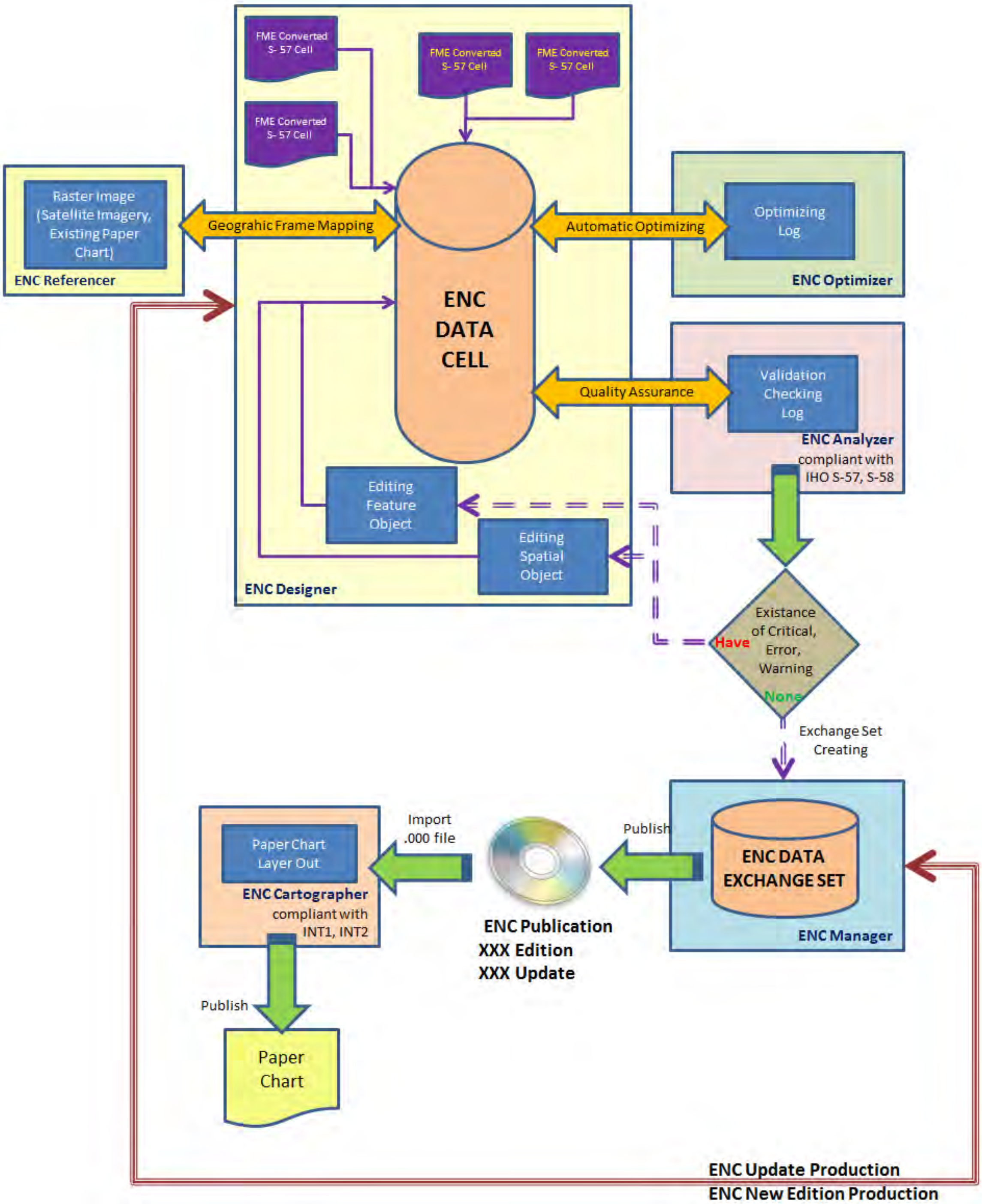


Figure 2 - 59 Flowchart for ENC Production

See detail in the following process have been processed to create ENC.

(1) S-57 FORMAT CONVERSION

ENC schema have been designed refer with S-57 - The IHO Transfer Standard for Digital Hydrographic Data with Object Catalogue (S-57 Appendix A Chapter 1) and Attribute Catalogue (S-57 Appendix A Chapter 2), it need to convert source data (such as ASCII data in CSV (comma separate value) file, vector data in DWG file etc.) .

The following example shows BOYCAR (Cardinal Buoy) object information from IHO S-57 Object Catalogue.

Object Class: **Buoy, cardinal**

Acronym: **BOYCAR** Code: **14**

Set Attribute_A: BOYSHP; CATCAM; COLOUR; COLPAT; CONRAD; DATEND; DATSTA; MARSYS; NATCON; NOBJNM; OBJNAM; PEREND; PERSTA; STATUS; VERACC; VERLEN;

Set Attribute_B: INFORM; NINFOM; NTXTDS; PICREP; SCAMAX; SCAMIN; TXTDSC;

Set Attribute_C: RECDAT; RECIND; SORDAT; SORIND;

Definition:

A buoy is a floating object moored to the bottom in a particular place, as an aid to navigation or for other specific purposes. (IHO Dictionary S-32 5th Edition, 565).

A cardinal buoy is used in conjunction with the compass to indicate where the mariner may find the best navigable water. It is placed in one of the four quadrants (North, East, South and West), bounded by inter-cardinal bearings from the point marked. (UKHO NP 735, 5th Edition)

References:

INT 1: IQ 130.3;

M-4: 461; 462.5, 462.6;

Remarks:

Topmark, light, fog signal, radar reflector and retro-reflector are separate objects.

Distinction: buoy lateral; buoy safe water; buoy isolated danger; buoy special purpose/general; mooring/warping facility;

Figure 2 - 60 Contents of Object Class BOYCAR in the S-57 Object Catalogue

Following example shows CATCAM (Category of cardinal mark) attribute information from IHO S-57 Attribute Catalogue.

Attribute: **Category of cardinal mark**

Acronym: **CATCAM** Code: **13**

Attribute type: E

Expected input:

ID		Meaning	INT 1
1	:	north cardinal mark	IQ 130.3;
2	:	east cardinal mark	IQ 130.3;
3	:	south cardinal mark	IQ 130.3;
4	:	west cardinal mark	IQ 130.3;

Definitions:

The four quadrants (north, east, south and west) are bounded by the true bearings NW-NE, NE-SE, SE-SW and SW-NW taken from the point of interest.

A cardinal mark is named after the quadrant in which it is placed.

The name of the cardinal mark indicates that it should be passed to the named side of the mark.

Remarks:

Cardinal marks do not have a distinctive shape but are normally pillar or spar. They are always painted in yellow and black horizontal bands and their distinctive double cone top-marks are always black. (Note that such top-marks are encoded as separate TOPMAR objects). Cardinal marks may also have a special system of flashing white lights and if such lights are fitted they are encoded as separate LIGHTS objects.

Figure 2 - 61 Contents of Object Class CATCAM in the S-57 Attribute Catalogue

Since IHO S-57 contains nearly 200 object classes and nearly 200 attributes, some objects require plural number of attributing processes, which are too much complicated process. In addition, those attributes are expressed in acronym comprised of 6 capitals. It should be another issues for ENC editors on how to relate the objects with indispensable attribute and acronyms expressed by 6 capitals.

Following Table 2 - 12 shows the examples of Navigational Aids stored in the database:

Table 2 - 12 Example of Navigational Aids stored in Database

1		333878.84	1172657.7	103.4815097	10.60452846	BOYSAW	Buoy, safe water	SV	Pillar	-	-	
2		334143.3	1177815.44	103.4836964	10.65117139	BOYCAR	Buoy, cardinal	A	Pillar	West	-	
3		335460.83	1177489.16	103.4957532	10.64827956	BOYCAR	Buoy, cardinal	B	Pillar	East	-	
4		334713.51	1178098.73	103.4888956	10.65375785	BOYLAT	Buoy, lateral	2	Pillar	-	Port	
5		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

ASCII data table in CSV format of point geometry will be produced, which data can be imported by FME attached to FME S-57 Writer from the database. Following Table 2 - 13 shows the example of produced CSV format file to convert with FME S-57:

Table 2 - 13 Produced CSV Data File to convert with FME S-57

	A	B	C	D	E	F	G	H	I	J	K	L
1	X	Y	cat	OBJNAM	BOYSHP	CATCAM	CATLAM	CATSPM	COLOUR	COLPAT	CONRAD	
2	333878.84	1172657.70	safe water	SV	Pillar				Red,White	Vertical stripes		
3	334143.30	1177815.44	cardinal	A	Pillar	West			Black,Yellow,Black	Horizontal stripes	Has radar reflector	
4	335460.83	1177489.16	cardinal	B	Pillar	East			Yellow,Black,Yellow	Horizontal stripes	Has radar reflector	
5	334713.51	1178098.73	lateral	2	Pillar		Port		Red		Has radar reflector	
6	335234.15	1177875.14	lateral	3	Pillar		Starboard		Green		Has radar reflector	
7	335945.44	1177909.37	lateral	4	Pillar		Port		Red		Has radar reflector	
8	336405.27	1177878.52	lateral	6	Pillar		Port		Red		Has radar reflector	
9	337311.06	1177839.50	cardinal	7	Pillar	West			Yellow,Black,Yellow	Horizontal stripes	Has radar reflector	
10	335360.96	1176985.66	lateral	8	Pillar		Port		Red		Has radar reflector	
11	339117.20	1185872.11	lateral	C	Pillar		Port		Red			
12	339543.85	1186165.41	lateral	D	Pillar		Port		Red			
13	339209.95	1184023.79	lateral	E	Pillar		Starboard		Green		Has radar reflector	
14	343926.69	1189213.82	lateral	3	Pillar		Port		Red		Has radar reflector	
15	344295.64	1188842.35	lateral	4	Pillar		Starboard		Green		Has radar reflector	
16	344020.78	1188554.38	lateral	5	Pillar		Starboard		Green		Has radar reflector	
17	343637.74	1188921.64	lateral	6	Pillar		Starboard		Green		Has radar reflector	
18	342500.95	1189313.85	lateral	7	Pillar		Starboard		Green		Has radar reflector	
19	343180.48	1189197.93	lateral	8	Pillar		Port		Red		Has radar reflector	
20	341504.43	1189783.59	lateral	9	Pillar		Port		Red		Has radar reflector	
21	341489.47	1189671.90	lateral	10	Pillar		Starboard		Green		Has radar reflector	
22	340430.45	1189878.81	lateral	11	Pillar		Port		Red		Has radar reflector	
23	340497.07	1189773.43	lateral	12	Pillar		Starboard		Green		Has radar reflector	
24	339264.85	1189199.71	lateral	13	Pillar		Port		Red		Has radar reflector	
25	342997.26	1190183.28	lateral	14	Pillar		Starboard		Green		Has radar reflector	
26	344286.75	1187816.82	special purpose	STOP	Pillar			Stop mark	Yellow			
27	344145.90	1187943.52	special purpose	STOP	Pillar			Stop mark	Yellow			
28	344109.29	1188118.69	special purpose	STOP	Pillar			Stop mark	Yellow			
29	343816.45	1188162.07	special purpose	STOP	Pillar			Stop mark	Yellow		Has radar reflector	
30	343796.16	1188202.74	special purpose	STOP	Pillar			Stop mark	Yellow		Has radar reflector	
31	343883.56	1188211.57	special purpose	STOP	Pillar			Stop mark	Yellow		Has radar reflector	

FME Desktop can transform source data format to destination data format with combination of graphically visual logical diagram under basis of left-right work flow which can easy to create and understand. By using the Transformer to map value from table to Object's Attributes or set the condition to select type of Attribute etc.

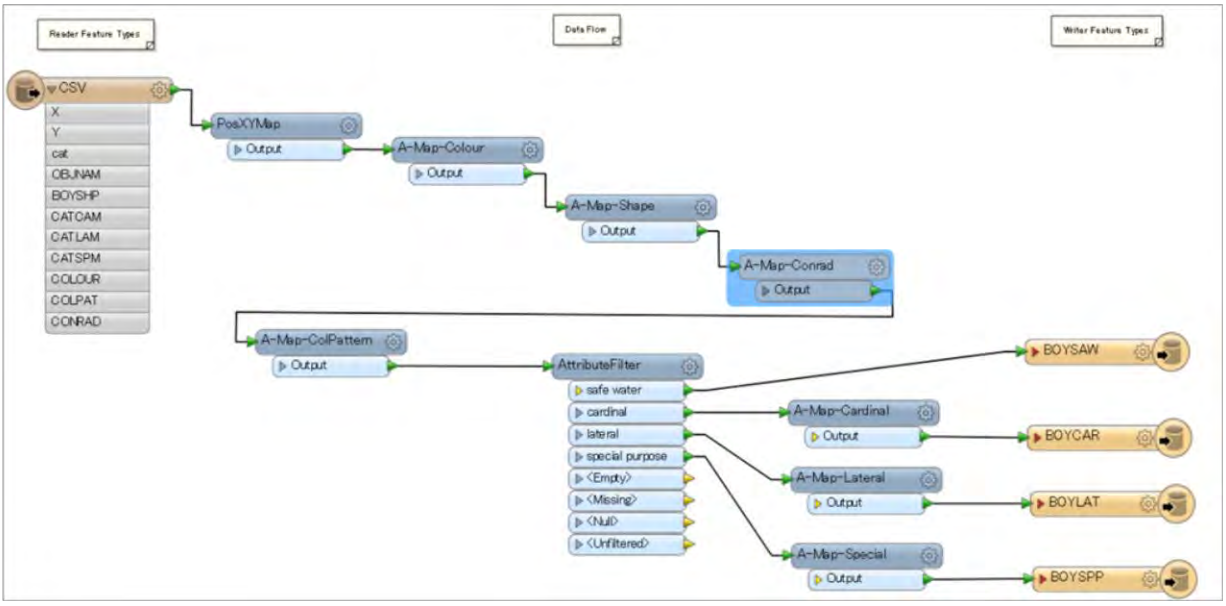


Figure 2 - 62 Example of Transforming Combination from ASCII data to Object Class Series "BOYXXX" of Navigational Aids in FME

Figure 2 - 63 shows imported CSV file (Detail in Table 2 - 13) with workflow chart, which converted and categorized input data to convert into S-57 data format. By each transformer, input data had been converted to S-57 attribute or categorized to S-57 object step by step. As shown in below example.

First, imported CSV and selected Output Feature Object matched with Imported Input data with S-57 Schema Importer from FME S-57 Writer as shown in Figure 2 - 63. Then converted and categorized to various attributes and feature objects shown as Example in Figure 2 - 64 and Figure 2 - 65.

Figure 2 - 63 S-57 Schema Importer from FME S-57 Writer to select S-57 Feature Object

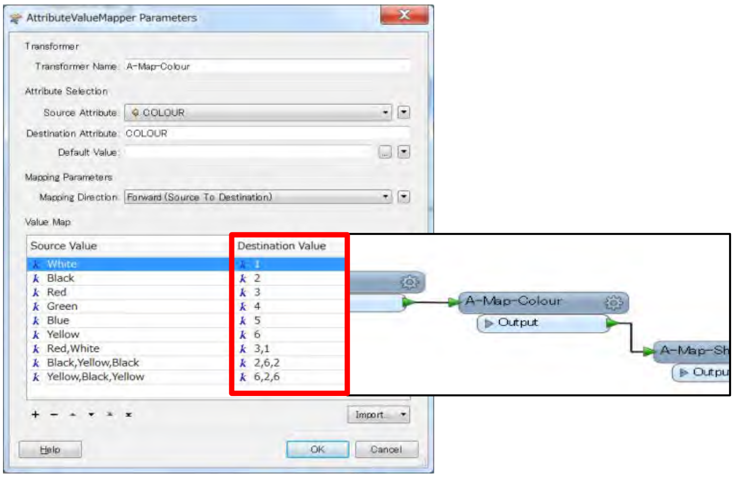


Figure 2 - 64 Example of Combination from ASCII data to ID defined by S57 by means of “AttributeValueMapper”

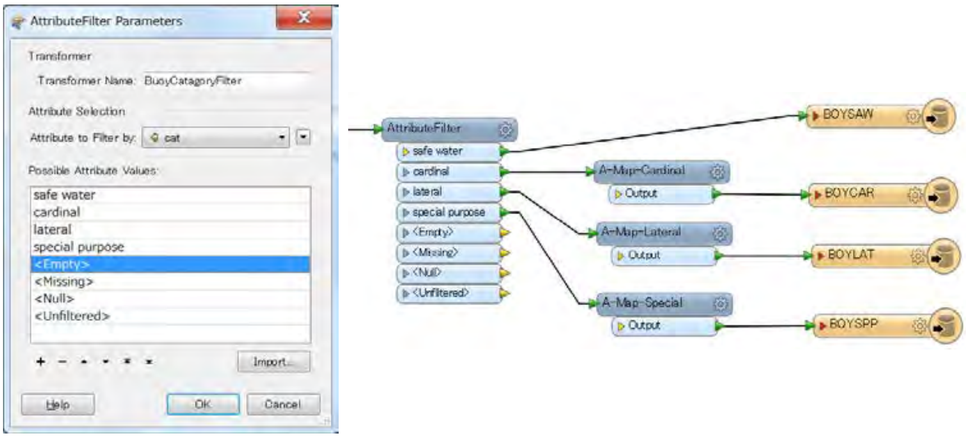


Figure 2 - 65 Example of Combination from ASCII data to ID defined by S57 by means of “AttributeFilter”

Below Figure shown not only CSV format file, but also Vector shoreline in DWG format file from AutoCAD can convert to S-57 data format in the similar way by FME

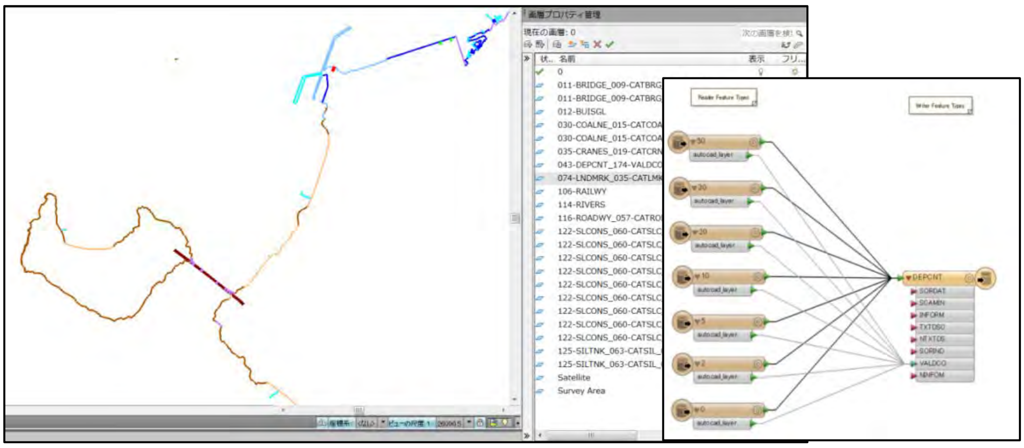


Figure 2 - 66 Example of Combination from Vector Shoreline data in CAD format to S-57

(2) ENC DESIGNER

ENC Designer is a graphical tool for editing digital hydrographic chart data based on the Special Publication S-57 of the Hydrographic International Organization. ENC Designer allows the modification of existing S-57 data as well as the creation of new charts by e.g. digitizing paper charts or raster charts. These chart files are also called “cells”. Cells contain geographic coordinates based on WGS-84 and qualitative information about objects. The data are presented according to the IHO Specification S-52 Ed.3.x including the Presentation Library which consists of a set of lookup-tables with symbolization instructions and procedures, symbol definitions, line styles, pattern definitions, and colour tables.

Set up ENC cell: To create a new cell, should specify the Producing Agency and Cell code. Following table, our survey area is designed with usage or navigational purpose for Order 5 - Harbour (Chart scale between 1/7,500 - 1/25,000)

Table 2 - 14 Cell Size and Chart Scale for Various Purposes using ENC

Navigational Purpose	Chart Scale	Recommended Scale for ENC	Cell Size
1 Overview	1/1,500,00 >	1/3,000,000 1/1,500,000	Over 8 degrees
2 General navigation	1/300,000 to 1/1,500,000	1/700,000 1/350,000	Within 4 degrees
3 Coastal navigation	1/80,000 to 1/300,000	1/180,000 1/90,000	Within 1 degree
4 Approach	1/25,000 to 1/80,000	1/45,000 1/22,000	Within 30 minutes
5 Harbour	1/7,500 to 1/25,000	1/22,000 , 1/12,000 , 1/8,000 , 1/4,000	Within 15 minutes
6 Berthing	> 1/7,500	1/4,000	Within 15 minutes

Original Project was designed for Navigational Purpose 5 - Harbour at scale 1/10,000.
Cell Boundaries set the survey area as follows;
North: 10° 45′ 00″, West: 103° 24′ 00″, East: 103° 34′ 00″, South: 10° 34′ 00″

Extension Project was designed for Navigational Purpose 3 - Coastal navigation at scale 1/80,000.
Cell Boundaries set the survey area as follows;
North: 10° 56′ 00″, West: 102° 50′ 00″, East: 103° 43′ 30″, South: 10° 13′ 00″

Both project had been set the Vertical Datum Level as the Mean Sea Level and Final Chart Datum Level created based on LAT (Detail in Chapter 2 - 6 - 1)

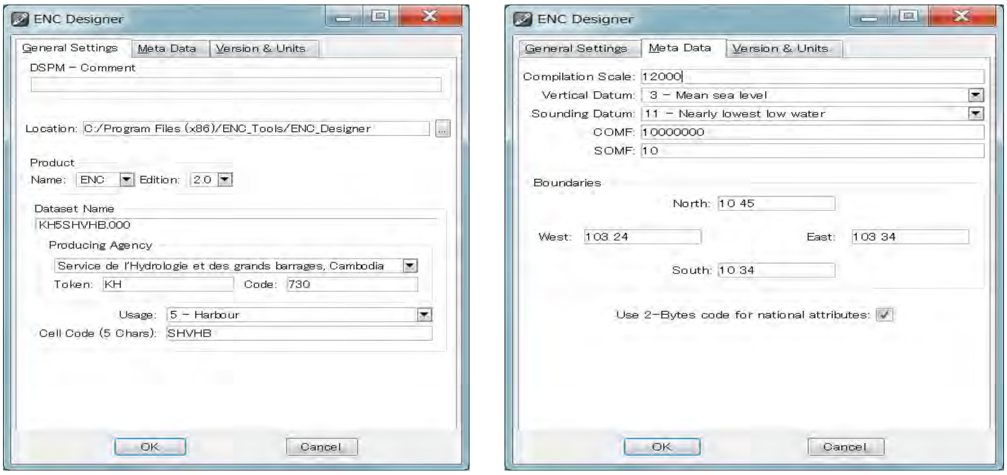


Figure 2 - 67 New Cell for Setting various Parameters by ENC Designer

The data of navigational aids, coastline, coastal structures and depth of water that C/Ps converted using FME will be copied to the new cell by using the duplicate function then start to product ENC (Refer to Figure 2 - 68 and Figure 2 - 69).

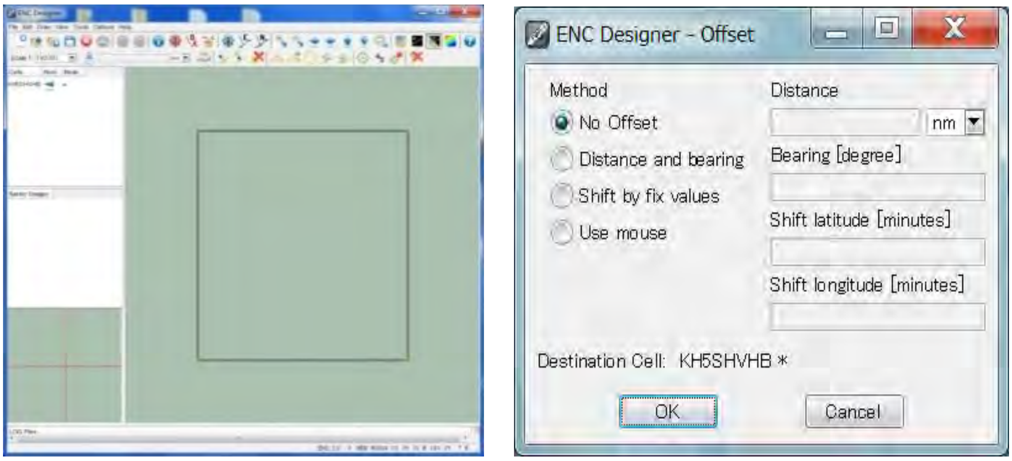


Figure 2 - 68 Duplication offset setting in ENC Designer

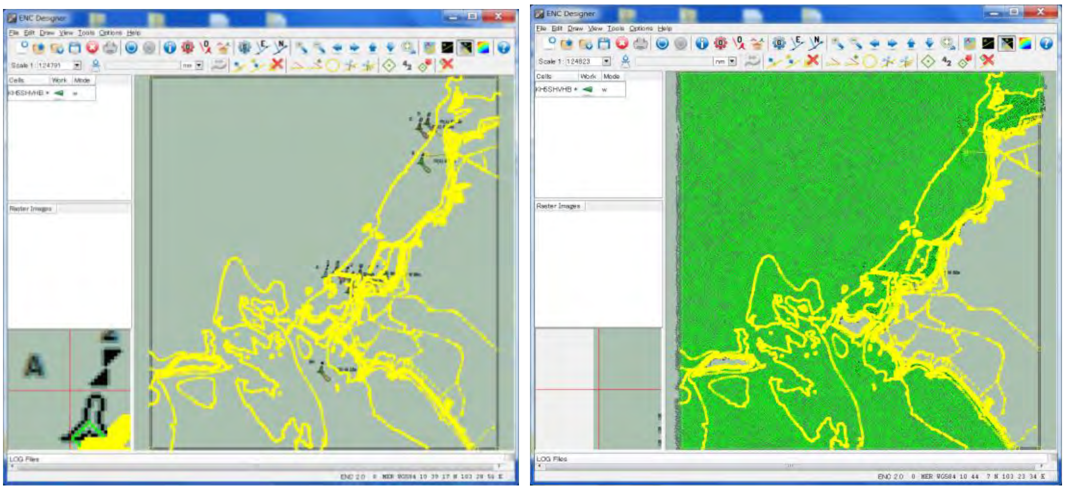


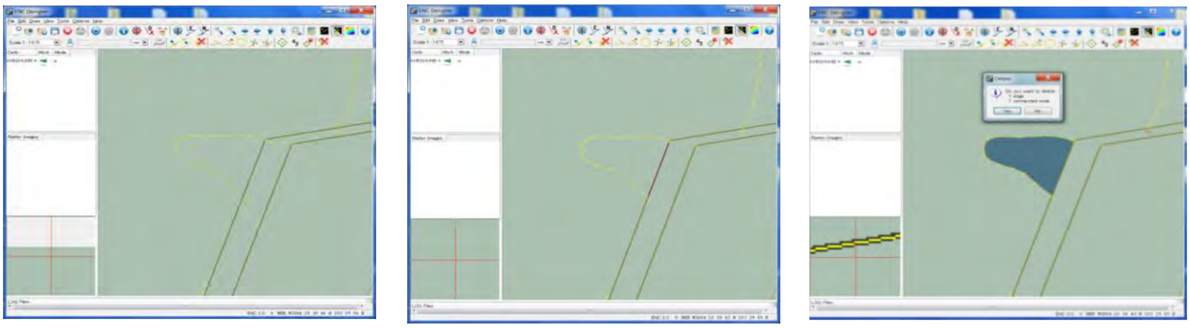
Figure 2 - 69 Example of duplication in ENC Designer

Figure 2 - 69 shows converted left view of coastline file combined with depth sounding and other file via duplication in ENC Designer.

In ENC Designer there are 2 exists kinds of objects (Spatial Object and Feature Object) to edit and manage.

1) Editing and Managing of Spatial object

For the purpose of making the spatial objects and the feature objects in compliance with the S-57, the editing functions of nodes and edge shall be used, respectively.



Before editing nodes and edges After editing node and edge Delete nodes and edges

Figure 2 - 70 Management and Modification of Node and Edge providing ENC Attributes

2) Editing and Managing with Feature Object

The feature object is the object which contains object attribute. The feature object created by selecting target the spatial object and adding the each mandatory object attribute. (As shown in Figure 2 - 71)

As an example, the new object of DEPARE (Depth Area) shall be created. Open the Object Editor>Browse Class list for feature object [DEPARE] and set Mandatory (must have) Attribute by inputting DRVAL1 (Depth Range Value; the shallowest value of a depth range) and DRVAL2 (Depth Range Value; the deepest value of a depth range)

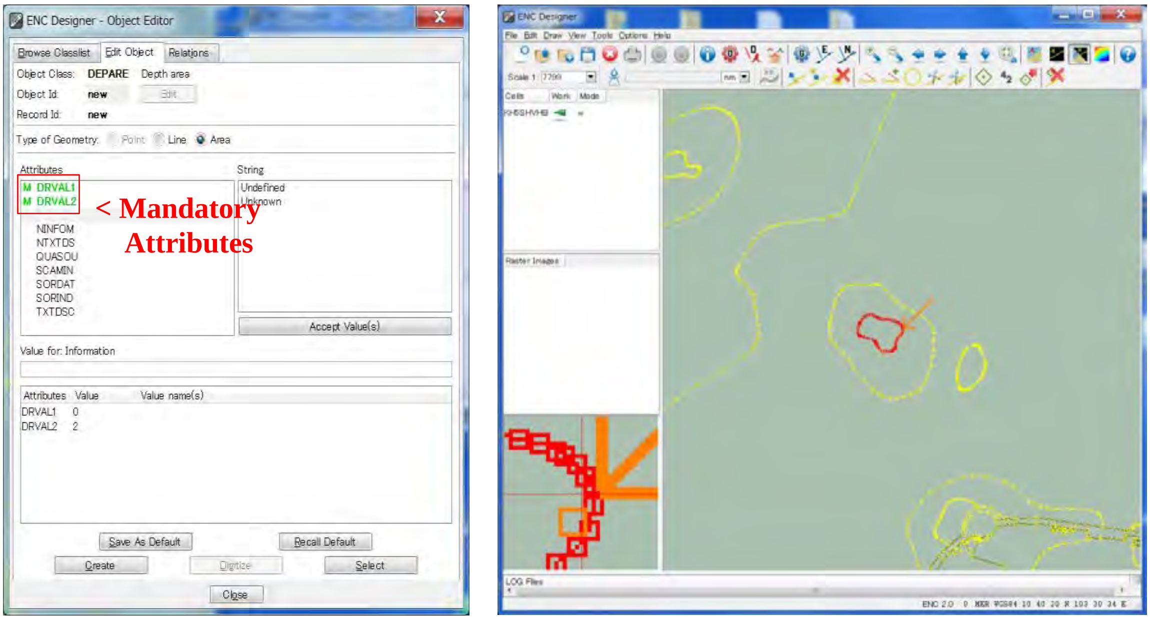


Figure 2 - 71 Creation of Feature Objects Providing ENC Attributes

An example shown below is the selection of Edge in order to create feature objects of surrounding contours of DEPCNT. Then, select edge to Create feature object for DEPCNT.

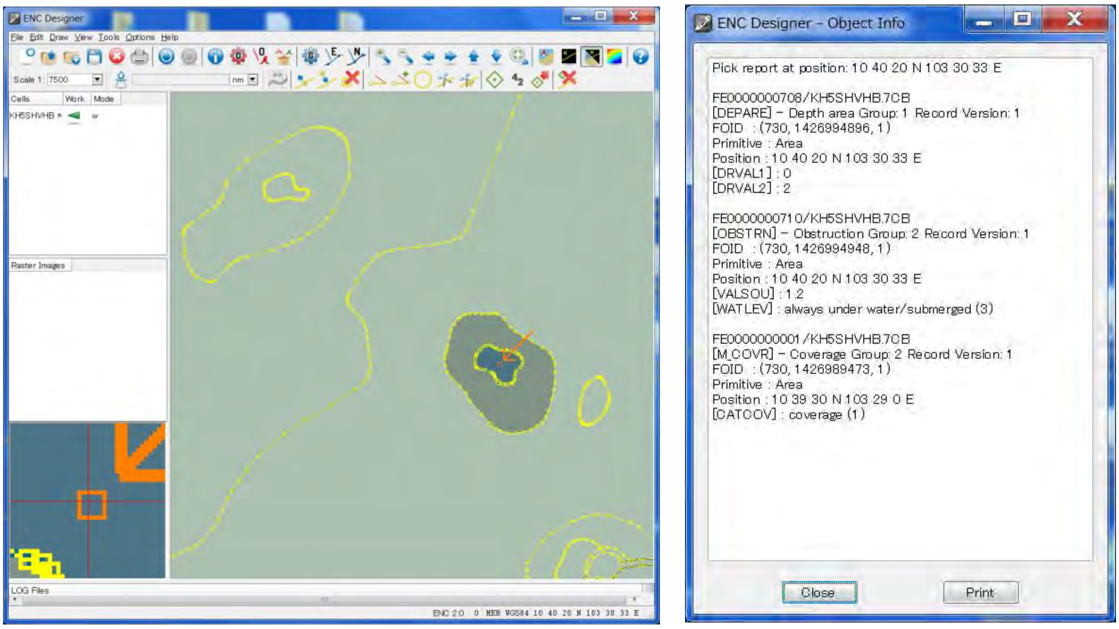


Figure 2 - 72 Confirming of Feature Objects that add to Spatial Object

An example shown above is the results of creating feature objects of underwater rock (OBSTRN) and the surroundings contours of (DEPCNT) 0m - 2m and 2m - 5m.

Beside there are the Meta Object Class defined by the Geo Object Class (existing in the real world entity) in the IHO S-57 are shown as: M_COVR defines the survey area and the cell area, M_NSYS defines the IALA Marine Time Buoyage System, M_QUAL defines the quality of survey data etc. Collection Object Class: C_ASSO, C_AGGR etc.

Moreover, Cartographic Object Class, which needs to be implemented within the ENC data cell for making the paper chart.

(3) ENC ANALYZER

ENC Analyzer is a quality assurance tool for S-57 compliant data. ENC, IENC, AML, PENC and ENC product specifications are supported. The majority of checks performed by ENC Analyzer have been built with reference to the IHO Transfer Standard for Digital Hydrographic Data:

- S-57 Appendix A: IHO Object and Attribute Catalogues
- S-57 Appendix B.1: ENC Product Specification
- S-57 Appendix B.1 Annex A: Use of the Object Catalogue for ENC
- S-58: Recommended ENC Validation Checks

To use after editing ENC data in ENC Designer to make sure without any critical, any errors and any warning before create ENC data set and publish ENC CD.

ENC Analyzer offers a simple user interface directly from ENC Designer interface whereby ENC cells, update cells and exchange sets can be loaded for validation checks and the results displayed in the LOG files window as shown in Figure 2 – 73

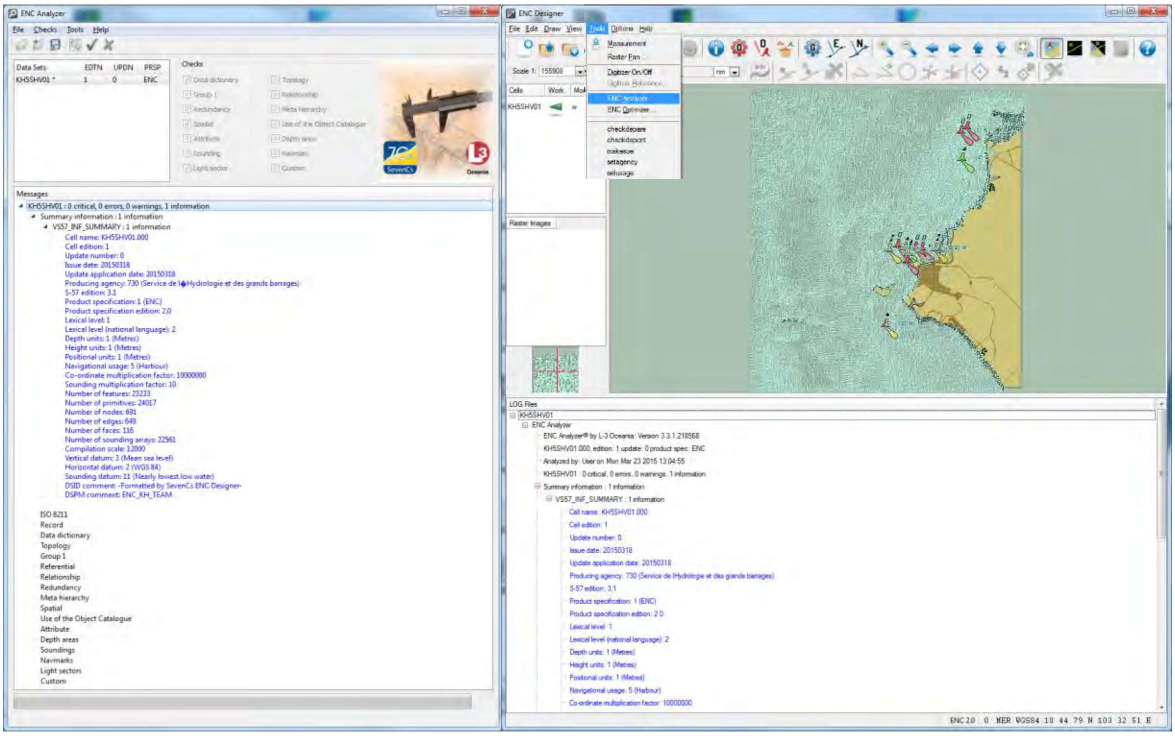


Figure 2 - 73 Display of ENC Designer based on the Result of ENC Analyzer

There are 13 checking categories available which can be selected individually or as a multi-operation.

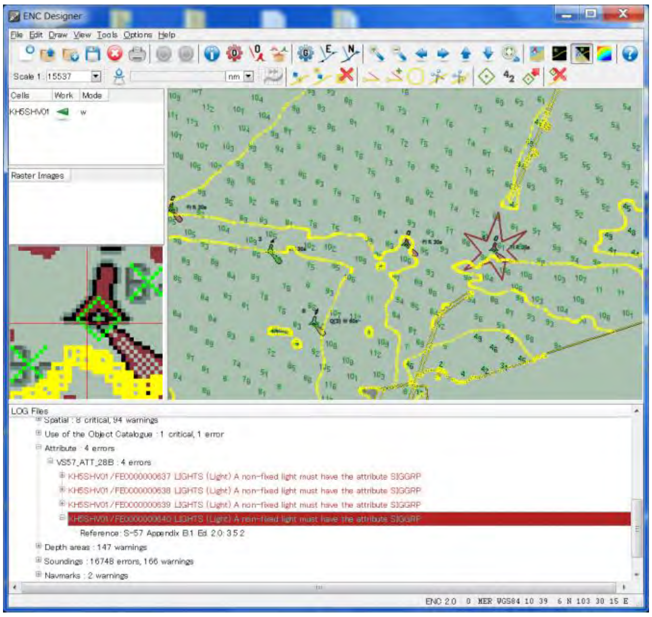


Figure 2 - 74 Display highlighting Error Location

When double click at the error messages automatically identified with highlighting the location of the errors and describe error.

(4) ENC OPTIMIZER

ENC Optimizer applies automatically processes to optimize produced S-57 Ed.3.x compliant digital chart data (ENCs). These automatic processes directly access and change spatial and feature objects of a data set. A number of optimizing functions allows to automatically assigned S-57 attributes and values. By means of these functions the processing time of the data production can be significantly reduced. Optimized files will support a better display performance of the ENC display in ECDIS.

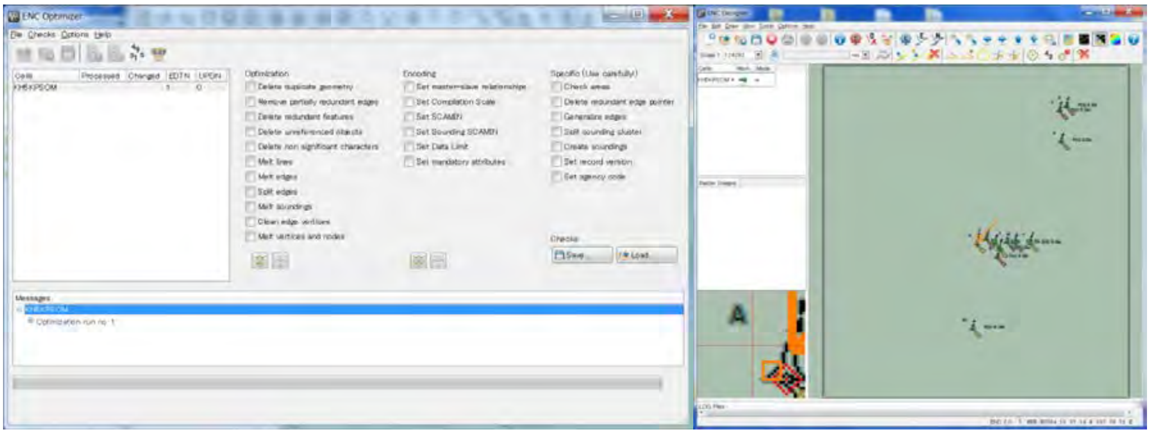
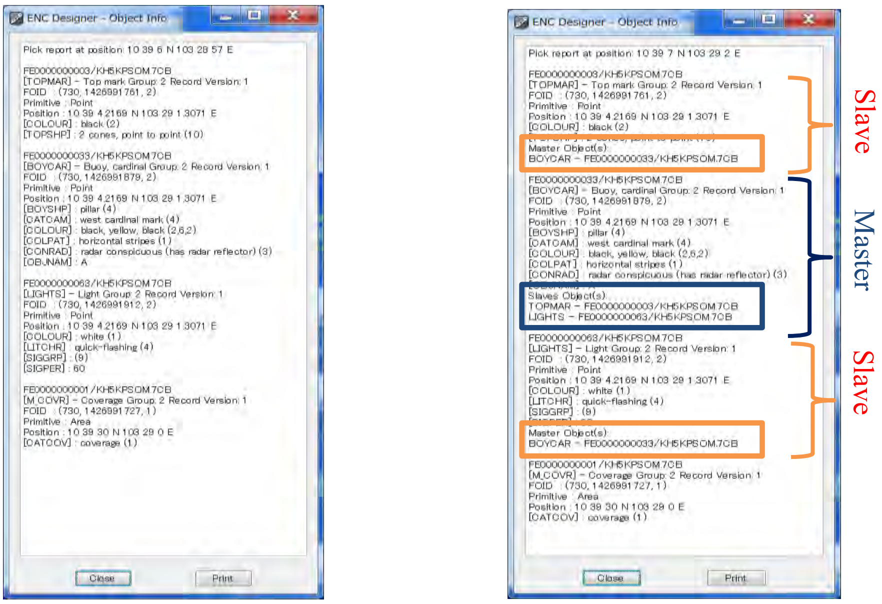


Figure 2 - 75 Example for ENC Optimizer Display

Figure 2 - 76 Left shows Object Info before application of ENC Optimizer. ENC Optimizer automatically searched and created the relation between BOYCAR, LIGHT and TOPMAR.

Figure 2 - 76 Right shows Object Info after application of ENC Optimizer that BOYCAR object became Master and LIGHT, TOPMAR became Slave in the object relation.



Before optimize with ENC Optimizer After optimized with ENC Optimizer

Figure 2 - 76 Details of Object before and after the Optimization by ENC Optimizer

Due to some optimization processes will totally change the ENC data cell and the automatic optimization process cannot offer 100% reliable. Hence should be careful on using optimization process in ENC Optimizer.

(5) ENC REFERENCER

ENC Referencer is a program to add the geographic frame to a raster image and map position of a raster image to the real position in real world. With this information a geographic position can be calculated for every point of the image. The used calculation mechanism will not touch the raster image. The reference information will be saved in a separate file. This file has the complete name of the image with the additional extension .ref file. After added the geographic frame, a raster image will can be open in ENC Designer in order to use as reference material in editing ENC data. For the geographic referencing, certain points with known geographic position must be defined. In case the 'least square method' is used, the number of reference points depends on the order of the polynomial used. If the order is 1, 2 and 3 required 4, 9 and 16 reference points orderly.

All reference points should be distributed evenly over the raster image. If the projection is known, four reference points are needed.

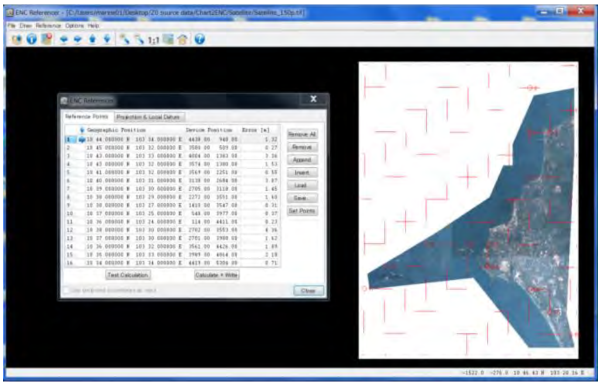


Figure 2 - 77 Example of Geographic Mapping of Satellite Imagery with place reference points in ENC Referencer

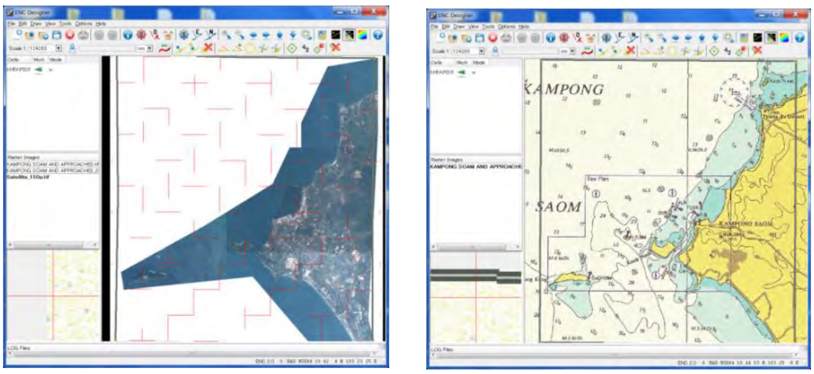


Figure 2 - 78 Satellite Imagery and Paper Chart being mapped geographic point display in ENC Designer

For the completion of geographic mapping, the projection (Mercator or Transverse Mercator or UTM or Gauss Krueger) and the geodetic datum of the source must be known and fixed. If the projection is not known or not specified, a geographic referencing can be made using the 'least square method'.

(6) ENC MANAGER

ENC Manager offers a workflow management environment for the systematic maintenance of S-57 data. Entire processes will be logged and can be monitored and edited by user. It allows creating update files, new edition and S-57 exchange sets in a hierarchical database-like structure. To provide the corresponding functions for each process. ENC Manager can interact with the data production tool (ENC Designer) and with the quality assurance (QA) tool (ENC Analyzer) directly within itself.

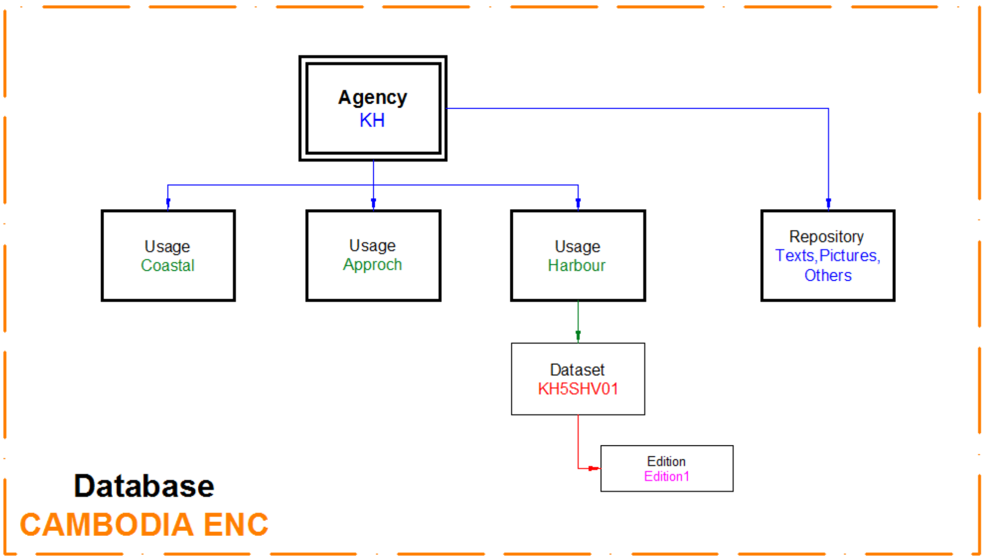


Figure 2 - 79 Data management structure in ENC Manager

The life cycle of an ENC contains with Creation, Quality Assurance and Data Maintenance.

- Creation: includes the production of ENC data files and also allows creating new editions to update of ENC data with both based on the IHO S-57 ENC Product Specification
- Quality Assurance (QA): ensures produced data which meet the IHO standard concerning data structure and encoding of data are delivered to the end user. Due to ENC Manager no have QA function tool inside, it can interact with external QA tools from ENC Analyzer. It can be possible to store result of the checking routines in a log file with added user's comments.
- Data Maintenance: handle in one or more databases. The databased are organized in at logical structure according to the navigational purpose of ENC. Data Maintenance also includes production of update files as well as handling different edition of ENC which specified by an edition number and update number.

Each ENC which is loaded into the database for further processing is characterized by a working status. (See in following Table 2 - 15)

Table 2 - 15 Status of ENC DB

Status (of ENC)	Possible Action	Used Tool
EDIT	Production of update file and new editions	ENC Designer (directly via ENC Manager interface)
QA	Checking data with check routines	ENC Analyzer (directly via ENC Manager interface)
OK	Data import Data delivery after successful QA check Change to EDIT status for data access	ENC Manager
CLOSED	Finishing edition	ENC Manager

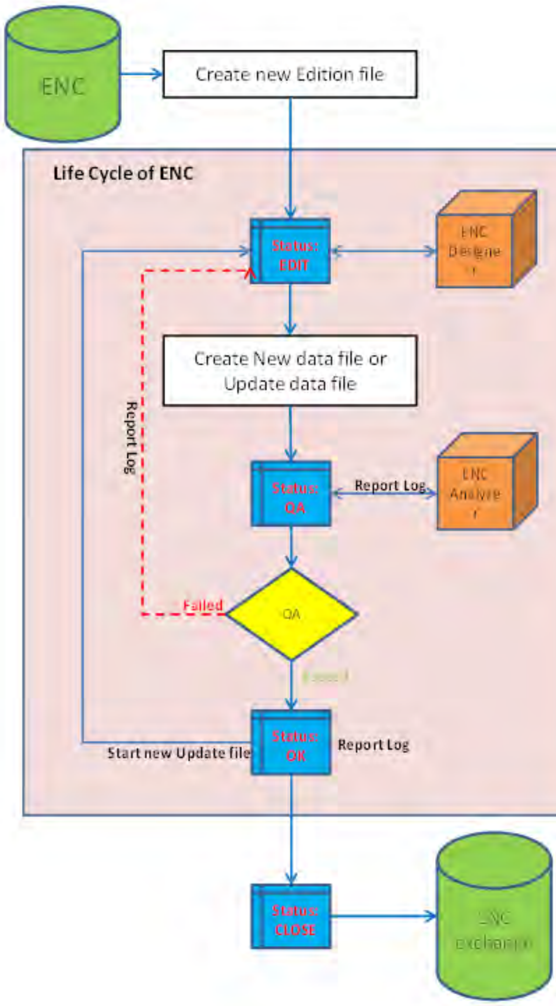


Figure 2 - 80 Workflow of Life Cycle of ENC and their Status in ENC Manager.

In ENC Manager can using ENC Designer to edit ENC data cell and checking validation with ENC Analyzer. Repeating for editing and checking until there is no have any critical, errors and warning in created ENC data cell. ENC Exchange set created from ENC data cell which passed Edit and QA process in ENC Manager.

Exchange set contain 3 kind of files, and able to comply and display with ECDIS. (Shown in Figure 2 - 81)

- 000 file format : ENC cell data
- README.TXT: Text file which is containing ENC cell data's information and cautions.
- CATALOG.031 : File that defined ENC version (031 means ENC Edition 3.1)

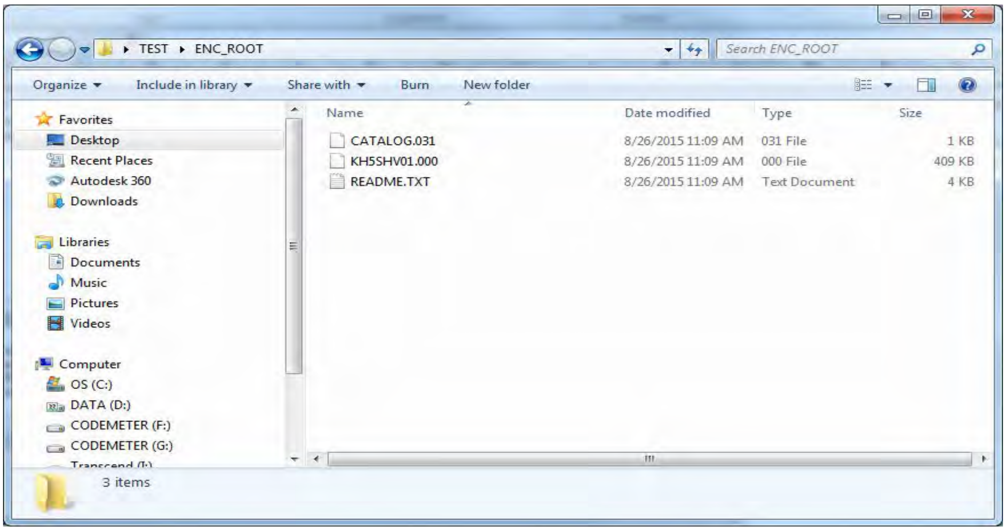


Figure 2 - 81 Directory Structure of ENC_ROOT

[ENC media volume production]

There are several mandatories for ENC media volume implementation in order to meet with S-57 and able to display in ECDIS with different manufacturers.

- Volume naming: An exchange set may be split across several media volumes. Therefore, each media volume must be uniquely identified within the exchange set. A file must not be split across volumes. Individual volumes must conform to the following convention

VSSXNN

"V" is the mandatory for first character
"SS" is the sequence number of the specific volume within the exchange set
"X" is the mandatory for forth character (separator)
"NN" is the total number of media volumes within the exchange set

- Directory structure

On each volume within an exchange set there must be a root directory called ENC_ROOT. The catalogue file for the exchange set must be in the ENC_ROOT directory of the first volume of the exchange set. The ENC_ROOT directory of the first volume may also contain a README file, containing ASCII to describe about ENC CD-ROM.

- File naming

README.TXT is the mandatory name for README file. Catalogue file of the exchange set must be named CATALOG.EEE Where EEE is the edition number of S-57 specification used for this exchange set (CATALOG is mandatory) Data set files must follow with data cell code from ENC Designer

Write exchange data set into CD-ROM and set for volume naming (Disc title) following with S-57 Appendix B.1 ENC Product Specification (see detail in Volume naming section). Open exchange set with ENC viewer software (Ex. SevenCs`s See My ENC) in order to confirm integrity and completeness.

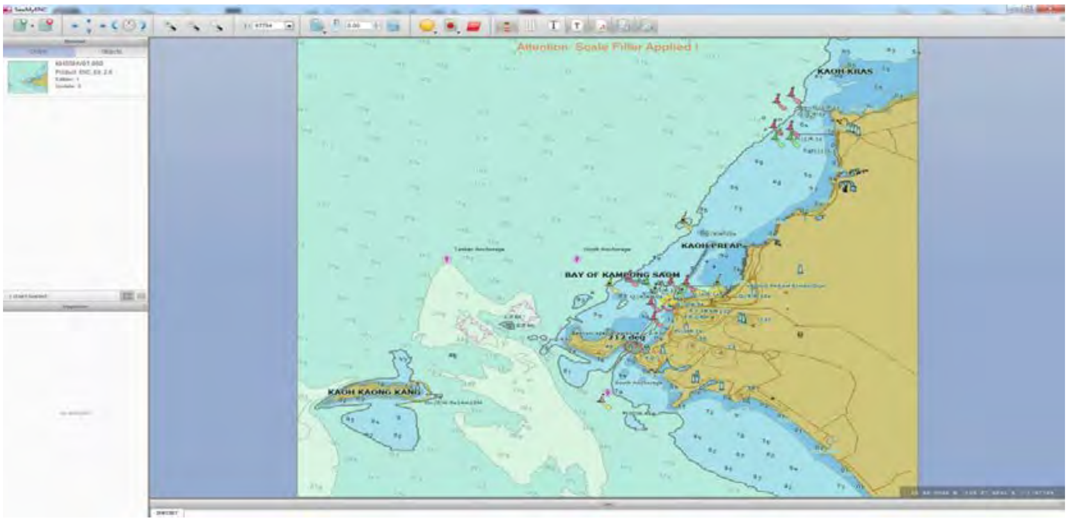


Figure 2 - 82 Confirming of created contents by ENC Viewer Software

Then, print disc label into the CD-ROM media surface to identify cell code, edition and the other detail of ENC production.

Figure 2 - 83 Example of Media Disk Label of ENC

(7) ENC CARTOGRAPHER

For ships or mariners who don't have ECDIS system. It is necessary to product the nautical paper chart as reference for sailing. ENC Cartographer is used to create and maintain INT1 and INT2 (Regulations of the IHO for International (INT) Charts and Chart Specifications of the IHO) compliant nautical paper charts from the S-57 ENC data set (000 file). By using ENC Cartographer, the user can create layout of the nautical paper chart by adding plans and insets, automatically generate template of object, text, map border, note or warning of navigational chart, raster file and all from the objects and attribute data of the loaded ENC data set. Moreover that charts need to be friendly to use for mariners or users in order to safety issue. ENC Cartographer can't directly correct or modify ENC data set as ENC designer do. Just only arrange position or some text which loaded ENC data set.

There are 2 main specific modes used to create the nautical chart, these are Scheming Mode and Edit Mode as shown below.

- Scheming Mode is used to layout the chart, set the scale, set position, set chart boundary and insets, adjust chart which compliant with INT1 and INT2.
- Edit Mode is used to perform all of the finer/detail cartographic enhancements and adjustments which are not able to be performed automatically from loaded ENC data set.

Scheming Mode Editing

- Set Chart paper size (A1, A0 etc.) and its orientation (portrait or landscape) of chart layout which depends on chart scale.
- Add ENC Data Cell to Panel and set Panel Properties (Panel title, Panel Extents, Chart Projection)
- Set scale bar inside the chart borders following INT2 conformity (for 1/20,000 scale, border scales with style P in INT2 Chart Spec Borders, Graduations, Grids and Linear Scales).

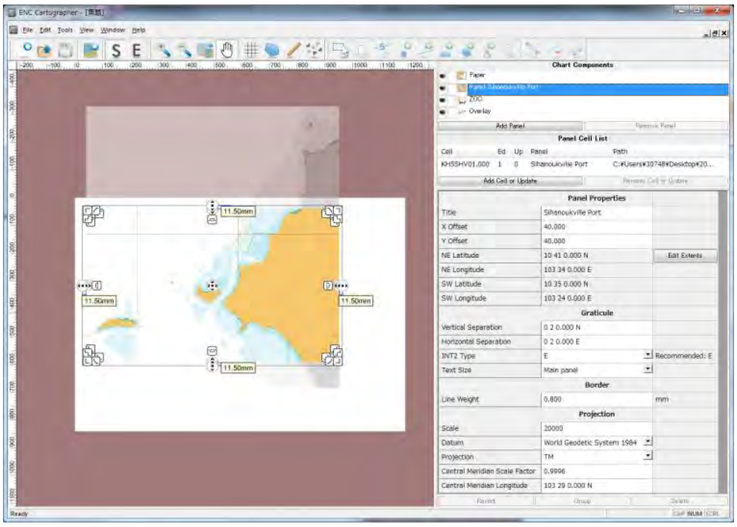


Figure 2 - 84 Adjusting the Paper Chart Area based on ENC File

Then move to Edit Mode Editing to do finer cartographer.

Edit Mode Editing

ENC Cartographer will generate an appearance in conformity with INT1 from loaded ENC data set.

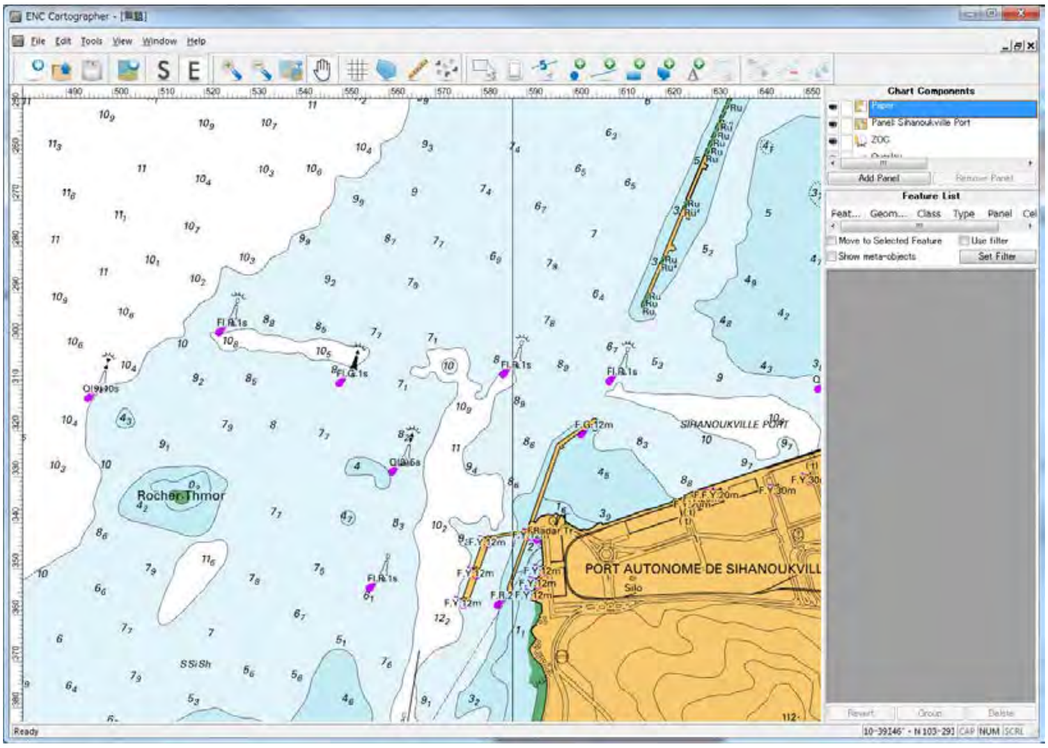


Figure 2 - 85 Chart Layout automatically generated in the ENC Cartographer from “000 File”

But generated layout still has some the untidy and unarranged objects that lead to miss some information or confuse to the mariners. Do the finer cartography within the chart by moving, adding, arranging necessary text and object to an appropriate position.

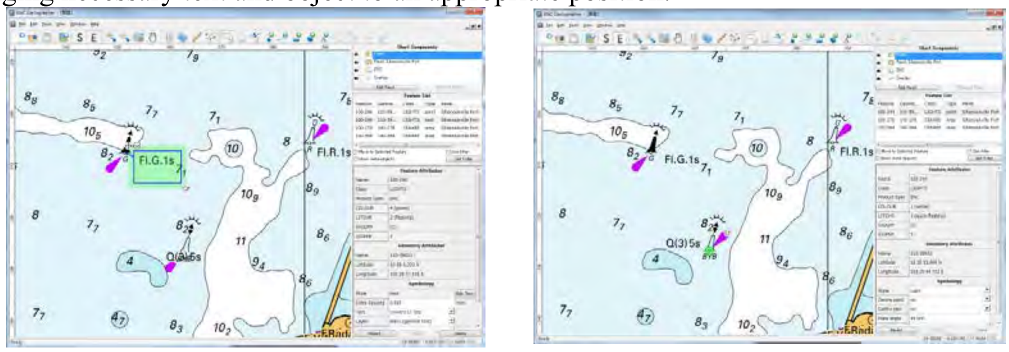


Figure 2 - 86 Example of Shifting Light-buoy Characteristic Text to Proper Space

Generally, all of the text should not be overlapped with the other texts and/or objects, such a grid tech, graticules, depth contour, coastline, shoreline construction and etc.

There are the priorities for display priority in the chart following these priority (1st depth soundings, 2nd navigation aids symbol and text, 3rd contour). For soundings, they have the priority first, when their position were overlap with the other objects (Ex. graticule). The mark must be arranged to hide the graticules, and make the soundings clear and easy to notice, refer to the following Figure 2 - 87:

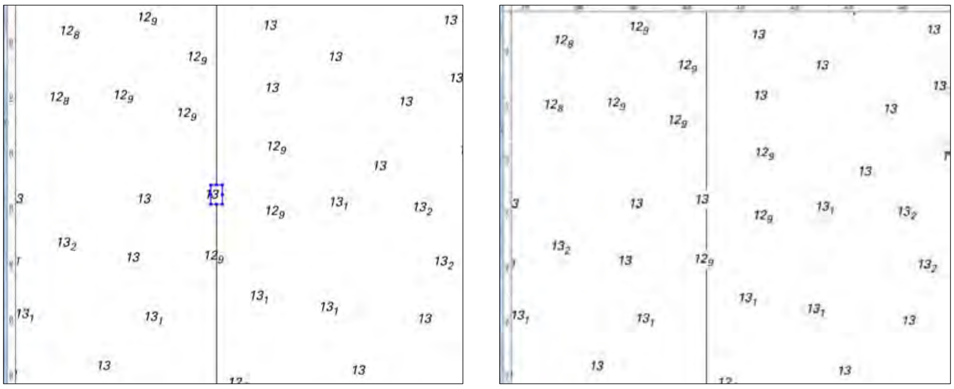


Figure 2 - 87　Example of Before and After the Masking Process was made on to the Depth soundings and Graticule

Text can be optimized in size, style, direction to fit with other object's layout of the chart, as well.

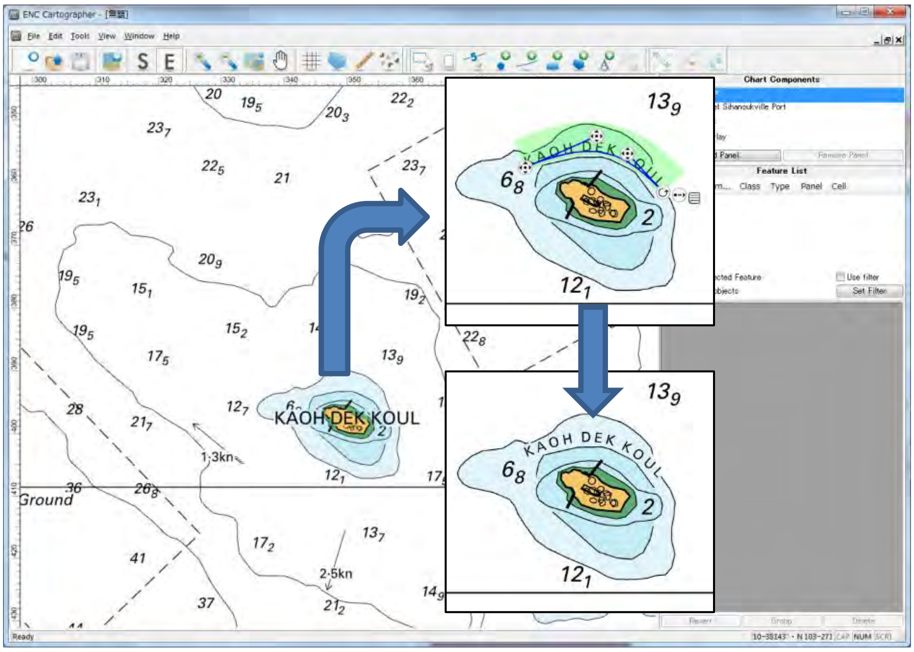


Figure 2 - 88　Example of Island Name shifted and arranged to harmonize with Contour Line

In order to produce chart, the study team had researched to confirm the name of places and islands in Cambodian words from Cambodian residents. The draft chart was sent to PAS's pilot team for their examination, and inquired for comments on it. PAS pilot team mentioned that most of the mariners had already become familiar with the old names as they were described in the old chart, which was published by UKHO. So, it was considered that it would be convenient for them to use the same name as well. Below Table shows the reply of PAS pilot team to study team after their examination.

Table 2 - 16 Verification result of Island Names from PAS's pilot team

Before Verification	After Verification
KOH POUS	KAOH POAH
KOH DEK KOL	KAOH DEK KOUL
KOH DOUNG	KAOH PREAB
KOH TAS	KAOH KAONG KANG
THMOR DOS	ROCHER THMOR

Moreover, SCAMIN is being arranged in order to not to confuse mariners by reducing the redundant information, and applying chart would be clearly understood of the contents at first sight.

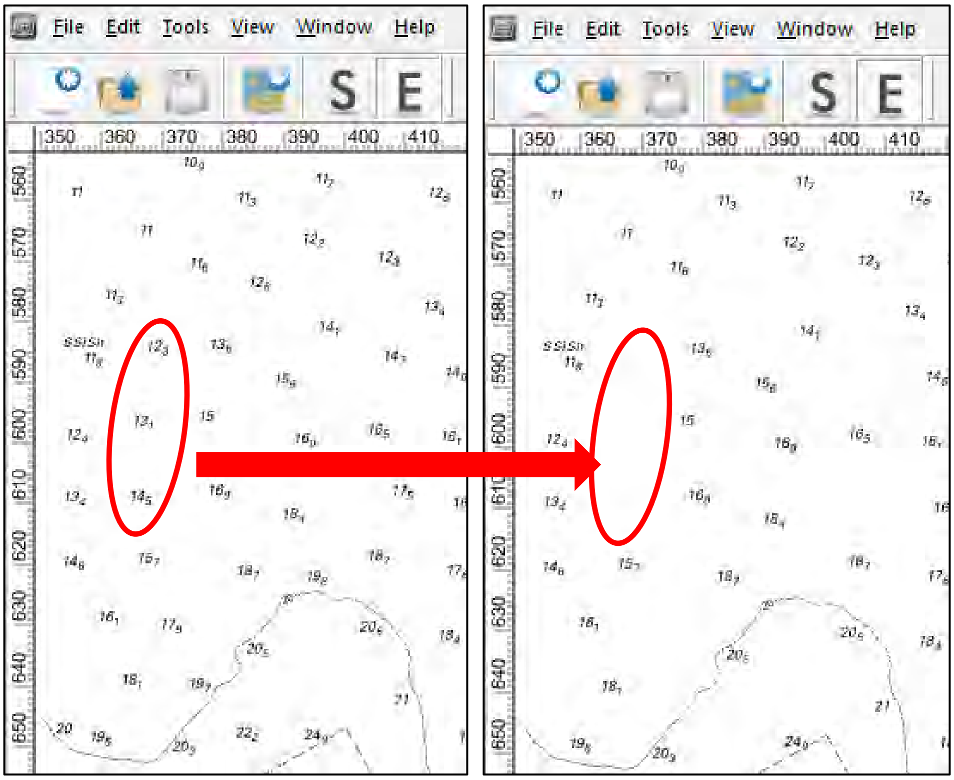


Figure 2 - 89 Depth Sounding Condition Before and After SCAMIN is being applied at a scale of 1/20,000

In order to enlighten the usefulness of navigational chart in various fields such as fishery industry, renewable resource development and academic research work, it should be facilitated for the users to be serviced in Cambodian language in the future.

Figure 2 - 90　Example of Chart that used display in Cambodian Language, for district name

With ENC Cartographer can add title or notes or cautions with the preset templates to tell more detail about chart to mariner (Shown in Figure 2 - 91).

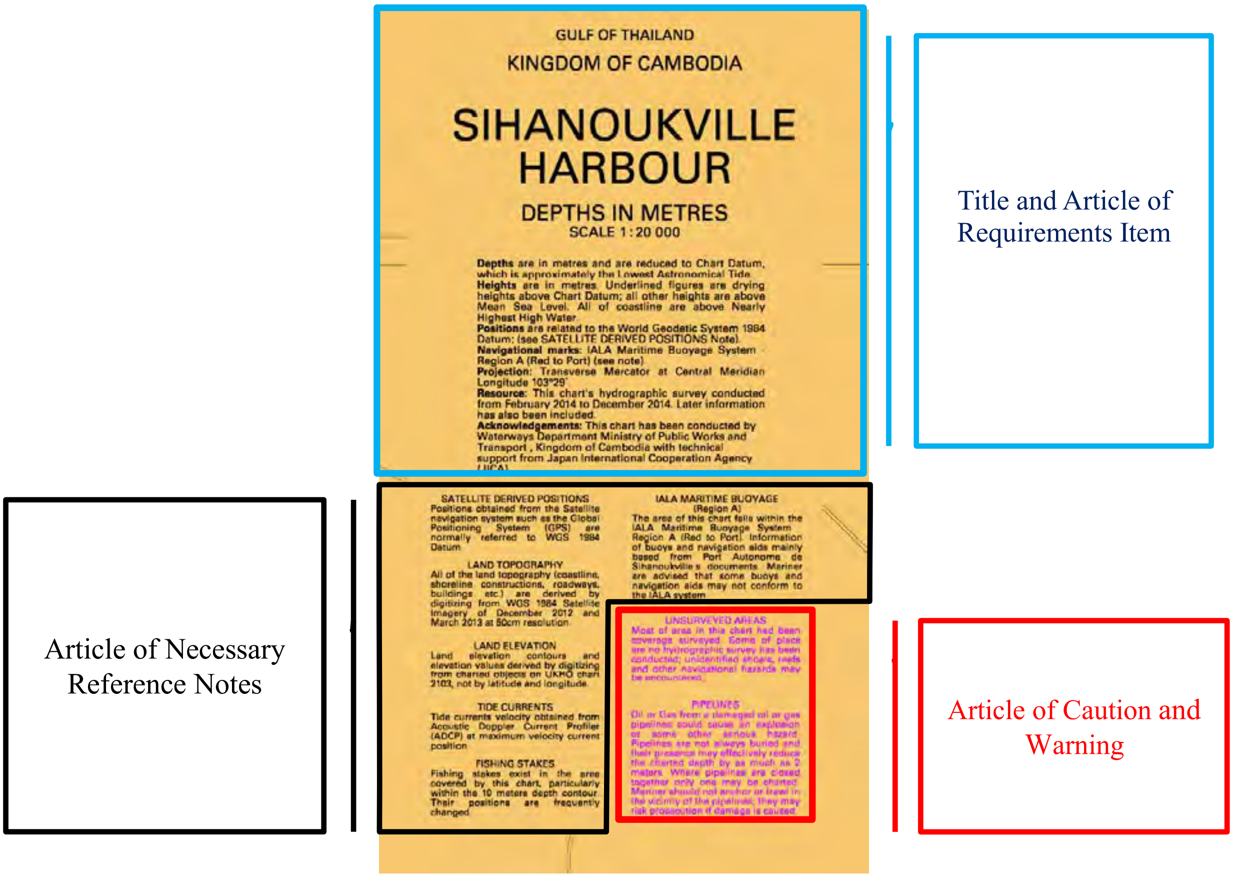


Figure 2 - 91　Adding Postscripts of Navigational Notes, Warnings or Relevant Matters Necessary to Mariners to the preset Template

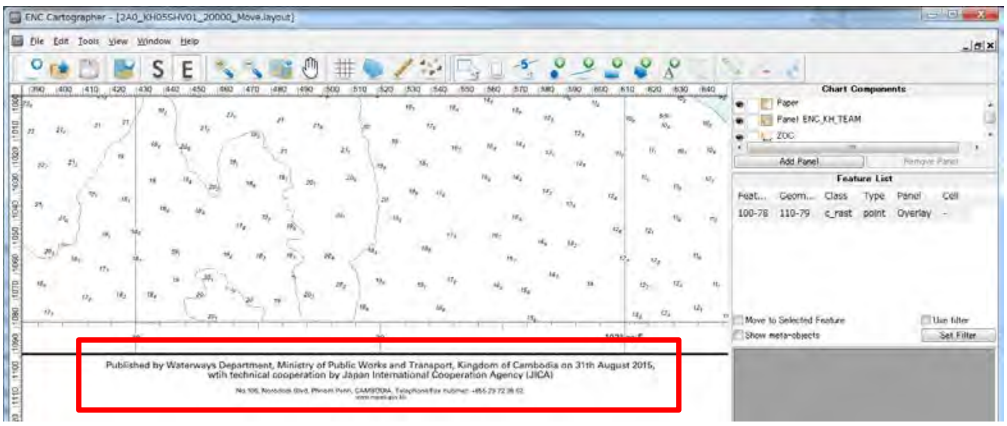


Figure 2 - 92　Example of Before and After the Footnote is adjusted

In ENC Cartographer can add the raster object (pictures and photos) to print into the chart. It supports raster file format of TIFF format and HRF format.

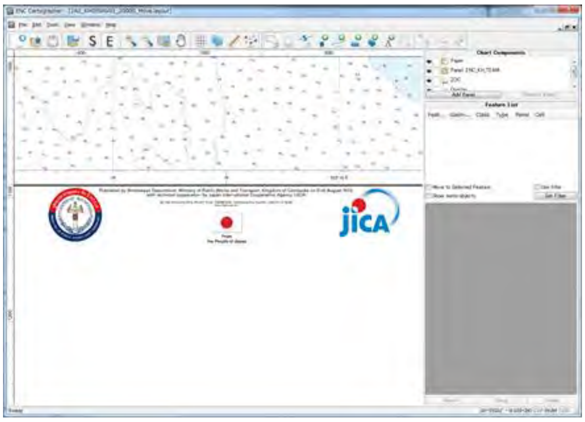


Figure 2 - 93 Showing Raster Images, Logo Marks, onto the Paper Chart

Then, the footnote is adjusted in its size, rotated and positioned in proper layout in the chart.
After that, it can export to print out to the paper with the printer and export to file with BMP or TIF file format.

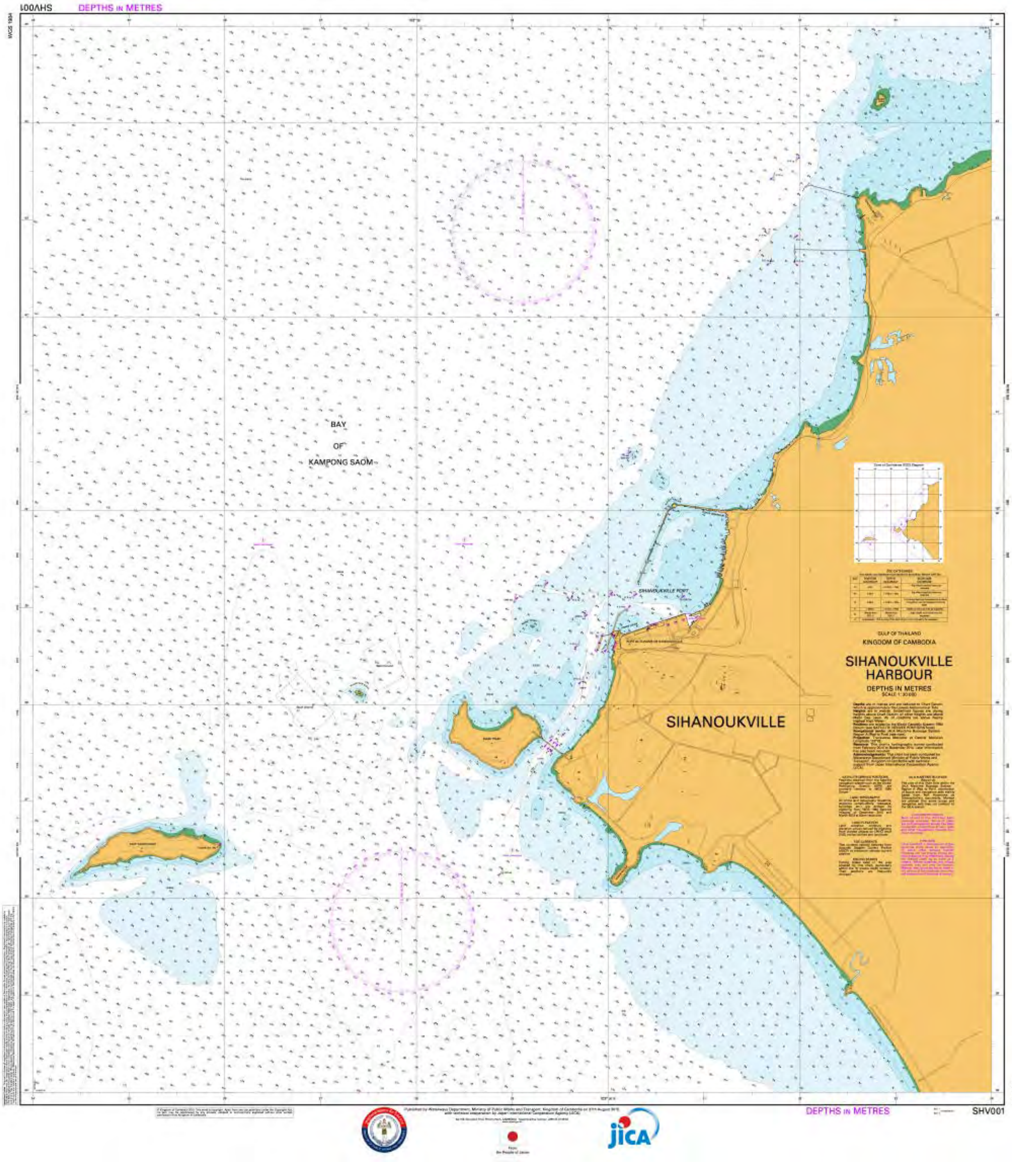


Figure 2 - 94 Finalized Layout of the Chart from ENC Dataset, Original Project

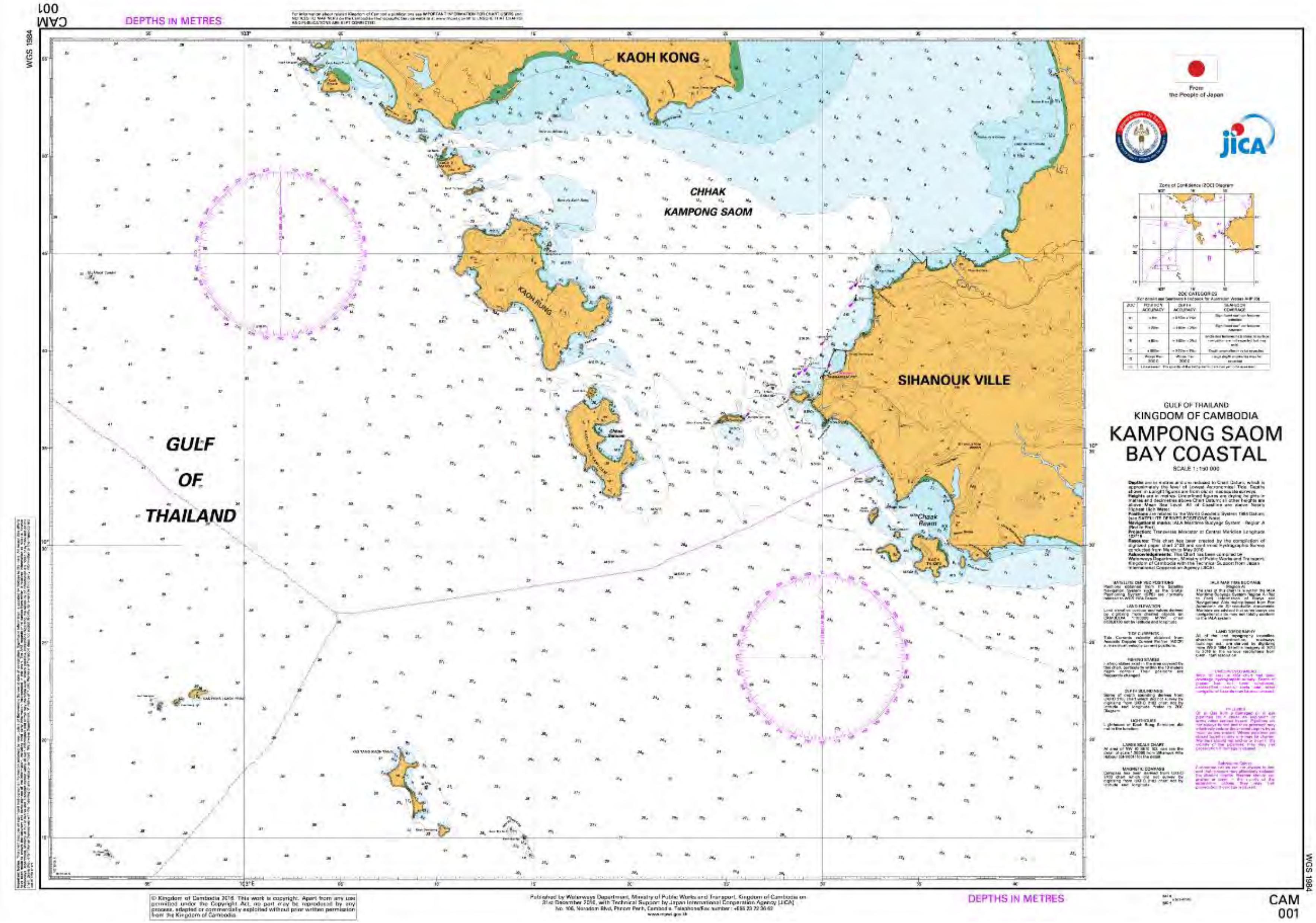


Figure 2 - 95 Finalized Layout of the Chart from ENC Dataset, Extension Project

2 - 7 - 2 Extension Project ENC

Most outstanding difference from the original Study of the Extension Project is to accommodate various diversified source data and create the ENC covering a wider area. Following shows the type of source data and application methodology:

- Depth data and Contour Line newly acquired:

  Depth data newly acquired were compared with depth data in the existing paper chart published by UKHO. Then, updating process was made to remove the old data and modify the contour line.

- ENC produced in large scale last year:

  Processes of thinning out of depth data, abstract delineation of shoreline, removal of unnecessary objects for small scale chart, i.e. beacons and light buoys, were made in order to be appropriate depiction good for the chart scale produced.

- Satellite Imagery:

  Shoreline and Low-water-line were extracted from the satellite imagery by digitizing.

- Paper Chart:

  The un-surveyed area in this project was filled with depth data and contour line derived from the processing below using existing paper chart published by the UKHO.

  Position data was derived from the comparison between the satellite imagery and the existing paper chart, and converted to new Lat. and Long., and digitized its depth at the location.

- Topographic Map:

  Contour line, road and railway information on land were extracted from the existing digitalized map provided by MPWT, which was the outputs by the technical assistance project donated by JICA. Following Figure 2 - 96 shows the topographic maps provided by MPWT.

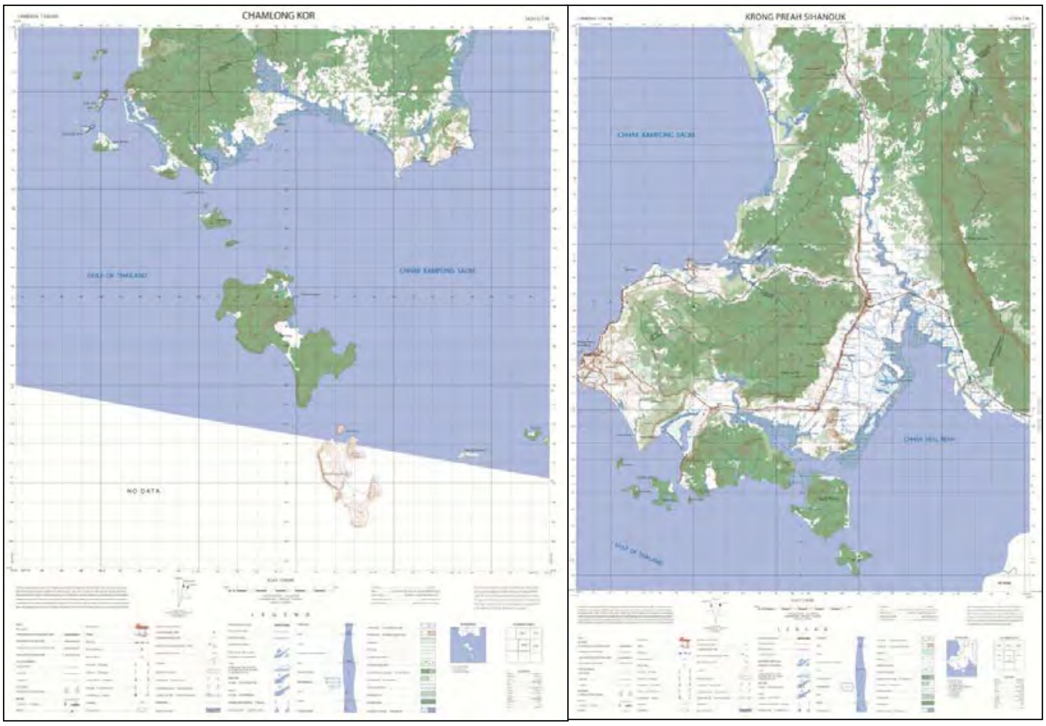


Figure 2 - 96 Existing Topographic Map, No. 5630 and No. 5730, provided by MPWT

Following Figure 2 - 97 shows the general procedures to adopt the depth data and contour line for the ENC. Lower left of the Figure shows the colour-coded software used for various processing in ENC production. All the software should be manage to operate properly for the outputs expected. Generally, these processing was duly performed by the study team and MPWT C/Ps.

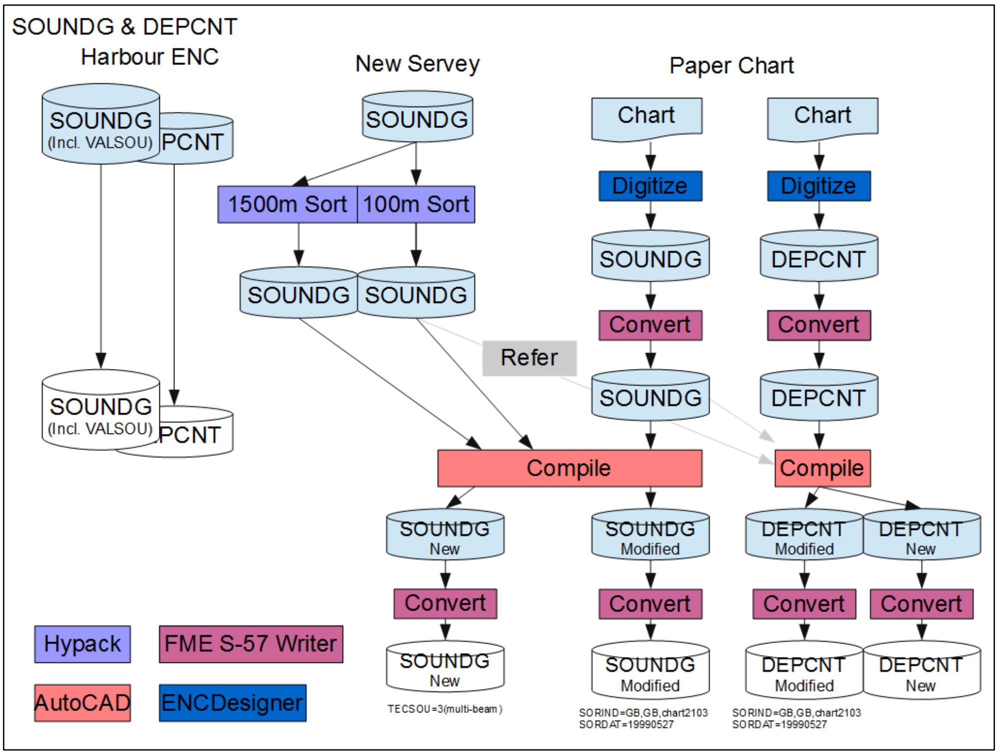


Figure 2 - 97 General Procedures to adopt the depth data and contour line for the ENC