Kingdom of Cambodia
Waterways Department
Ministry of Public Works
and Transport.

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart in the Kingdom of Cambodia

Final Report

Summary

March 2017

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

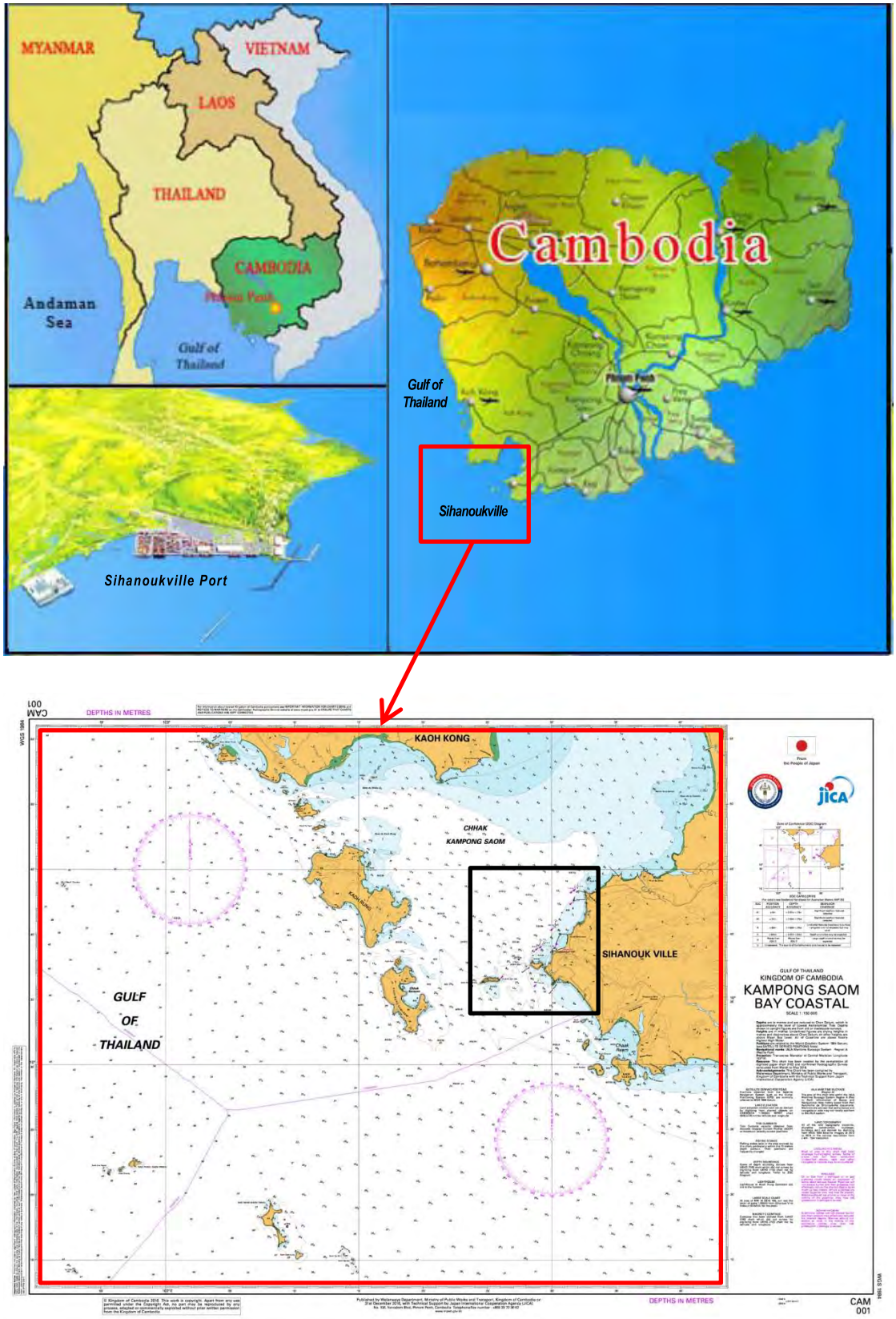
AERO ASAHI CORPORATION

EI
JR
17-034

TABLE OF CONTENTS

APPENDICES:

Study Area Map



Photos

Ambient structures and facilities in the Sihanoukville Port


Sihanoukville Port : Northern Oil Jetty and Oil Containers


Sihanoukville Port: Bulk Cargo Pier


Sihanoukville Port : Breakwater and Old Pier

International Passenger Cruises visited to Sihanoukville Port

Seabourn Sojourn (Bahamas)

Volendam (Netherlands)

International Passenger Cruises anchored at Offshore (Length more than 290m)

Diamond Princess (England)

Queen Mary 2 (England)

Night view of International Passenger Cruises in Sihanoukville Port

Volendam (Netherlands)

Crystal Symphony (Bahamas)

Survey Boat Rigging

MBES Transducer rigged on to the side frame

Launching Survey Boat after finished Rigging

MBES Transducer being raised up when transiting

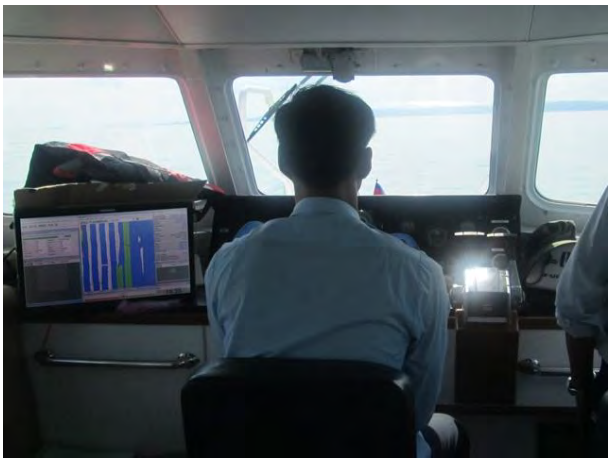
GNSS Antennas Installation

MBES Hydrographic Survey System

Navigation and Data Acquisition Computer

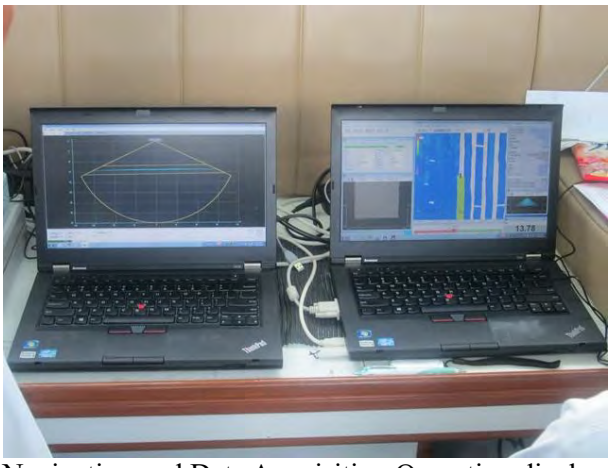
MBES Hydrographic Survey

MBES Transducer during Hydrographic Survey



Navigation Monitor with Survey Boat Operator

Snapshot of Hydrographic Survey operation



Navigation and Data Acquisition Operating display

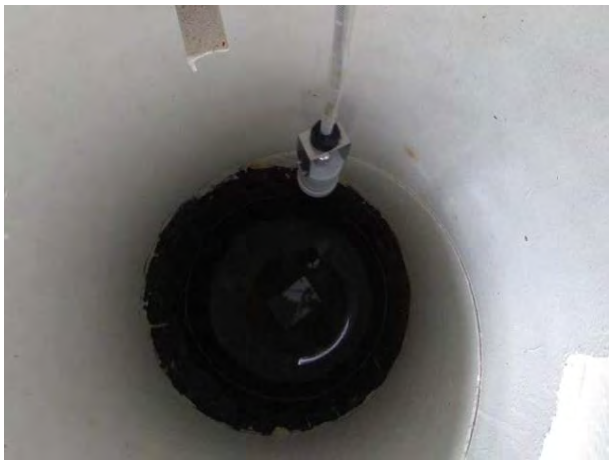
MBES hydrographic Survey Operation

Tide Station inside the Sihanoukville Port after finished renovation.

The distance view of Tide Station.

The close-up view of Tide Station.

Inside Tide Station.
RMD5225WLB-2 Tide Gauge.



Inside Tide Well.
Measurement sensor. (Always underwater.)

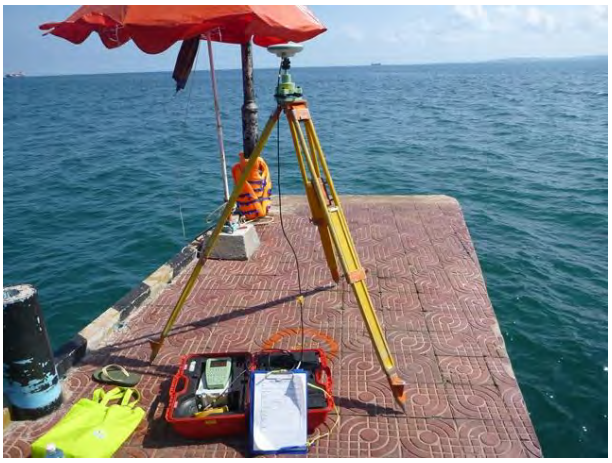
Tide Pole.

Saving of Tidal data
and Check of the Tide Gauge.

GNSS Ground Control Point Survey

Observation at GCP3 point

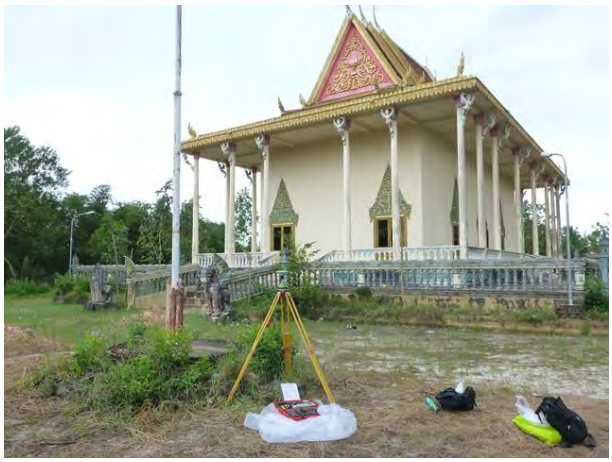
Observation at GCP4 point



Observation at GCP7 point (KAOH DEK KOUL)

Observation at GCP11 point (KOAH KAONG KANG)

Observation at National GPS Point [SIHA]



Observation at National GPS Point [No.1801B]

Leveling Survey

Leveling survey from PAS BM point to Tide Station BM point

Hydrographic Survey Data Processing

Lecture and Explanation about Data Processing

Data Processing Work at PAS Seafarer Office

Joint Coordinating Committee Meeting

The Minister of MPWT, Cambodia, and the Chief Representative of JICA Cambodia Office as the chairman and the co-chairman at the Joint Coordination Committee Meeting

ENC Workshop

For enlightenment of ENC usage in Cambodia, the ENC Workshop was held by inviting Domestic stakeholders of ENC users.

ENC Seminar

ENC Seminar held at the end of project, Cambodia Government Organization and International Organization and Cambodian Private port, and Private Shipping Company took part in the ENC Seminar.

Abbreviation Table

Abbreviation	Name or Means
AIS	Automatic Identification System
ASEAN	Association of South‐East Asian Nations
CDC	Council for the Development of Cambodia
C/P	Counterpart
DHSDAS	Digital Hydrographic Survey Data Acquisition System
DHSDPS	Digital Hydrographic Survey Data Processing System
EAHC	East Asian Hydrographic Committee
ENC	Electronic Navigational Chart
EMRA	Electronic Mekong River Atlas
ECDIS	Electronic Chart Display and Information System
F/R	Final Report
GNSS	Global Navigation Satellite System
GOC	Government of the Kingdom of Cambodia
GOJ	Government of Japan
IHO	International Hydrographic Organization
IMO	International Maritime Organization
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
MB	Multi-Beam(Hydrographic Survey)
MBES	Multi-Beam Echo Sounder
MLMUPC	Ministry of Land Management, Urban Planning and Construction
MRC	Mekong River Commission
M/M	Minutes of Meeting
MPWT	Ministry of Public Works and Transport
MPWT/WD	MPWT/Waterways Department * From 13th Oct. 2016, MPWT/Waterway Department name changed to MPWT/Waterway Infrastructure and Port Construction Department ** In this report will use as MPWT/WD
MPWT/MMD	MPWT/Merchant Marine Department
PAS	Port Autonome de Sihanoukville / Sihanoukville Autonomous Port
PPAP	Phnom Penh Autonomous Port
R/D	Record of Discussions
S-57	IHO Transfer Standard for Digital Hydrographic Data (Special Publication No.57)
SHV	Sihanoukville
SOLAS	The International Convention for the Safety of Life at Sea
UKHO	The United Kingdom Hydrographic Office

List of Figures, Tables and Photos

Chapter 1 IMPLEMENTATION POLICIES OF THE STUDY

Chapter 2 PROGRESS OF PROJECT and OUTPUTS

Chapter 5 OTHER ACTIVITIES

Chapter 6 SURVEY RESULTS

Chapter 1 IMPLEMENTATION POLICIES OF THE STUDY

1 - 1 Background of the study

In the Kingdom of Cambodia (henceforth “Cambodia”), since Sihanoukville port (henceforth “SHV”), is only a deep port facing to the open ocean, a dynamic approach and its acceleration of port development should be of a paramount essential to enhance the international trade of Cambodia with the rest of the world. In this respect, Japanese government has agreed to assist its development and to facilitate the activity of Sihanoukville Autonomous Port (henceforth “PAS”) and the operation of the Sihanoukville port Special Economic Zone (SEZ), which adjoins PAS. As one of the basic infrastructure pertaining to the activities of import and export through the ports and harbours, nautical charts are the most important tools for the incoming and outgoing ships to and from the ports.

It should be essential to keep the navigational safety of vessels with sounding information and relevant facilities. The present chart around the SHV port, scaled at 1/20,000 had been published in 1997 by the United Kingdom Hydrographic Office, which was the recompilation of old chart that France and Russia Published before the cold war era, hence the sailing ships going to and from the port have been exposed to danger due to the uncertainties of depths and the positions. This deplorable issue will certainly result in the significant degradation of national credibility.

In addition, installation of Electronic Chart Display and Information System (ECDIS) has been made compulsory to the passenger liner of more than 500 GTs and the tanker of more than 3,000GTs (for new ships) from July 2012 under the International Convention for the Safety of Life at Sea (SOLAS) of the International Maritime Organization (IMO), and will be not only imposed gradually on the new ships but also on the exiting vessels according to the vessel type and a scale, therefore Electronic Navigational Chart (ENC) in accordance with the international specification corresponding to ECDIS is required should the present situation still continues, the competitiveness of the SHV port will be declined seriously along with the deterioration of port functioning. Considering the background mentioned above it is necessary to produce urgently ENC based on the digital data obtained by the modern hydrographic survey in and around SHV port.

Accordingly, the Cambodian government had decided to ask for technical assistance to the government of Japan to develop the demonstration project for ENC production in and around the SHV port and to enhance the capacity building through the project. Having the request from the Cambodian government officially, Japan International Cooperation Agency (JICA) carried out the preliminary study in February 2013 and examined the request, the project scope, the contents, etc. and the Record of Discussions (R/D) was signed on 15th March, 2013. This project aimed not only to produce ENC around SHV port but also to carry out the technology transfer concerning capacity building for updating, maintenance and management of ENC, taking into consideration the weakness of institutional/technical base of Ministry of Public Works and Transport /Waterways Department (MPWT/WD), in order to produce and publish a navigational Chart and ENC (C&ENC) in the near future. The study team and the counterpart team had worked together on the final stage of the Original Project by the completion of ENC production (navigation purpose 5) around SHV port in April 2015, based on the result of the First stage of Hydrographic survey activity from October 2013 to May 2014, and the Second stage of Hydrographic survey activity from November 2014 to March 2015 involving technology transfer.

Members of C/P in this process have learned its knowhow and technology through the lectures and OJT of hydrographic data acquisition, processing and analysis in order to acquire the charting information. However, institutional structures of MPWT/WD, which is responsible for the hydrographic activities, are vulnerable and fragile difficult to maintain status quo. Therefore, it is important to recognize the accumulation of experience on hydrographic activities and enhancement of institutional structure of MPWT/WD in order to conduct the hydrographic survey and generate ENC by themselves.

In addition to the container ships, recently more than 30 vessels of 60,000-ton class cruise ship, including one of the world's leading international cruise ships, e.g. MS Queen Elizabeth, visit SHV port frequently. Taking into account the present situation of the port, publication of medium scale ENC for navigation purpose 3 (Coastal Navigation) corresponding to British Admiral (BA) chart 2103 (1 /

150,000) had been requested as the most stringent issue from the maritime officials and PAS' pilots, leading large vessels into the ENC port area, of which ENC had already been produced by the original project.

Given such circumstances, the extension project was requested from MPWT at the 3rd JCC meeting of 22nd April, 2015. And, also pointed out was the WD's organizational vulnerability. Therefore, a sustainable development of hydrographic survey technology would further be assisted by the extension project. R/D of Minutes of Meeting was revised to include the scope of extension project in consultation with MPWT.

The M/M was signed by the Minister of MPWT and the chief Representative of JICA Cambodia office. The Extension project has been carried out in accordance with the revised R/D, which has been retouched to the M/M already agreed.

1 - 2 Purpose of the study

In order to achieve the respective objectives raised in this project, each mission should be carried out with emphasis on the following items:

(1) Carry out the hydrographic survey based on IHO hydrographic survey standard (S-44) around the SHV port and produce ENC for Navigation Purpose 5. In the extension project, produce ENC for Navigation Purpose 3,
(2) Contribute to the enhancement of digital hydrographic survey capability of MPWT/WD by transferring the technology through the On the Job Training (OJT) to C/Ps during the Study period. In the extension project, realize the fixing of knowledge and technology to update ENC based on cultivating the knowledge and skills of hydrographic survey and ENC production so far,
(3) Improving capability building of C&ENC compilation by transferring the technology through the training in Japan and the OJT with the study team for two C/P.
(4) Improving and guaranteeing Safety Sailing in SHV port and surroundings.
(5) Enlightening "importance" of C&ENC to the maritime-affairs related organizations in Cambodia.

1 - 3 Study Area

The original study area (NW: N10°45' E103°24' and SE: N 10°34' E103°34') is shown in black frame area of Figure 1 - 1. The hydrographic survey of the above area was carried out by using the multi-beam sounding system for about 120 days. The extension project area (NW: N10° 56' E102° 50', SE: N 10° 13' E103° 43.5') is as same as UK chart 2103 (1 / 150,000). Coast lines are extracted from satellite imagery.

Hydrographic survey of Navigable straits and sparse-depth area surrounded by the dotted lines shown in Figure 1 - 1 are carried out by multi-beam and single beam sounding for about 50 days in effect.

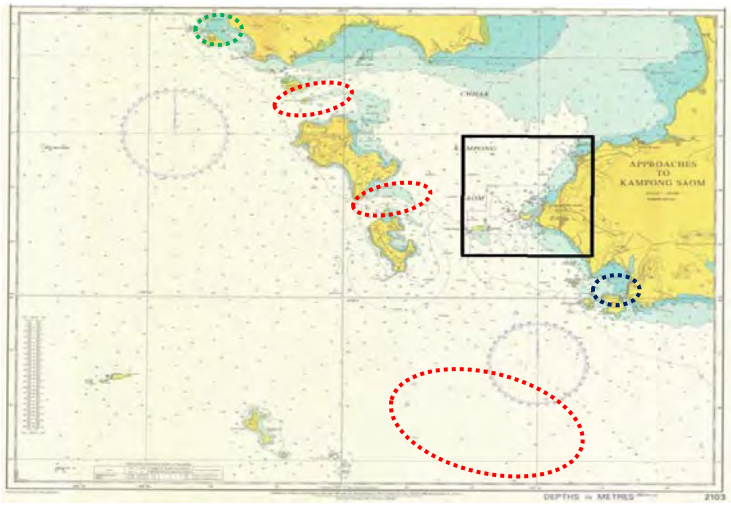


Figure 1 - 1 Study Area

Whole area shows the Extension Study Area, which corresponds to the area of medium scale ENC of Navigation Purpose 3. A black square frame on the map indicates the original project area that corresponds to a large scale ENC of Navigation Purpose 5.

(1) Natural conditions

The weather data are collected from the meteorological station of SHV. The meteorological observation was performed from 1957 to 1972, but the station was closed from 1973 to 1981. Then the observation started again from 1982.

1) Climate

The climate of SHV is particularly marked by the changing of wind direction depending on the season. In a year, there are two typical seasons, which are the Northeast Monsoon season and the Southwest Monsoon season. During the Northeast Monsoon, it is the dry season with light cloudy, few rainfall and the moderated air temperature. During the Southwest Monsoon, it is the rainy season with cloudy sky and rainfall mostly followed by a storm. During the transition period, when the season change, the direction of wind, rains and storm are movable.

2) Temperature

Climate Table 2011, 2014 shows the monthly average of maximum and minimum temperature in 2011 and in 2014, respectively. According to these data, the average temperature in 2011 and 2014 was 27.3°C. The yearly average temperature is typical one for a tropical climate. The coolest month is January with a monthly average temperature of 26.2°C and the hottest month is April with a monthly average temperature of 28.7°C. These temperatures are the same as the ones of 1985-1995 (by Report of Master Planning of SHV Port (PAS) in 1997 (henceforth "RMPS").

3) Wind

Climate Table 2011, 2014 shows the monthly maximum wind speeds in 2011 and in 2014 respectively. It is realized that through the year, the strong wind occur mostly in a Southwest Monsoon season with the direction of West, Southwest, an exceptionally Northwest. The record of strong winds during this period is 20 m/s with the direction of Southwest. Climate Table 2011, 2014 shows the wind rose of SHV. It shows that the south wind in outstanding. The Report of MP shows the wind direction with maximum speed in each month through the year of 1960 to 1969 and it shows that the Maximum wind speed is 27 m/s the direction of West. The season for the discrepancy in the high occurrence wind rose direction between both data is that the location of the station observed was different and, in particular, the level of anemometer was 10m to 15m above the sea level. During the dry season, the south wind is outstanding and rainy season, the south-west direction.

4) Topographic condition

A Northern part of the Study area is facing the KOMPONG SAOM bay with a depth of 5m to 10m. The SHV Port area is enclosed by a low rolling hill, by which the wind of North-East Monsoon is broken. KAOH RUNG and KAOH RUNG SAMLOEM Furthermore, KAOH POAH, KAOH KAONG KANG, KAOH PREAB and KAOH DOUNG exist in the Study area. Hilly side of the hinterland is covered with a sandy soil made of weathered sandstone, otherwise outcropped. This ground condition was formed by the orogeny movement at the latter of Cretaceous Period and it appears overall of SHV.

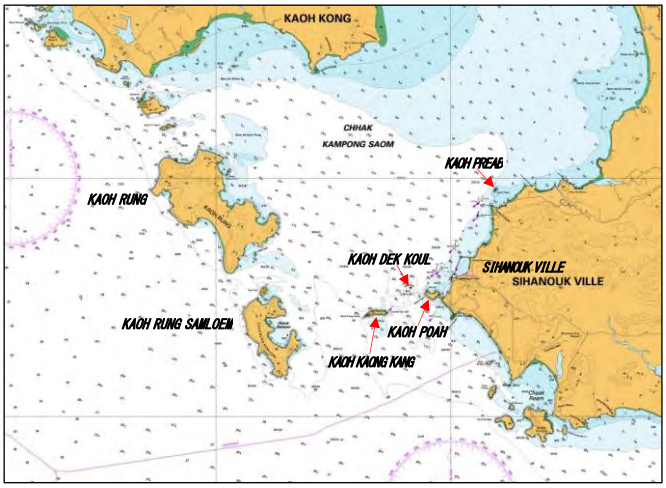


Figure 1 - 2 The Outskirt of the SHV Port

1 - 4 Basic Policies of the Study

The outlines of this study are described in the table below.

Table 1 - 1 Summary of Tasks for the Production of Navigational Chart; i.e. ENC

Study div.	Work Item	Work descriptions	Quantity
Japan	(1)-a Collection of relevant materials and information, organizing and analysis (1)-b Examination of basic operation,process and procedure (1)-c Preliminary study	* Establishment of study structure/ Collection of existing data * Provision of Equipment * Acquisition and analysis of satellite imagery (PLEIADIS-0.5m) (WorldView-0.8m and RapidEye-5m) * Examination of installation place for tide gauge/rigging the transducer of MBES onto the survey boat Examination of data acquired/processing of Digital * Hydrographic survey and editing process of Vector Fair Sheet and ENC * Basic policy and procedures of C/P training, process etc.	1 set 1 set 1 set
Japan	(2) Preparation of Inception Report	Completion of Inception Report on August 2013	1 set
Cambodia	(3) Briefing of Inception	Submission and explanation of Inception Report at 1st JCC on September 2013	1 set
Cambodia	(4) Consultation of the study contents	Consultation on ENC (S-57) production process with C/P and agreement	1 set
Cambodia	(5) Collection/ organizing of existing information in Cambodia	Collection of national GNSS base points and BMs etc. around Sihanoukville	1 set
Cambodia	(6) Acquisition of relevant Chart information and Analysis	A) Carrying out Geodetic Control Point Survey and Leveling (OJT) B) Processing of Satellite Imagery (delineating shoreline, dried lines and dangerous rock) C) Acquisition of Digital Hydrographic survey data (OJT). Analog method may be used. D) Tide observation and tidal current measurement E) Data Processing of DHS data (OJT) F) Producing Vector Fair sheet (OJT)	10 points 1 set 1 set
Cambodia and Japan	(7) Production of Chart and ENC	A) Data processing and analysis for editing ENC (OJT) B) Producing approach ENC and paper chart in and around SHV (OJT) and coastal navigation ENC to be connected to the preceding ENC. C) Conducting on-site training of ENC production (4) and in Japan/Philippines (2)	1 set 1 set 6 times
Cambodia and Japan	(8) Progress report and interim report	Briefings and discussion on the Progress and Interim Report to C/P organization around after 8 months and 16 months, respectively, from the commencement of the project. Interim Report2 will discuss on March 2016.	1 set 1 set
Cambodia and Japan	(9) Draft Final Report	Briefing and discussion on the Draft Final Report to C/P organization at the Final JCC meeting or at the seminar time. Results and contents of Agreement should be confirmed on the Minute of Meeting. Planning of seminar session on the project.	1set
Japan	(10) Preparation of final report	Submission of the Final Report on the Project to JICA	1set
Cambodia and Japan	Technology transfer	The parts of OJT in (6) and (7) were almost achieved for original purpose.	1set

Work in Japan | Work in Cambodia | Work in Cambodia & Japan

1 - 4 - 1　Technological Policies

The items being kept in mind in executing the project in terms of technical aspects are shown as follows.

Technological policies 1:　IHO Standards and Specifications (S-4), (S-44) and (S-57)

The work concerning C&ENC productions around SHV port in the study should be based on the IHO Standards and Specifications such as S-4, S-44 and S-57. Electronic Mekong River Atlas (EMRA) based on S-57 are available in Cambodia, however the compilation methodology is different from the concept of S-4. During the course of study, based on the discussions on the new work regulation and chart figure provision for MPWT/WD regarding the present digital hydrographic survey, the methodology and its relevant techniques for C&ENC compilation were proposed to MPWT/WD, hence the study advanced efficiently and smoothly.

Technological policies 2:　Survey Datum and Standard of Data Processing

The hydrographic survey in this study has been planned to carry out based on the following standard, however the details were agreed by the negotiation with the MPWT/WD on the working specification after the beginning of the project.

Table 1 - 2　Projection and Geodetic Datum

Projection	UTM (Universal Transverse Mercator)
Geographical coordinate system	WGS-84/ITRF2008
Ellipsoid	WGS-84(a: 6378137.0m, f: 298.257223563
Chart Datum	LAT: Lowest Astronomical Tide, which is the plane that water level will be lowest in 19 years of Planet period, that is calculated 60 tidal component estimated from the harmonic analysis of tides of at least more than 1 year observation.
Elevation	MSL or the elevation of existing benchmarks
Hydrographic Survey Standard	S-44 of IHO
Chart Compilation Standard	S-4 of IHO
ENC Production Standard	S-57 of IHO (Navigational Purpose: 3and5)

Technological policies 3: Digital Hydrographic Survey Data Acquisition and Processing

(1) Digital Data Acquisition

Positioning / Navigation Systems and Depth Sounding System shown in the R/D are the constituent tools for the Digital Hydrographic Survey Data Acquisition System (DHSDAS), which influence on the depth-sounding accuracy given in a chart. The accuracy of depth-sounding data is based on the IHO standard of S-44. The Multi-Beam Echo-Sounder (MBES) constitutes the core of DHSDAS shown in Figure 1 - 3 planned to donate to the C/P organization after the end of this project. Therefore, the MBES was procured by taking into consideration of the technology transfer so that the C/P organization could carry out uniquely hydrographic survey around SHV and the Mekong River Route in future. The MBES selected to this project has a proven track records in the industry of world wide, which has the sounding capability of seabed (river bed) based on S-44 up to 50m depth and performs flexible function with high accuracy (variable frequency: 200KHz - 400KHz, Beam width: less than 2 degrees, Number of Beams:256, and Selectable Sector Coverage 10 to 130 degrees). DHSDAS shall be composed of D-GNSS with SBAS function measuring ship position at sea and the motion sensor detecting swing-position of the survey boat (motion of MBES' transducer) and the sound velocity sensor detecting continuously of sea surface acoustic velocity for adjusting the sound ray refraction of the sound wave. The performance and the combination of acquisition interval of each apparatus constituting of DHSDAS may affect greatly on the accuracy of the depth data acquired. The uncertain error factor exerted on the accuracy of depth is made into minimum by taking synchronization of each data. Therefore, SONIC2020, having the function of synchronization of each acquiring data, was introduced as a series of integrated DHSDAS. In the extension study, guide and advise so that knowledge and skills gained in the OJT is taking root and continuing, the planning and data acquisition work of hydrographic survey are carried out primarily in C/Ps. perform the digital hydrographic survey data acquisition including the digitization of the existing analog data.

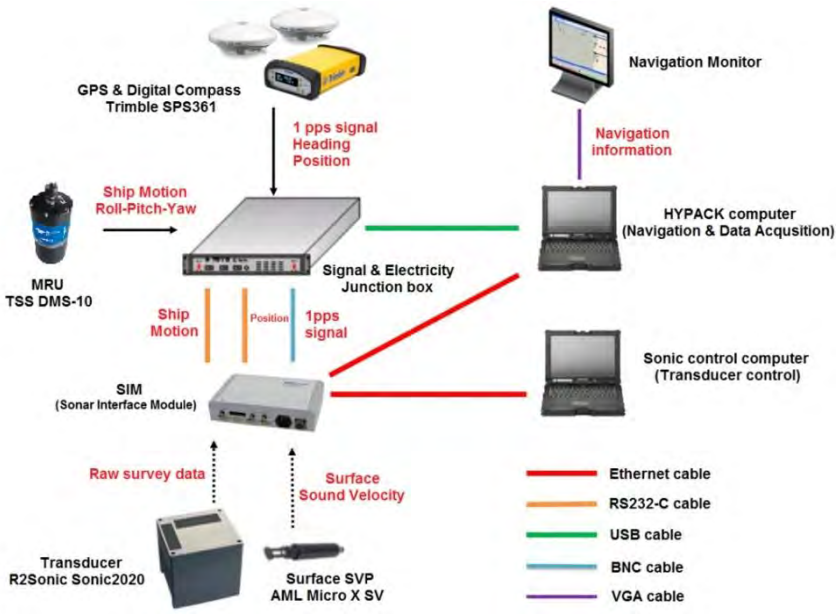


Figure 1 - 3 Digital Hydrographic Survey Data Acquisition System (DHSDAS)

In view of obtaining the high quality sounding data to accelerate smoothly data processing, the best position of the transducer is at the bottom of the survey boat. However it was difficult to rig the transducer as bottom mounted at this time, accordingly the transducer was installed as side-mounted shown in the following Photos (done by the Engineering Department, PAS): It contrived so that the relation between the transducer and GNSS antenna and Motion Sensor could become to the unchangeable position. The respective off-sets of each sensors, MBES transducer, GNSS antenna and Motion Sensor, were made rigid to each other. The sounding activity by DHSADS was commenced on 1st Feb. 2014.

Rigging of Transducer as side-mounted:30th Jan.2014

Complete Installation View at Survey Feb. 2014

Transducer had been firmly fixed to the boat side by this installation work.

Winch

Tip(Blue) is Transducer

Transducer Cable is in Pipe

Trimble D-GNSS Twin Antenna at the Roof of Bridge

TSS-10 at the center of gravity position

from left: UPS, GNSS receiver (Yellow)
and SONIC-SIM, and Junction Box
and SONIC control PC, and HYPACK SURVEY PC
(Feb. 2014 – Apr. 2014)

Sounding view by DHSDAS

Bridge, Navigation Monitor

PAS Patrol Boat used to Survey

Air-con (door R) and Generator

Hoisting Patrol boat for launching after the completion of Installation Work of DHSDAS and Hull/Engine (31 Jan. 2014)

Photo 1 - 1 Mobilization and Rigging of Survey Equipment on to the Survey Boat

Under weather conditions of high temperature and humidity, taking into account the stable power supply of the survey boat for hydrographic survey period to carry out continuously 8 hours on 1 day for several months, generator (8kVA), stabilized power supply and air conditioning were prepared to make the condition so that the survey boat crew, C / P and study team can carry out the hydrographic survey in cooperation. In the extension project, the generator will be replaced with new one because it is severe deterioration from offshore work environment suffer a harsh wave splash for two years.

(2) Data Processing

The data recorded by the multi-beam sounding system are huge and the raw data volume (day, time, depth, yaw/pitch/roll values, etc.) recorded by carrying out one-day (8 hours) of sounding work became 0.2 GB, approximately. This raw data acquired were processed by interactive computer processing tool, and then the Digital Terrain Model (DTM) file and Vector Fair Sheet file are created. In the original project, as the 120 days were expected virtually for sounding work, the raw data volume was amounted to about 24 GB. The data processing of 24 GB were performed step by step. The data processing for acquired raw data of 24 GB should be needed for a total of about 3,411-man-day (a total of 115 months), which was based on the official standard of the Japanese hydrographic survey data processing. Among the total months needed for data processing, the amount of 106 months, which made a reduction by 9 months from the total Man/Month estimated, should be considered to be appropriated for the actual Man/Month needed (as direct excessive personnel cost). Hence, the 106 months were separately added to the original cost as the data-analysis expenses. This data processing was carried out in Japan, separately, spending for 53 Man/Months because of some constraints on the study work staying in Cambodia. The data amount of data processing in the extension project is expected to approximately 10 GB. It is a policy that all of the data processing is carried out by eight C/P. However the data inspection and verification of quality assurance implemented by Study team in Japan.

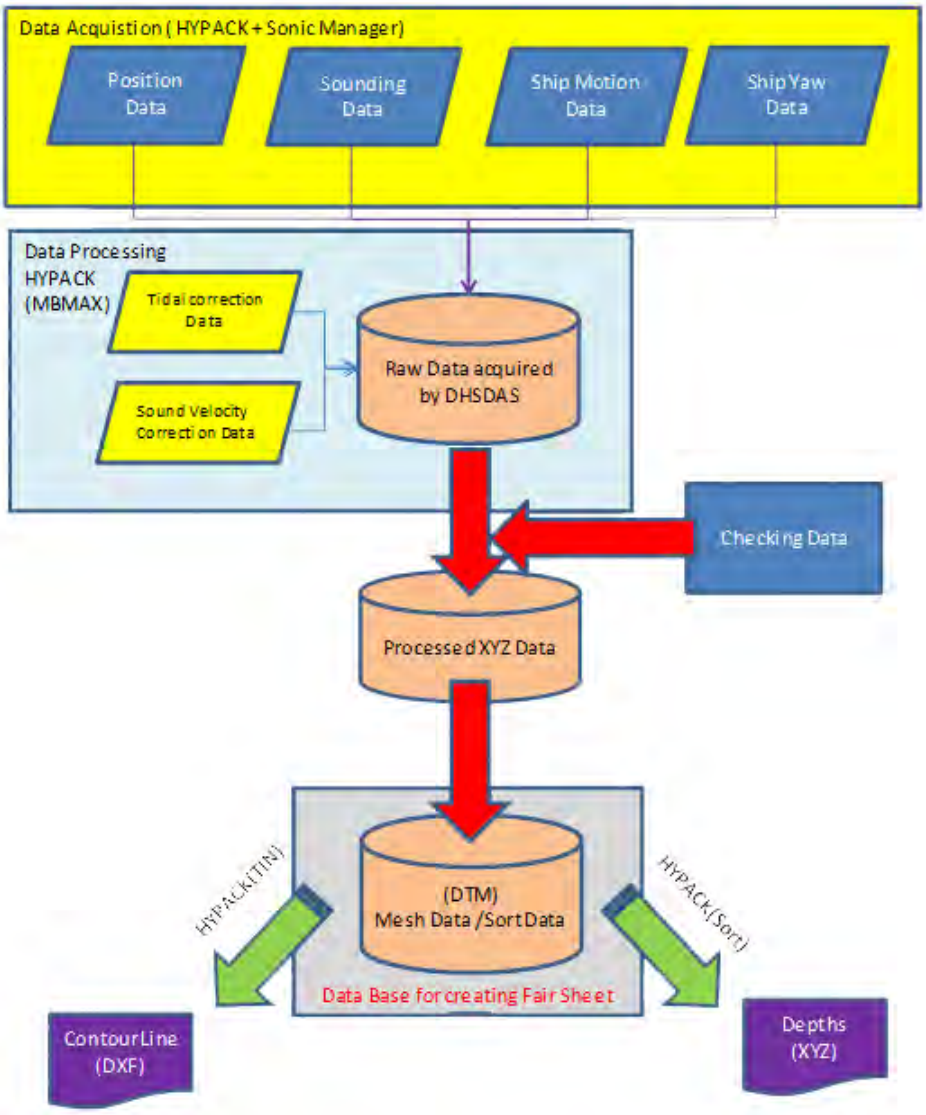


Figure 1 - 4 Flowchart of MBES Data Processing by “HYPACK”; DHSDPS

Technological policies 4: Compilation of Chart (ENC)

As general software used by ENC production system, there are "CARIS" made in Canada, "SevenCs" made in Germany, and "Chart King" made in Japan. SevenCs software has the circumstances developed only for ENC production, and since it has done compactly and a price is also a half-the-sum compared with CARIS, it is using in Hydrographic Offices (the chart-publication-organization) of some European and Asian countries such as German, Malaysia, Singapore, etc. where the number of C&ENC publications is comparatively little. (There is also an example of Indonesia, the Philippines, etc. which are incidentally using CARIS and SevenCs together.) The SevenCs system is the best for MPWT/WD producing, maintaining and updating ENCs from the above viewpoint. Generally, ENC is produced by scanning the existing paper chart and creating raster data, and evaluating and vectorizing various chart information. However in this project, ENC file (S-57 format) shall be planned to produce through the software (FME) changed into S-57 from Fair Sheet file (SHAPE, CAD). The flowchart producing ENC from Fair Sheet file by SevenCs ENC production system is shown below.

ENC produced in the extension project is also used in combination to vector by quantifying the various chart information by creating a raster data by scanning the existing paper charts because of producing by collecting work of a minimum of chart information data necessary based on UK chart2103 with the scale 1/150,000.

Technological policies 5: Structure of Personnel Training for Sustainability

Five personnel from MPWT/WD were participated and finished JICA Group Training Course in "Hydrography for Charting, Disaster Prevention, and Environment Protection (International Accredited Category B for Hydrographic Survey)" from 2011 to 2013. These five personnel have been planned as the C/Ps of the hydrographic survey activity in this project. And they should be expected to become the main hydrographic surveyors, as they had the OJT from DHS Data Acquisition stage (about six months) to DHS Data Processing stage (about seven months) for gathering information of C&ENC production, based on the knowledge and the technology of the above-mentioned JICA training.

On the other hand, two personnel of MPWT/WD who were participated in the project of Electronic Mekong River Atlas (EMRA) of Mekong River Committee (MRA) were planned as trainees for editing C&ENC. The specification of this EMRA created based on S-57 had some differences from the International Chart Specification, due to their original expressions of their own. It was found in the first-step work of formation of ENC data structure. Based on the examination, it was considered that C/Ps had a certain amount of knowledge about S-57. However, according to the detailed study report, it was mentioned that they still had some anxiety on their capability and the chart-editing knowledge due to a lack of experience.

Further, opportunities of giving lectures and technical training in Japan by the expert editor of navigational chart and ENC had been increased for them to provide the editing knowledge of navigational chart and ENC. In order to build a sustainable development system in terms of human resources, the OJT policy was applied for technology transfer, providing them with operational manuals specifying the complicated and diversified methodologies of ENC production. It was planned that they would be able to establish the “Echo-Training-System” to train their staff by themselves.

Technological policies 6: Publicity Campaign for C&ENC;
Seminar on dissemination of project outputs

A seminar was initially scheduled at the end of the project. The processes and the contents of technology transfer relating to the generation of C&ENC around SHV port would be scheduled to present both by the C/Ps and the study team at the seminar. The dissemination of the project information should be the major important issue for the MPWT/WD to let the public to well aware of the navigational safety and the importance of navigational chart, especially ENC. In this respect, comments and information as to the project carried out and the generation of C&ENC might be given

by the related organizations such as the Cambodian government, foreign countries, donor organizations and others. Then after the collection of useful comments from all the organizations/institutions and countries concerned, the utilization of the data and the outputs from the projects could be discussed for the further sustainability of all the routine works of digital survey together with the data generated.

Moreover, as the Cambodia is the most developing countries in terms of the generation of C&ENC in the Southeast Asia area, therefore it is strongly recommended to invite the officials concerned from the neighboring countries and hopefully join the EAHC in order to share the technical progress and the information about issues in the areas.

Since the initial project had been extended for one more year, ENC WORKSHOP was held at PAS organized by the C/Ps on 18th December 2015 as an epoch in the ENC world, instead. A Seminar above-mentioned was scheduled to be postponed and held in 13th December 2016.

1 - 4 - 2 General operation policies

General operation policies 1: General items

In conducting this project, all members of the study team have implemented under sufficient recognition and understanding about the technical cooperation of ODA, and communicated in order to establish its aim should be performed intentionally.

General operational polices 2 : Safety Measure

The study has conducted by taking the safety-measures defined by JICA. Since the hydrographic survey has been the work on the sea, it was assumed that the sudden change of weather and/or the man-overboard should likely to happen at any time. Therefore, the action regarding the evacuating should be done exchanging the information fully with the captain, bearing in mind the marine-work-security-guideline issued by the Japan Marine Surveys Association and should ensure the safety of the study member. The latest overseas safety information from the Ministry of Foreign Affairs should be available, and an early correspondence should be urged at any time.

General operation policies 3: Study Structure for conducting the Project

The control point survey, the hydrographic survey and the supplementary survey were conducted as the field work by collaborating with C/Ps of MPWT/WD. The members of the study team were as follows:

(1) Leader/ General Management (Management and Hydrography and Cartography/ENC)
(2) Sub Leader (Management Group and Hydrography)
(3) Navigator/Survey Operation
(4) Multi-beam Operator, Data Acquisition of Hydrographic Survey /Data Processing (A) and (B)
(5) Land surveyor/Control Point Survey and Leveling
(6) Electronic Engineer in charge of GIS/CAD Operator for Vector Fair sheet
(7) ENC Expert/C & ENC Compilation
(8) Oceanographer/Tide and Tidal Current for Charting
(9) Coordinator

The C/Ps of hydrographic survey were comprised of more than four persons and C&ENC editing were assigned two persons. Briefing and progress of the study have been reported in JCC formed by Minister of MPWT and the representative of JICA Cambodia Office as the common chairpersons and Task Force. C / Ps is also expected to be 8 people by receiving the intention of MPWT / WD in the extension project,

General operation policies 4: Holding Seminar

The workshop regarding the project had been planned at the time of Inception Report Meeting however it was not able to be held at the time. This Workshop was held by C/Ps themselves at PAS in SHV on 21st Dec. 2015 as closing workshop of the Original Project. As for the Seminar on Technology-Transfer aiming at the dissemination and utilization of ENC, which will be the final result of the project, will also be held with the official announcement at the end of this project. The study team will assist and support MPWD/WD so that they can manage by themselves to hold the technical seminar on December 2016.

General operation policies 5: Safety management

The study team and C/Ps shall comply with the JICA safety rules and regulations. Since a high temperature and humidity condition continue in the rainy season, in considering heat exhaustion, taking well water is kept in mind in every day. In order to prevent the disease of infection, such as the disease organ infection and "Malaria", "Japanese encephalitis", etc. through a mosquito, while paying sufficient attention for sanitary conditions such as drinking water, foods, cooking method, it devises for not being bit by the mosquito, by wearing clothes to which hands and feet are not exposed, insecticide etc. A first-aid kit shall be always carried and when abnormalities are felt for condition, it shall take immediately and shall avoid serious illness.

1 - 5 Extension Project

Taking a glance on the recent activity in SHV port, it is characterized by a rapid increase of container ship along with frequent visits of international cruising vessels, larger than 60,000 tons of more the 30 times per year during the dry season.

Given these circumstances, maritime related personnel in Cambodia such as the management of PAS and the pilots that operate the visiting vessels to the port requested the production of ENC for Navigation Purpose 3, a medium scaled chart for coastal navigation, corresponding to BA Chart 2103 scaled at 1/150,000. MPWT had officially requested to extend the original project at the 3rd JCC Meeting held in 22nd April 2015. JICA study team also supported this request indicating that although the series of technical transfer on the digital hydrographic survey and the knowledge of ENC production had been performed ever since the commencement of initial project, further accumulation of empirical knowledge should be a paramount importance to secure the sustainability on the technology of hydrographic survey and compilation of navigational chart in view of their organizational vulnerability.

JICA had started its discussion on the Extension Project with MPWT, following the examination on their request, project area proposed and assistance contained. And finally, both parties, i.e. the Minister of MPWT and the Chief Director of Cambodia JICA Office, agreed and signed in the revised R/D of Minutes of Meeting for the Extension Project on 10th November 2015. The Extension Project itself had duly been performed based on the revised R/D of M/M.

1 - 6 Study Team

Following Table 1 - 3 shows the constituent member and their assignment for the project:

Table 1 - 3 Constituent Member and their Assignment for the Project

Role and Charge	Name	Dispatch Record		Dispatch Numbers	Duration
Study Team Leader	Shoichi KOKUTA	Year 2013	Cambodia	1	50 days
			Japan		45 days
		Year 2014	Cambodia	4	205 days
			Japan		53 days
		Year 2015	Cambodia	3	112 days
			Japan		105 days
		Year 2016	Cambodia	4	139 days
			Japan		37 days
Deputy Team Leader	Toshihisa KAWAIDA	Year 2014	Cambodia	2	44 days
			Japan		
		Year 2015	Cambodia	1	17 days
			Japan		15 days
		Year 2016	Cambodia	2	31 days
			Japan		27 days
Surveys for Control point, Leveling Point and Topography	Takeshi TAKANASHI	Year 2013	Cambodia	1	30 days
			Japan		15 days
		Year 2014	Cambodia	1	14 days
			Japan		7.5days
		Year 2016	Cambodia		
			Japan		10days

Measurements of Tide and Current	Kazufumi WATANABE	Year 2013	Cambodia	1	30days
			Japan		
		Year 2014	Cambodia	1	14 days
			Japan		
		Year 2015	Cambodia		
			Japan		29 days
		Year 2016	Cambodia		
			Japan		20 days
	Kei TAKASHITA	Year 2016	Cambodia	4	42 days
			Japan		10 days
General Direction of Survey Activity	Hisaaki MAKIUCHI	Year 2014	Cambodia	2	152 days
			Japan		
		Year 2016	Cambodia	1	57 days
			Japan		
Digital Hydrographic Survey - 1	Morgan SHIMIZU	Year 2013	Cambodia	1	30 days
			Japan		
	Tokuyuki HASEGAWA	Year 2014	Cambodia	1	92 days
			Japan		
	Shigeru MIYAMURA	Year 2013	Cambodia		
			Japan		15 days
		Year 2015	Cambodia	1	7 days
			Japan		
		Year 2016	Cambodia	3	42 days
			Japan		12 days
Digital Hydrographic Survey - 2	Kittisak WANGKIJWORAKUL	Year 2014	Cambodia	3	228 days
			Japan		10 days
		Year 2015	Cambodia	3	112 days
			Japan		10 days
		Year 2016	Cambodia	3	136 days
			Japan		10 days
GIS, CAD1	Kazufumi WATANABE	Year 2014	Cambodia	1	59 days
			Japan		
		Year 2015	Cambodia	2	94 days
			Japan		
		Year 2016	Cambodia	2	73 days
			Japan		
GIS, CAD2	Takao IKEDA	Year 2016	Cambodia	2	60 days
			Japan		10 days
ENC Production and Technical Transfer	Ichiro NAKAGAWA	Year 2013	Cambodia		
			Japan		30 days
		Year 2014	Cambodia		
			Japan		9 days
		Year 2015	Cambodia	2	20 days

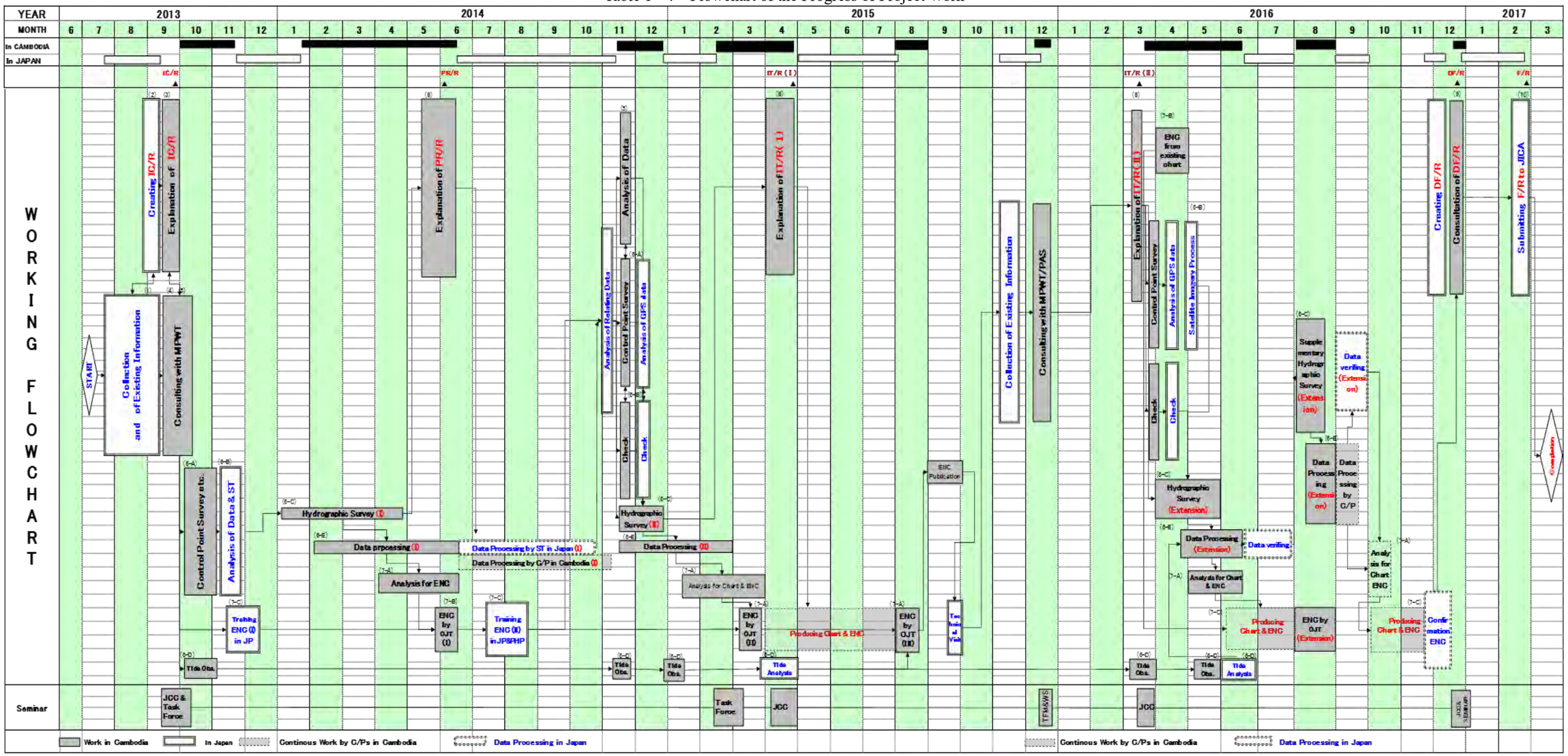
			Japan		12 days
		Year 2016	Cambodia	4	49 days
			Japan		9 days
Coordination of Project Activity and Assistance of Survey Activity	Kei TAKASHITA	Year 2013	Cambodia	1	30 days
			Japan		
		Year 2014	Cambodia	5	87 days
			Japan		
		Year 2015	Cambodia	4	57 days
			Japan		
		Year 2016	Cambodia	1	27 days
			Japan		
	Naomi TAMURA	Year 2016	Cambodia	4	55 days
			Japan		

Note: Dispatch numbers and duration include company's burden.

1 - 7 Progress of Project Work

Following Table 1 - 4 shows the flowchart of the progress of project work.

Table 1 - 4 Flowchart of the Progress of Project Work



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 and RapidEye 5m 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.

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
2) The result of Bench Mark owned by PAS
3) BA Charts around SHV port
4) Tide and Tidal Current Table published by the United Kingdom

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.

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.

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.,

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 accuracy of observation result is satisfied with “overseas survey work regulation” specified by JICA.

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.

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.

(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.

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.

(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
b) To plot GCP points on to the satellite imagery imported
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).

(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.

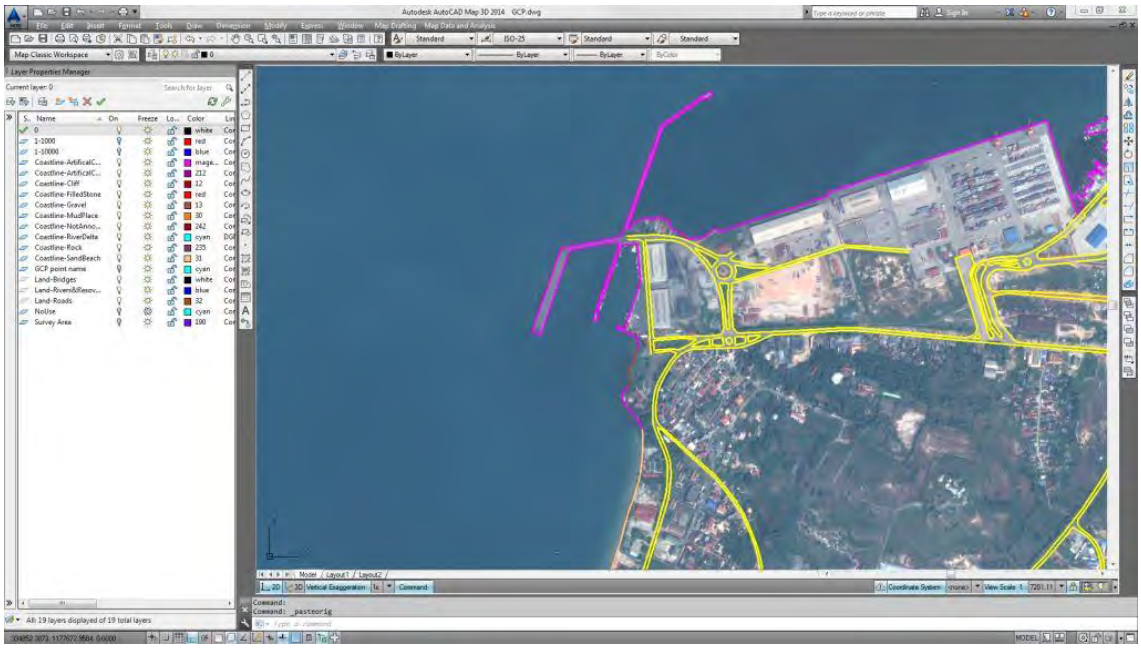


Figure 2 - 1　Shoreline Classified Complying to IHO S-57

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

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.

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 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)

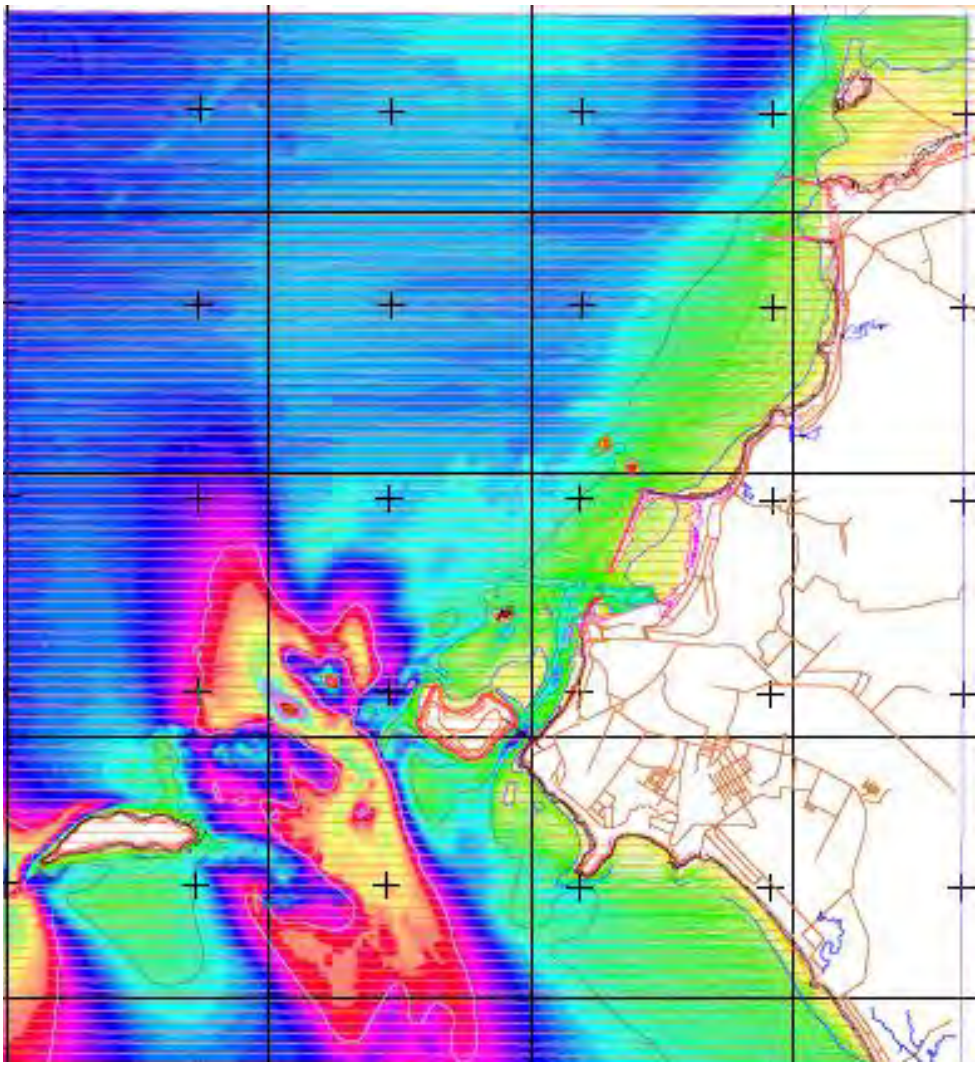


Figure 2 - 2 Quick Report of Colour-coded Depth Map in the Original Project Area

As shown in Figure 2 - 2, 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 - 1 SurveyBoats
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.

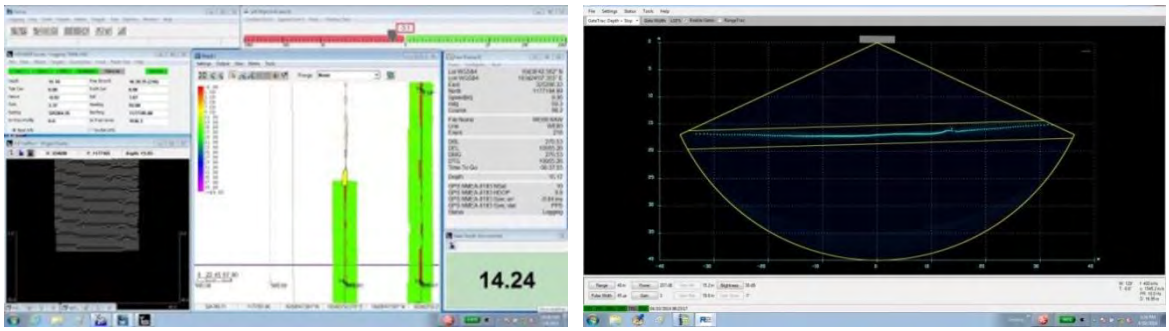


Figure 2 - 3 Navigation Display operated by HYPACK, and Control View of MBES, SONIC 2020

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 - 2 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 - 3 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 - 3 Renovation of Tide Station in SHV

2) 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.

Table 2 - 1 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)	

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.

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.

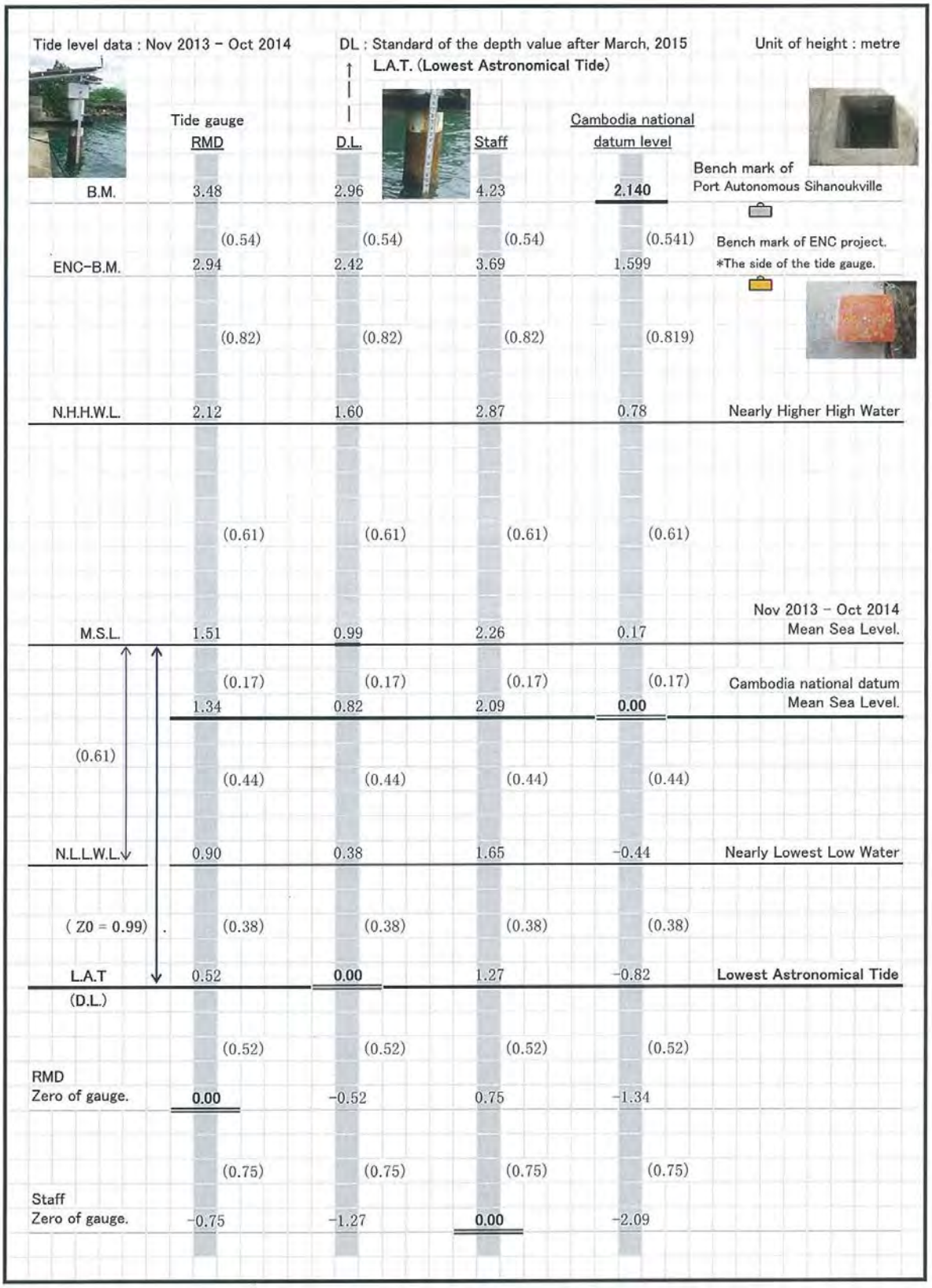


Figure 2 - 4 Final figure of Relation of Height and datum level

(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 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.

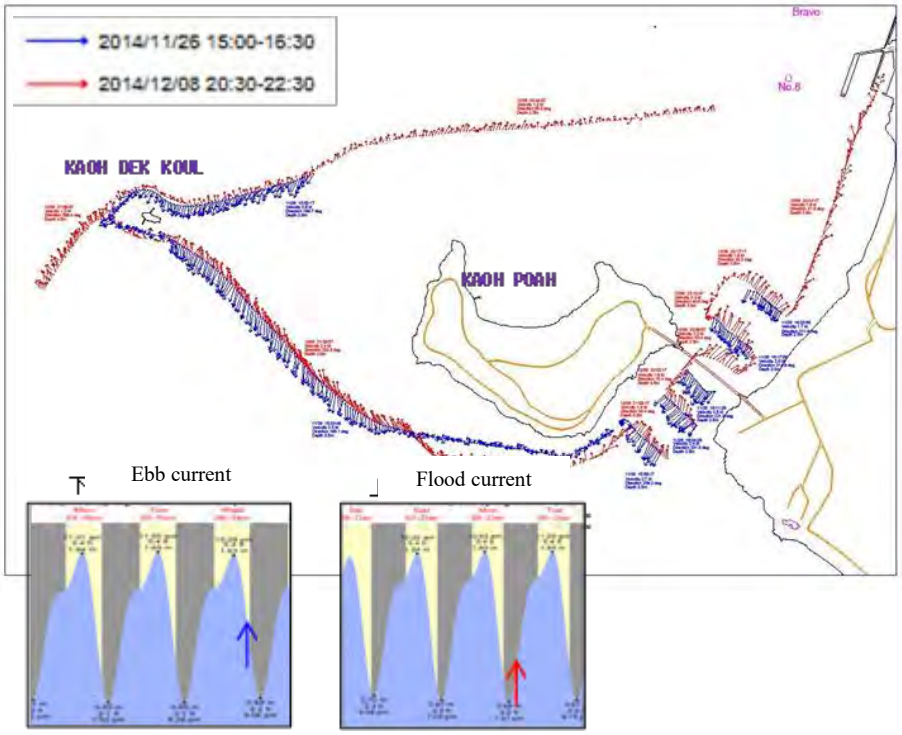


Figure 2 - 5 Results of ADCP Line Transect Current Profiling:
Blue arrows indicate ebb current and Red arrows indicate flood current.

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.

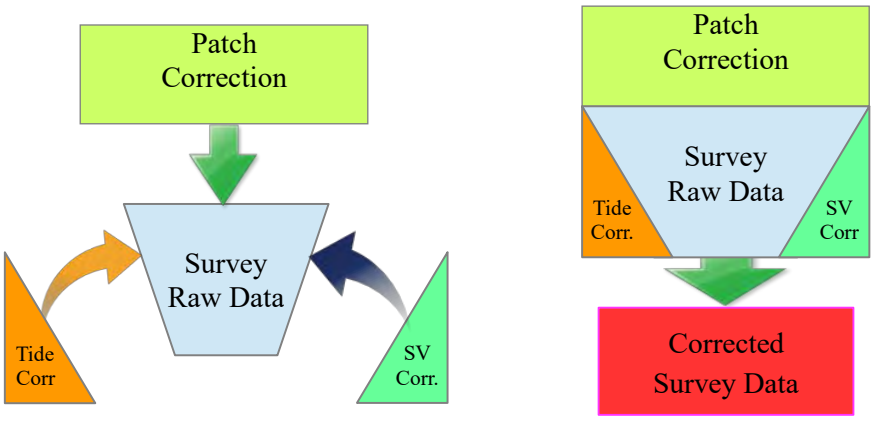


Figure 2 - 6　Survey Raw Data and the relationship of Correction Files

Technology transfer on the process of DHSDPS was carried out to the 4 C/Ps for about 100 days on the basis of OJT. Outline of the data processing . 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

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.

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

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.

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.

(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.

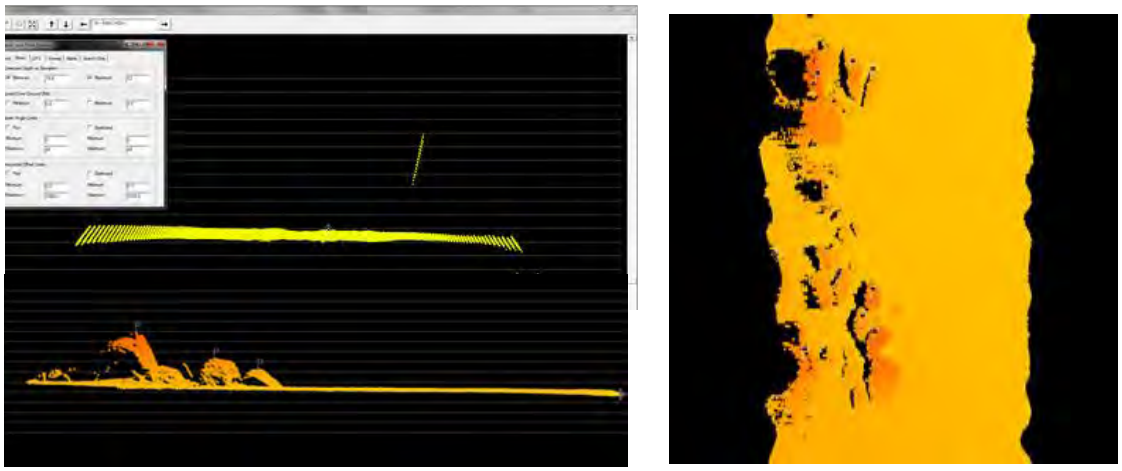


Figure 2 - 7 Left view shows the cross section of rocky reef and Right view shows from top view

(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.

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.

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.

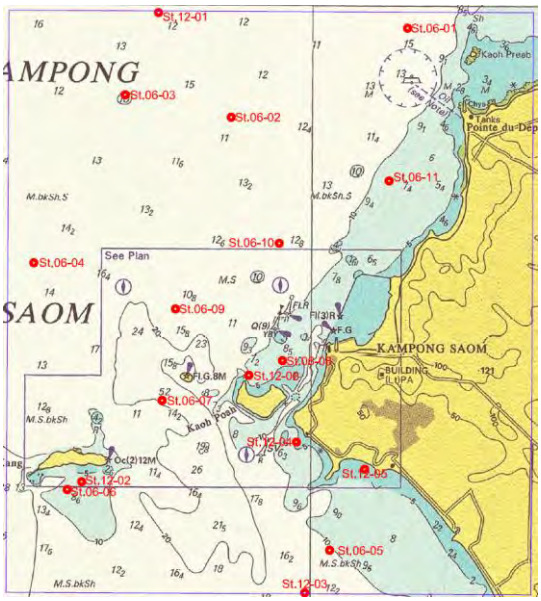
During the Extension Project, inspection of depth data was carried in the same manner. However, the depths of crossing point were inspected, as the adjacent lines were absent in the

Extension Project. There is no any inspected depth sounding exceeding the limit of TVU, which meant the inspected depth sounding accuracy was acceptable.

(5) 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:



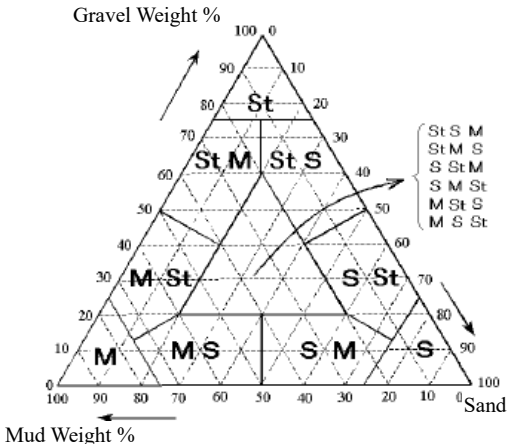


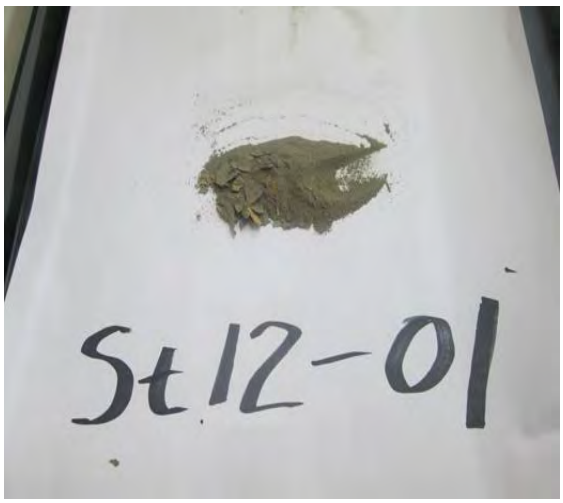
Figure 2 - 8 Location for Bottom Material Identification

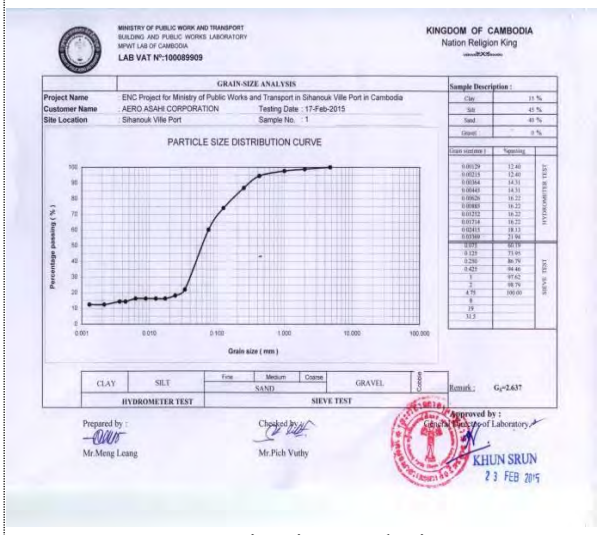
Table 2 - 2 Bottom Material Type and Particle Size

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

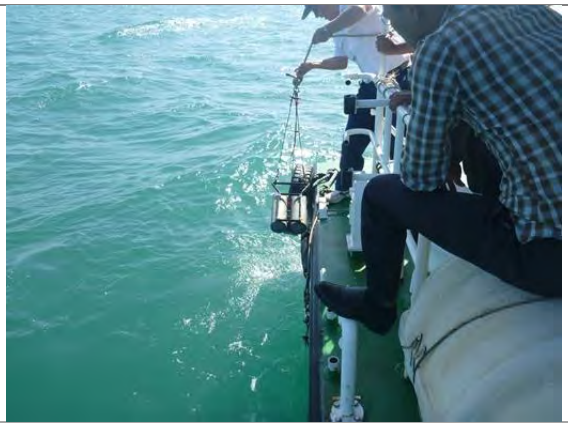
Followings Photo 2 - 4 show the example of bottom sampling

St 1 2 - 01	Date:	2014.12.15





Grain Size Analysis



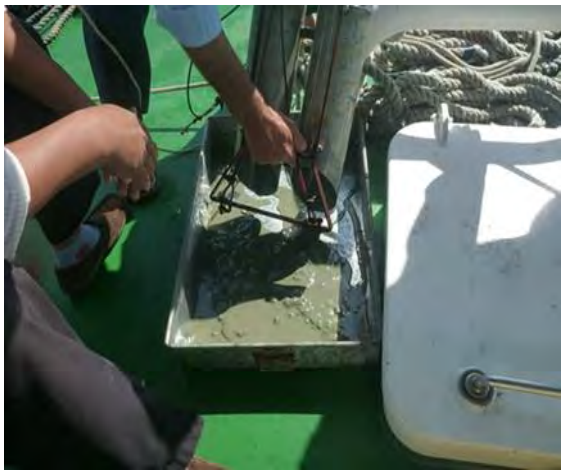


Photo 2 - 4 Example of Bottom Sampling

(6) 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 - 3　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

(7) 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).

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.

(8) 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.

(9) 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 – 9 shows one part of the example of Draft Vector Fair Sheet near SHV port.

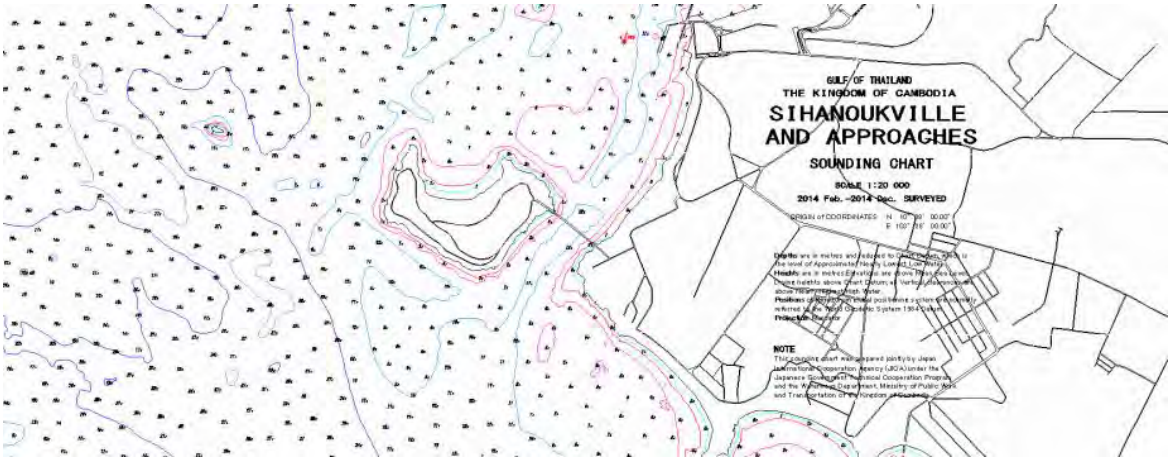


Figure 2 - 9 Example of Draft Vector Fair Sheet near SHV port

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 - 10 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.

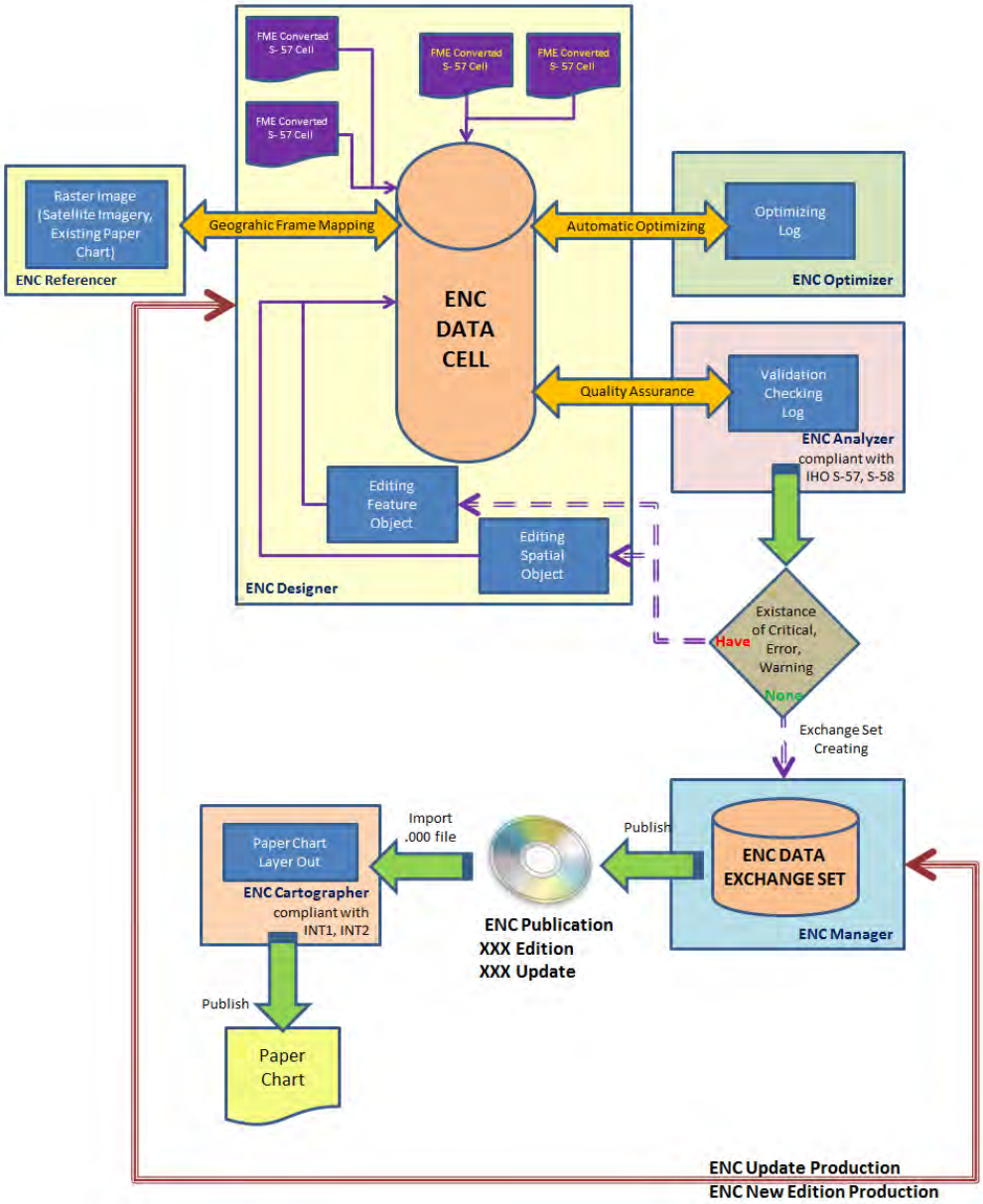


Figure 2 - 10 Flowchart for ENC Production

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.) .

(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 - 4 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

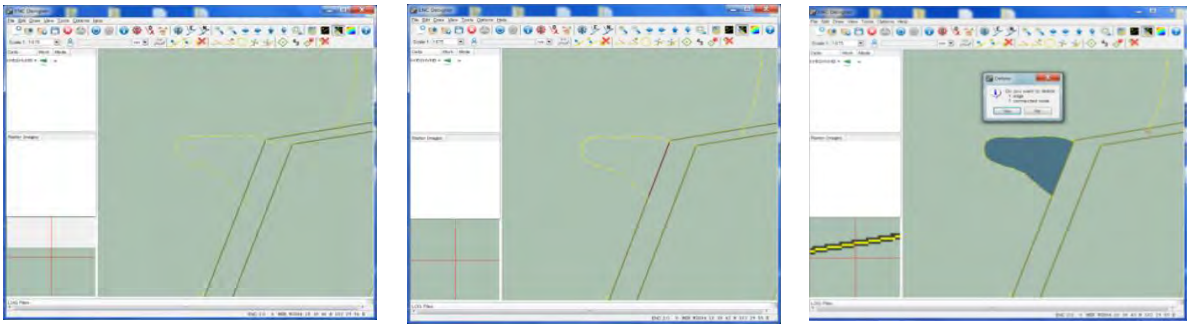
Original Project was designed for Navigational Purpose 5 - Harbour at scale 1/10,000.
Cell Boundaries set the survey area as follows;
North: 10° 45′ 00″, West: 103° 24′ 00″, East: 103° 34′ 00″, South: 10° 34′ 00″

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″

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 - 11 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 - 12)

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)

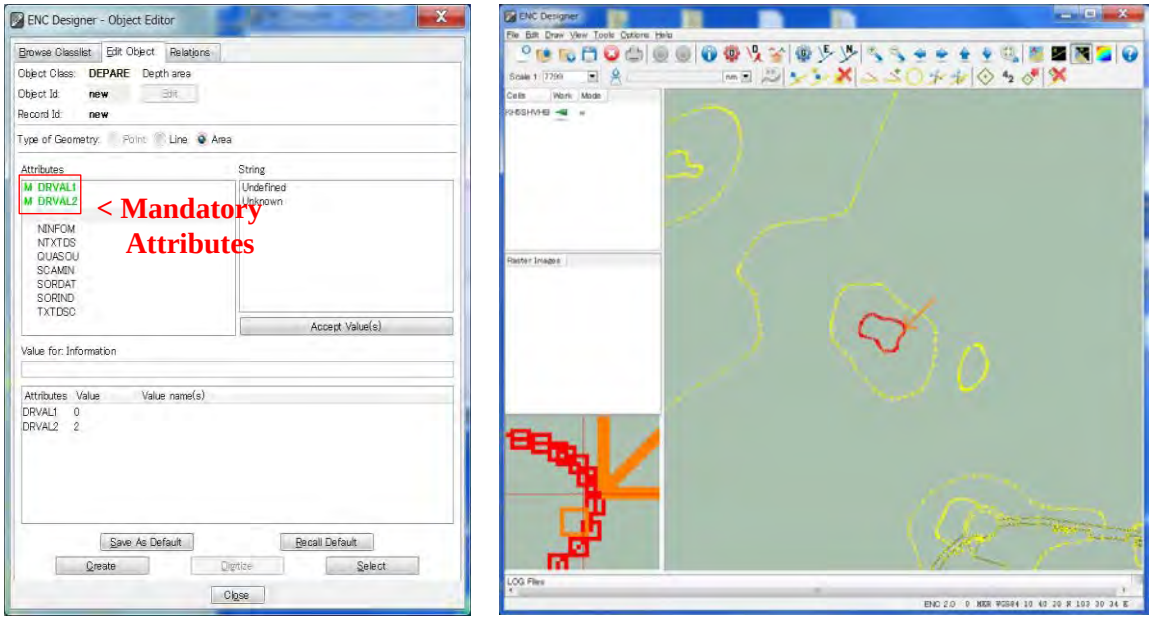


Figure 2 - 12 Creation of Feature Objects Providing ENC Attributes

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.

(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 – 13.

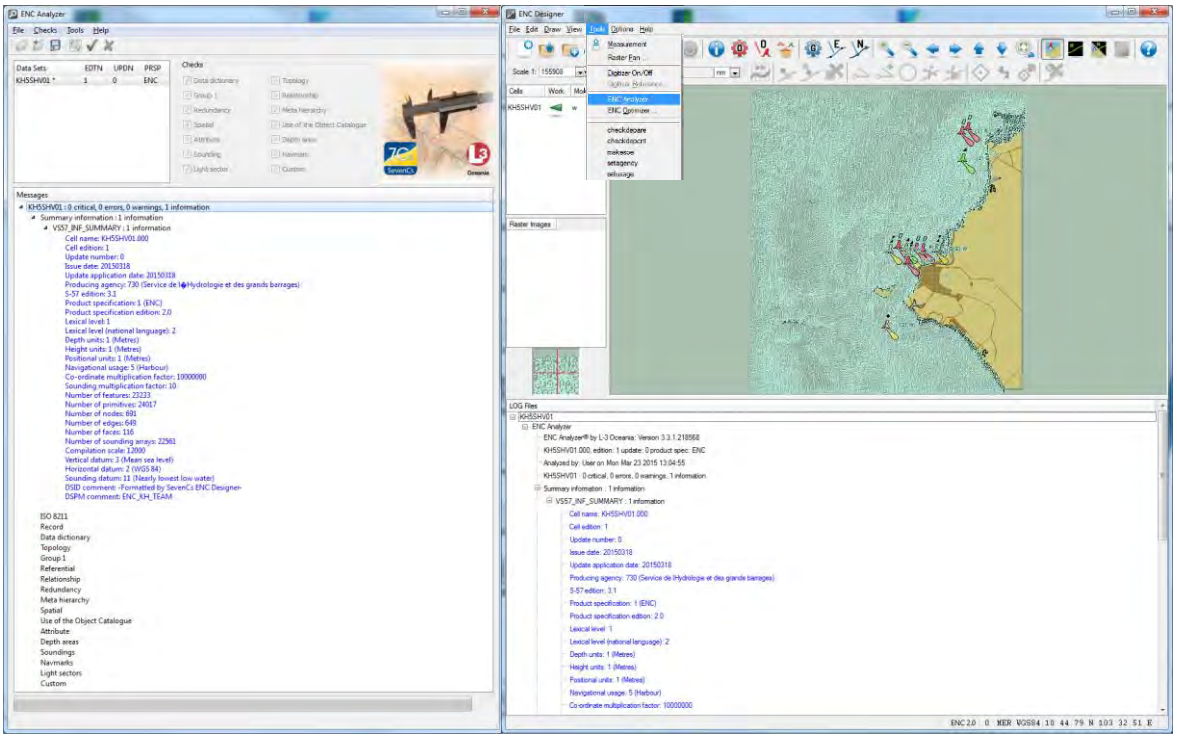


Figure 2 - 13 Display of ENC Designer based on the Result of ENC Analyzer

(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.

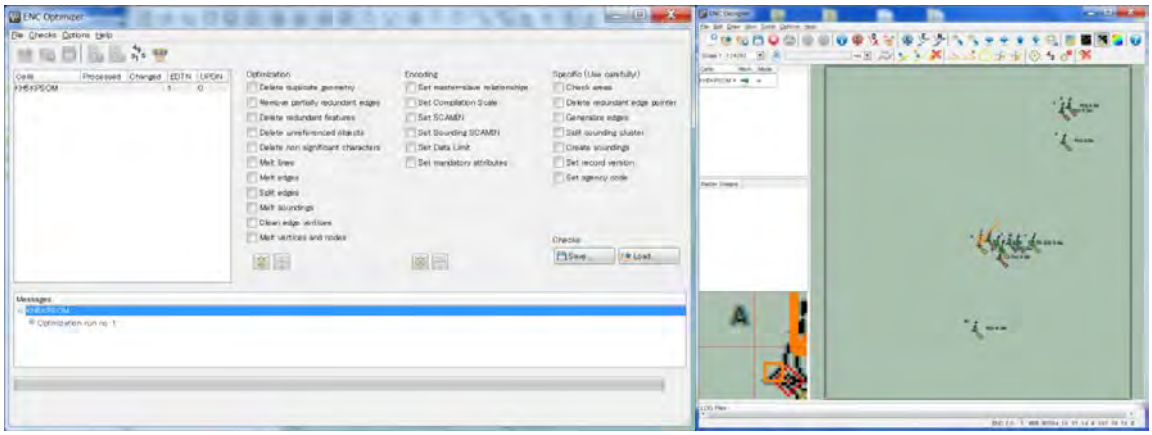


Figure 2 - 14 Example for ENC Optimizer Display

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.

(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.

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 - 15)

- 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)

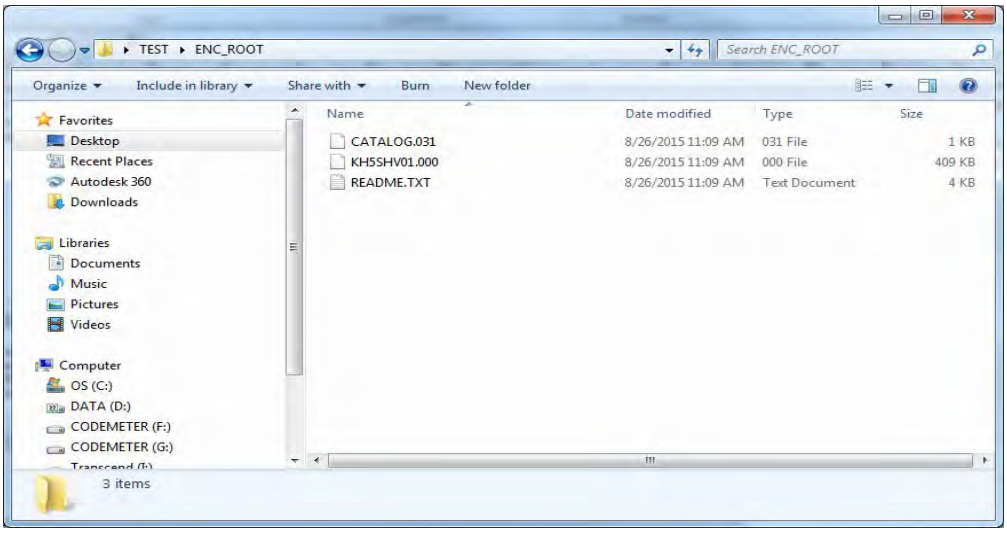


Figure 2 - 15 Directory Structure of ENC_ROOT

[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.

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

Figure 2 - 16 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.

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.

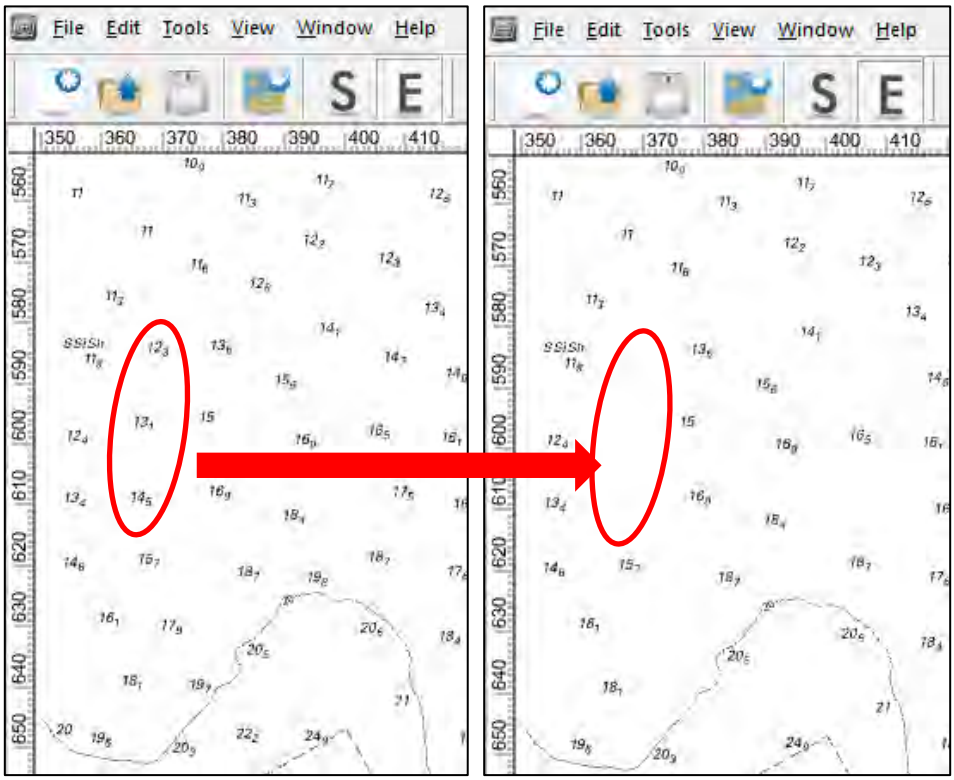


Figure 2 - 17 Depth Sounding Condition Before and After SCAMIN is being applied at a scale of 1/20,000

With SCAMIN data quantity decreased 20% , but in the shallow area (less than 10m) was not thinner.

With these editing processes, the Original Project shown in Figure 2- 18 and the Extension Project shown in Figure 2- 19

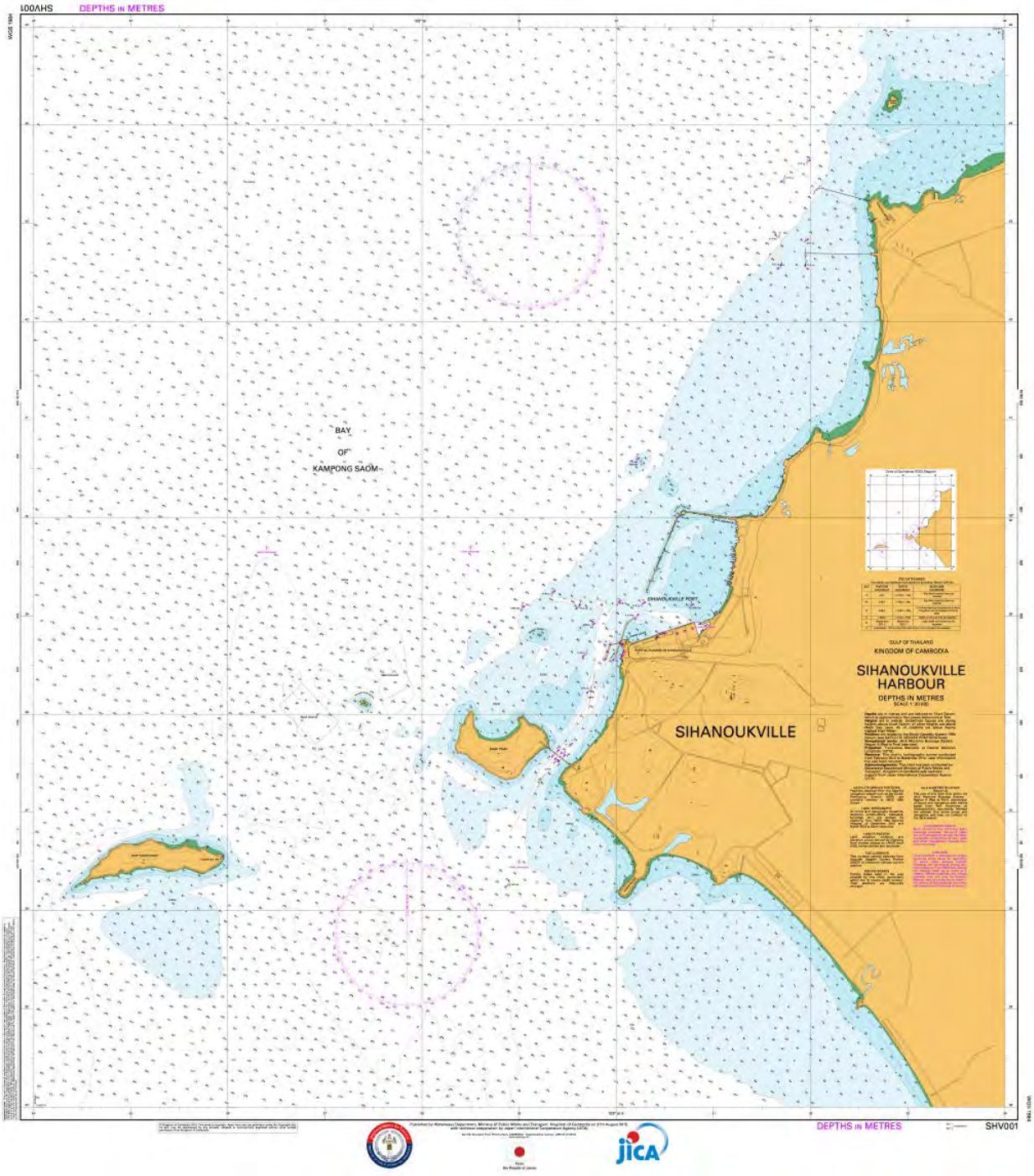


Figure 2 - 18 Finalized Layout of the Chart from ENC Dataset, Original Project

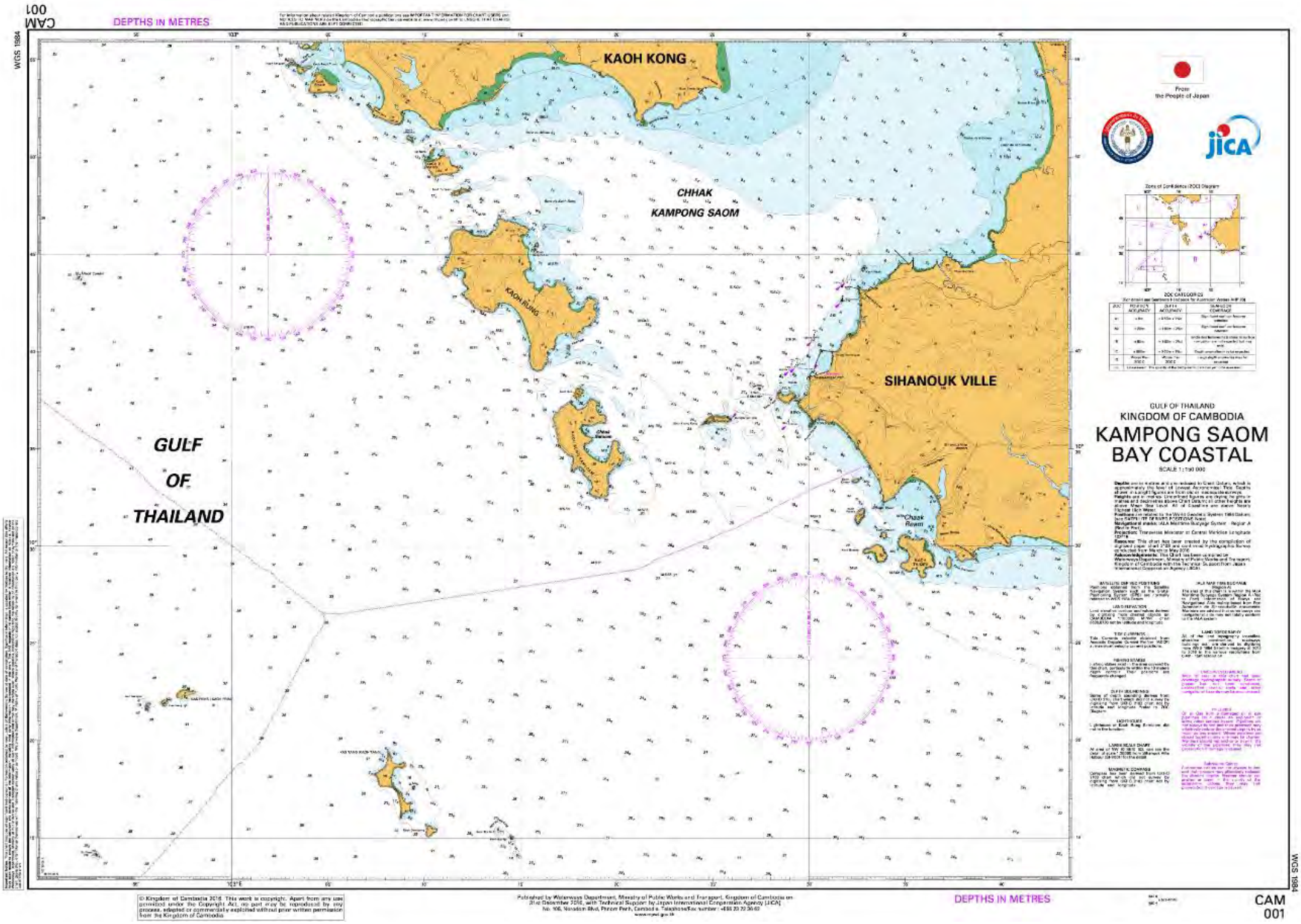


Figure 2 - 19 Finalized Layout of the Chart from ENC Dataset, Extension Project

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 - 20 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.

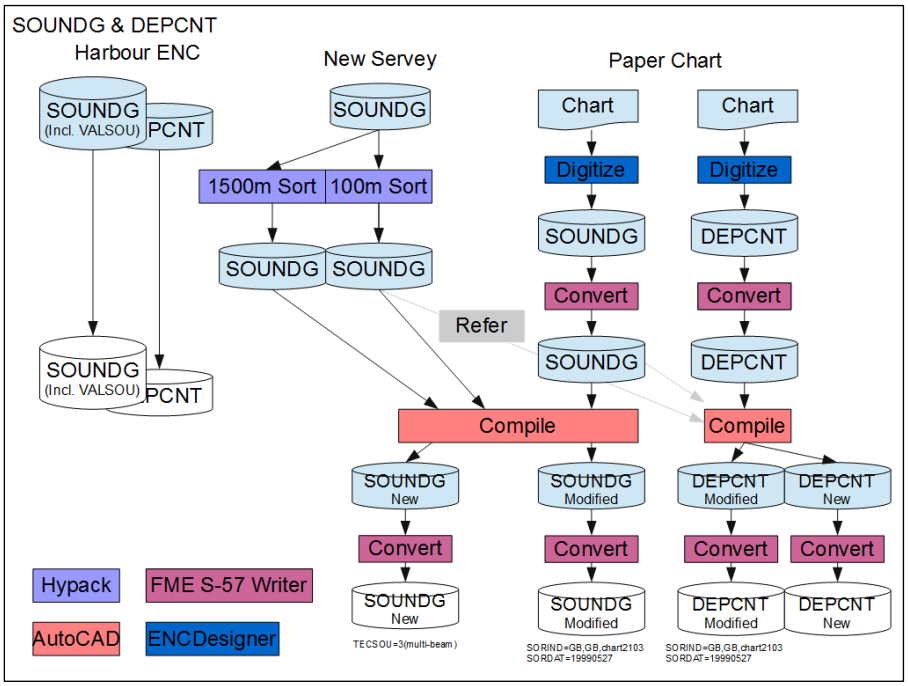


Figure 2 - 20 General Procedures to adopt the depth data and contour line for the ENC

Chapter 3 PROGRESS SITUATION OF TECHNOLOGY TRANSFER

Operations to meet the goal of technology transfer are as followed.

(1) The hydrographic survey and Nautical charting capability in MPWT/WD of Cambodia should be strengthened by carrying out technology transfer, then producing and updating C & ENC can be carried out by themselves.

(2) Moreover, contribute to the strengthening of institutional building to produce an environment to be a member country of IHO, which will be able to publish officially ENCs.
As the result of discussion reached with MPWT/WD, prescription for digital hydrographic survey on the basis of S-44, IHO international standard for hydrographic survey, and ENC production manual based on S-57, standard specification of ENC production, were made to be performed along the technology transfer shown in Table 3 - 1 below:

Table 3 - 1 Outlines of Technology Transfer

No.	Technology transfer	Work descriptions of Technology Transfer	Methods
1	(6) A) Carrying out Geodetic Control Point Survey and Leveling	- Ground control point location determination - GNSS survey - Pricking - Geo-Reference method of Satellite Imagery - Extracting coastline method from Satellite Imagery	Obtainment of each process through OJT
2	(6) B) Processing of Satellite Imagery (delineating shoreline, dried lines and dangerous rock)	- Ground control point location determination - GNSS survey - Pricking - Geo-Reference method of Satellite Imagery - Extracting coastline method from Satellite Imagery	Obtainment of each process through OJT
3	(6) C) Acquisition of Hydrographic survey data	- Digital Hydrographic Survey Date Acquisition - Digital Hydrographic Survey Date Processing - Quality control (accuracy) management - Creation of Vector Fair Sheet - Creation of Operating and Working Manual	Obtainment of each process through OJT
4	(6) D) Tide observation and tidal measurement	- Oceanographic Observation Method (Tidal Level and Current data Acquisition) - Tidal Harmonic Analysis technique - Determination technique for Chart Datum - Quality control management	Obtainment of each process through OJT
5	(6) E) Data Processing of DHS data	- Digital Hydrographic Survey Date Processing - Analog Hydrographic Survey Date Processing - Quality control (accuracy) management - Vector Fair Sheet production	Obtainment of each process through OJT
6	(7) Production of Chart and ENC	- Nautical Charting Method - ENC Compilation Method - Quality control (accuracy) management - Creation of Operating and Working Manual	Obtain process through training in Japan and OJT

3 - 1 Detail of Carrying out Technology transfer

3 - 1 - 1 (6) A) Carrying out Geodetic Control Point Survey and Leveling

(1) September - October 2013

This site work was carried out together with 3 C/P and 2 support staff of PAS. Simultaneously the technology transfer for Geodetic Control Point and Leveling also had been carried out.


Mr. MAK SAMNANG


Mr. ROS SUWANNARITH


Mr. CHHIM MORN


Mr. SEAP SOKUN


Mr. NUON CHANNARITH

Photo 3 - 1 C/Ps and Pilots of PAS who conducted the Control Point Survey

Photo of Geodetic survey and Leveling was carried out at SHV on September - October 2013


GCP 2


GCP 4


NGP 1801B


NGP 18D

Photo 3 - 2 Control Point Survey by means of GNSS

GNSS control point survey was carried out under the guidance of the study team by divided in the 3 parties. To realize the technical transfer in OJT smoothly, procedures on the operation of GNSS was prepared in advance. Last GNSS survey session was requested to carry out by C/Ps team themselves. Study team considers that the C/Ps fully understood the GNSS observation technology.

Study team requested for the C/Ps to prepare the GCP station record, which described the selection of GCP and GNSS observation.


Photo 3 - 3 A Prior Consultation and Ex Post Facto Meeting between Study Team and C/Ps

Photo 3 - 3 shown the baseline analysis carried out by C/Ps after the lecture of GNSS observation given by Mr. Takanashi, Geodetic Survey Expert of the study team, at the room of Chief Security of PAS.

Photo 3 - 4 Leveling Survey


Photo 3 – 5 L: PAS leveling Point and
R: Newly installed B.M. PAS Tide Station

Leveling between ORI01(BM)-Tidal Station

25 Oct. 2013 Fine day no wind (Instrument; Leica)

Measure: Mak Samnang
note : Ros Sovannarith
Staff : Morn Chhim

St.Name	Dis.	Backward	Forward	Differ	Obs.Hieght	Corr.	TruthHeight	Backward	Forward	Differ
ORI01 (Fix)					2.140					
	13	2.330	1.003	1.327	3.467			1.021	2.347	-1.326
	50	0.503	1.613	-1.110	2.357			1.505	0.395	1.110
	30	1.471	1.577	-0.106	2.251			1.517	1.411	0.106
	30	1.334	1.425	-0.091	2.160			1.424	1.336	0.088
	30	1.302	1.603	-0.301	1.859			1.590	1.287	0.303
	15	1.417	1.610	-0.193	1.666			1.567	1.374	0.193
ENC-BM	13	1.373	1.441	-0.068	1.598	1	1.599	1.482	1.413	0.069
				-0.542						0.543
Tamnporary Staff Top			1.285	0.088	1.754	1	1.755	1.326		-0.087
old BM			1.092	0.341	2.007	1	2.008	1.072		-0.341
ORI01 (Fix)					2.140					
	11	1.573	2.097	-0.524	1.616			2.032	1.507	0.525
shore line	9	1.002	2.028	-1.026	0.590	0	0.590	2.022	0.997	1.025
(28 Oct.2013 9:40)				-1.550				(28 Oct.2013 9:40)		1.550

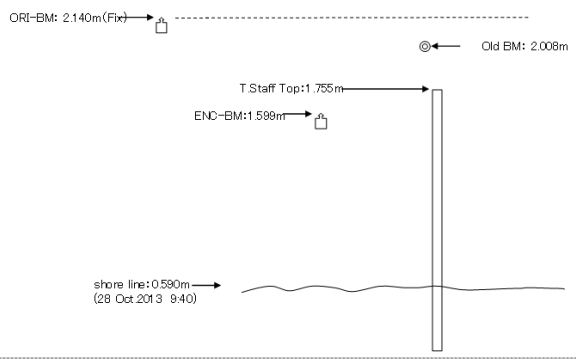


Figure 3 - 1 Field Notebook of Leveling Survey

Photo 3 - 4, Photo 3 - 5 and Figure 3 - 1 shown observed leveling documents.

(2) December 2014

The supplementary survey in order to fix the position and height of navigational marks such as light house was carried out in December 2014. This survey was carried out by the following C/Ps (Shown in Photo 3 - 6) led by Mr. LONG BUNLONG, leader of C/Ps. For the handling and instruction of GNSS equipment, study team prepared the operational manual in advance for them to be used in OJT. It is considered that they understood the methodology of GNSS observation through OJT.


Mr. LONG BUNLONG


Mr. KY CHANNA


Mr. AN VUTHEA


Mr. CHHIM RASMEY


Mr. SOK VANNAK

Photo 3 - 6 C/Ps who had the Training of GNSS

In Photo 3 – 7 Left : GNSS observation carried out on the bridge way to KAOH POAH. To find the position of Navigational Aid : Red lamp and Green lamp. Basically for Navigation Aid information, the study team gathered information from PAS, but there are not the sufficient information about these bridge lamps, so GNSS had been carried out.

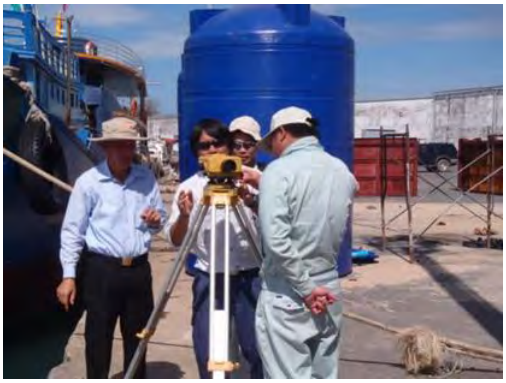


Photo 3 - 7 GNSS Observation and Leveling Survey

In Photo 3 – 7 Right : Leveling survey was carried out again between BM of PAS and the newly installed BM of PAS tide station after 2013 leveling. C/P carried out this survey was well versed in knowledge and experience through the road maintenance project. Therefore, study team asked C/P to conduct leveling survey by themselves after lecture and support while carried out from the study team.

3 - 1 - 2 (6) B) Processing of Satellite Imagery

During the extension project, the training of extraction of shoreline data out of the satellite imagery was carried out using ArcGIS.

Technology Transfer on the accuracy check of satellite imagery and the extraction of shoreline data out of the satellite imagery were made by means of using ArcGIS manufactured by ESRI USA, which was procured for this project. ArcGIS is the comprehensive GIS software used worldwide enabling the processing of vector data and raster data in an advanced technology. C/Ps only knew its name of the software but did not have any experience to use it for their services, so far. Technology Transfer was aimed at contributing not only to use it to this project but also to apply it to their upcoming own services.

(1) Period:

Technology Transfer was divided into two terms, 1st - term, from 19th Apr. 2016 to 1st Jun. 2016, and 2nd - term, from 8th Aug. 2016 to 19th Aug. 2016, and executed simultaneously with the bathymetric survey on the sea. C/Ps were divided into 2 teams, 4 personnel each, and the same training was scheduled individually, proceeding along the manual prepared in advance by the study team.

(2) Contents Execute:

[1st Training]

1) Basic Operation of ArcGIS:
2) Basic Process on Satellite Imagery:
3) Accuracy Check and Geometry Correction:
4) Setting of Feature Templates:
5) Delineation of Shoreline and its Editing:
6) Conversion to CAD:
7) Other Effective Tools:

Following tools were explained to C/Ps as supplemental information:

a) Utilization of LANDSAT imagery:

LANDSAT imagery has a maximum resolution of 15 m, i.e. 15 m in panchromatic imagery and 30 m in multi-spectrum imagery, and has various frequency band in addition to RGB and also plenty of archive operated by the U.S. and available to everyone for download freely once one make an user registration with free of charge. Hence, there will be any possibility to utilize it on various opportunities for C/Ps activity. C/Ps also showed their keen interests on it. Study team explained on the methodologies to download and of display on ArcGIS, creations of RGB imagery, Pan- Sharpened imagery, and etc.,

b) Methodology on Shapefile creation using the location of Geotagged Photographs, developing of photograph on ArcMAP:
c) Import of GPX and KML Files:

[2nd Training]

During the 2nd - term training, reviews and training on setting the coordinate system and adding of location information, geometry correction on raster data without location information, and the explanation on the file interchange between ENC data file and the data set of the File-Geodatabase of ArcGIS mentioned above. Major training conducted is shown as follows:

1) Setting of Coordinate System and Adding of Location Information:
a) Read out the coordinates and collect coordinate system information out of the existing map,
b) Setting of corresponding coordinate system on ArcMAP,
c) Geometry correction on to the scanned data of the existing map,
d) Determination of the necessity for coordinate conversion on the ArcMAP display,
e) Coordinate conversion by the geo-processing process.

2) File-Geodatabase:
  a) Outline of File-Geodatabase structure,
  b) Methodology on the operation of File-Geodatabase,
  c) Methodology on setting the domain, methodology to limit the input value on to the specific attribute field.

[Evaluation]

After the 1st -term training, study tem asked each trainee to give an evaluation by themselves. Following Table 3 - 2 shows its results. There might be some different evaluations from the study team's appraisal because the evaluations were made by themselves. In addition, there were times when some trainees could not participate in the trainings due to the other engagements. However, it seemed that almost all the trainees achieved to a certain degree on the Technology Transfer. Therefore, study team hopes that each trainee would drive their motivation to review the technology where they could not fully understand, and deepen their knowledge referring to the operational manual the study team prepared.

Table 3 - 2 Summary of Self- Evaluation after the Technology Transfer

Technology Transfer Topic			Understanding Level (Please put check mark)			
			Excellent	Good	Fair	Poor
Vector data processing	Basis of ArcGIS	Minimum components of shapefile to open in ArcMAP	0	6	1	0
		Setting the coordinate system	0	7	0	0
		Creating New Shapefile	0	7	0	0
		Basic operation of Geoprocessing tools such as Dissolve	0	5	2	0
		Basic operation of drawing and editing tool	0	7	0	0
		Importing AutoCAD .dwg file into Map document	1	5	2	0
	Drawing Coastlines for ENC	Creating feature template in order to draw features with attribute	1	4	2	0
		Drawing coastline and 0m contour (low tide) line by interpreting satellite images	1	5	1	0
		Importing Shapefile to AutoCAD and separating layers by attribute value	0	5	2	0
Raster data processing	Satellite Image Processing	Adding Satellite images in Map document	1	4	2	0
		Assigning band number to RGB channel in ArcMAP	1	4	2	0
		Pansharpening satellite image	1	3	3	0
	Accuracy Inspection	Adding XY ascii data such as .csv file into Map document and converting it to shapefile	0	5	2	0
		Checking accuracy of georeferenced raster data such as satellite image using ground control points(GCPs)	0	4	3	0
	Geometric Correction	Geometric correction of raster image	0	4	2	1
		Saving modified raster image to another file or dataformat	0	4	2	1

It should be important to understand the significance of setting the coordinate system and the geometry correction, allocating the coordinate information on to the imagery in raster format, which should not be avoided to use the ArcGIS in their job. Based on the key points raised in the Technology Transfer, the practical training of setting the coordinate system and the coordinate conversion were carried out at the 2nd - term Technology Transfer. And, study team also explained that the File-Geodatabase has the capability of managing the ENC data. Study team believes that it's not enough to simply learn the operation of the File-Geodatabase, actually, as it is the highly sophisticated and too much complicated software. Therefore, in a way, sustainability of the Technology Transfer should totally be dependent upon their motivation to learn more in-depth knowledge and the strong will to achieve the objectives. However, each trainee is believed to acquire another measures in hand to approach to the issues, and expected to tackle them in different methodology for the solution. Study team hopes that each trainee would work more hard and try again and again to commit their responsibility.

3 - 1 - 3　(6) C) Acquisition of Hydrographic survey data

Refer to shown at Chapter 2 - 6 - 4 following technology transfer held by OJT.

(1) Preparing MBES survey project with HYPACK

1) Creation of New project and setup following geodetic coordinates to the HYPACK

2) Creating Survey Plan line

(2) Installing equipment in survey boat

1) Equipment installation

With the support from PAS's mechanics, the customized attachments and modified patrol boat to install equipment were made and carried out (shown in Photo 3 - 8).

The outfitting/installation of DHSDAS to survey boat are affected on accuracy of Multi-Beam sounding as discussed below. Therefore, the OJT training of the outfitting/installation and its release were done respectively by C/Ps divided into two groups because the sustainable technology transfer is very important too, after closing the supplementary survey at the second Hydrographic survey.

Photo 3 - 8　Survey Boat, PAS Patrol Boat; “KOH DEKKOL”, and Installation of Transducer to the Side Frame of Hull

2) Measure distance between equipment with origin point

Measuring from origin point 0,0 (center of motion sensor) to installed equipment at the survey boat to find out equipment offset, then input to HYPACK.

3) Setting for HYPACK hardware and HYWEEP hardware to recognize equipment installed with HYPACK and input equipment's offset value.

(3) Data Acquisition process in Digital Hydrographic Survey

Sound velocity measure was carried out by sound velocity profiler (AML Minos X) to correct sound velocity and reflection for the raw data of DHSDAS in each day of survey. The survey boat has been navigated and surveyed by captain/operator to insure for safety of ship, crews, operator, and maximize efficiency in time and fuel for data acquisition and a crew has been assigned for observing any possible dangers, contacting with other ships for safety. These knowledge, technique, mechanism including boat maneuvering, mechanism, important watch of survey-navigation and maintenance of equipment etc. are transferred with OJT.

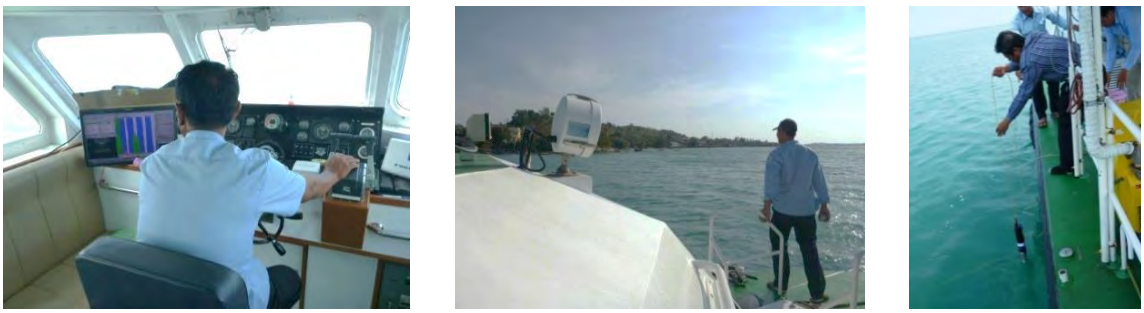


Photo 3 - 9　Survey Boat's Navigation, Lookout and SVP Operation

(4) Technology transfer for data acquisition

There existed some differences on hydrographic survey capabilities of each trainee, especially in multi-beam sounding capability, even with their completion of JICA group training on Hydrographic survey. In order to keep the hydrographic survey to proceed smoothly, following measures and steps have been established as a technology transfer to make it effectively, discussing with C/Ps.

1) Lectures on DHSDAS:

Training on DHSDAS was so planned that C/Ps could memorize important things using whiteboard, and tried to have them take memo in their notebook, as there were not any reference materials for training from the very beginning. The time for Q&A were held for the trainees in order not to leave any uncertainties after the training

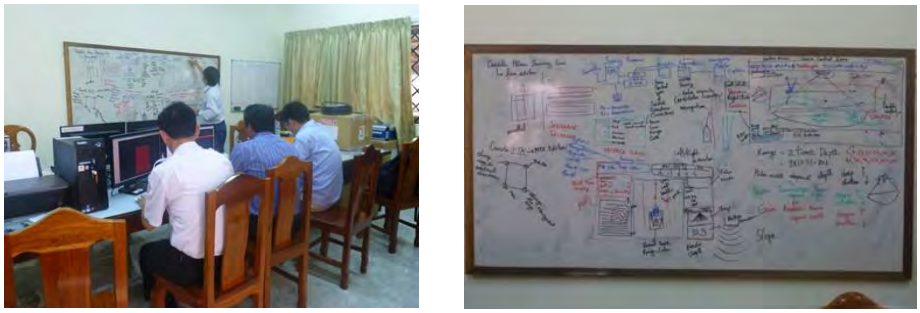


Photo 3 - 10　Lectures on DHSDAS by using Whiteboard

2) Lecture Methodology:

The trainings on operations of equipment and software were lectured by the study team, in addition to the review work. After the lecture given by the study team, a series of operation of each items using equipment and software were also requested for each trainee to operate individually, and confirmed their understanding. Study team requested to the well versed trainee to give necessary explanation and operation to the trainees, who were not yet understood the operation.

Photo 3 - 11　Training on DHSDAS

3) OJT on Operation and Maintenance of Survey Equipment guided by Study Team:

Photo 3 - 12 Training of System Operation and Maintenance guided by the Study Team

4) Gain the experience form OJT with the support from the study team member

Photo 3 - 13 OJT on MBES on board the Survey Boat

5) Proficiency Rating by Each Trainee:

Following Figure shows the proficiency rating by each trainee to evaluate their own operational knowledge on the DHSDAS, which would be helpful for study team to frame a Technology Transfer

Cambodia ENC 2014 – Sihanoukville harbor and surroundings
Understanding Level Questionnaires in Technology Transfer

Name : LONG DUNLONG Team : 2 Rotation Time : 01 Date : 10 Feb 2014 ~ 23 Feb 2014

Technology Transfer Topic			Understanding Level (Please put check mark)				Comments
			Excellent	Good	Fair	Poor	
Hydrographic Survey	Digital Hydrographic Survey Data Acquisition	MB Equipment installation			✓		
		HYPACK setting for MB data acquisition (Geodesy, HYPACK HARDWARE, HYSWEEP HARDWARE)			✓		Relation between Geodesy survey + Sound (MB) survey.
		Navigation preparation (Coastline, MTX, Plan line)			✓		Geo. reference setting.
		MB Data acquisition(Data logging, Target creating)		✓			
		Survey ship navigation		✓			
		MB Patch test			✓		
		Sound velocity profiling		✓			
		Data backup from ship		✓			
		MB Equipment maintainance			✓		
		Safety issues for hydrographic survey		✓			
	Digital Hydrographic Survey Data Processing	Create Tide corrections file		✓			Need more trained about AutoCAD
		Create Sound Velocity corrections file		✓			
		Calculate Patch correction			✓		3D Map HYPACK
		Convert Raw to Corrected – Phrase 1		✓			HARDWARE & HYSWEEP
		Noise deletion (Line survey base editing) – Phrase 2		✓			HARDWARE setting.
		Save in HS2 file format		✓			
		Create MTX files		✓			
		Create tracklines			✓		
		Create line reports			✓		
		Create plot sheet by HYPLOT			✓		

Figure 3 - 2 Proficiency Rating made by Trainee on the Questionnaire

6) Operational Manuals on DHSDAS:

In order for trainees to facilitate the hydrographic services, the label of each equipment was translated into Cambodian language, and created operational manuals of DHSDAS.

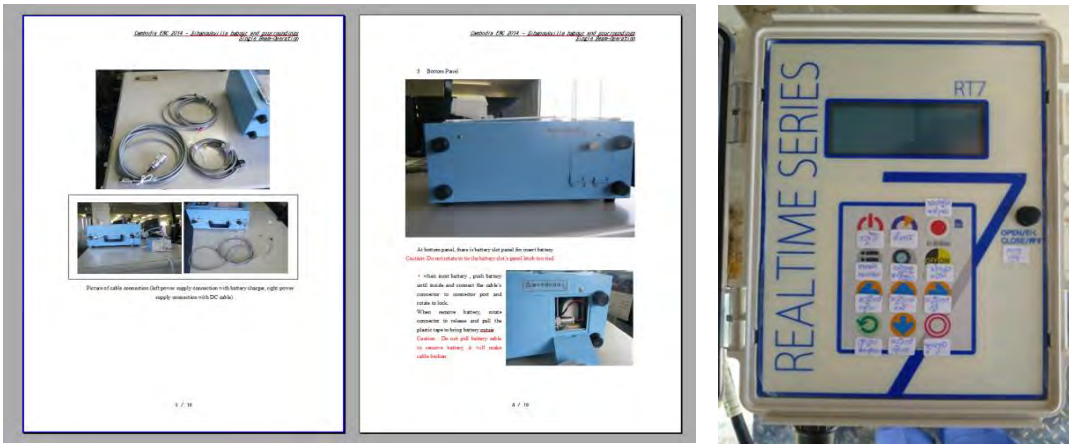


Figure 3 - 3 Operations Manuals in English, and labels in Cambodian Language

Study team requested C/Ps to evaluate by themselves giving their proficiency rating on the right columns Figure 3 - 2 every month. Individual trainee was trained separately referring to their evaluation. The C/Ps were divided into 2 parties that each of them could operate different operations, e.g. when one party worked on 1st - term hydrographic data processing, the other party devoted reviews on the hydrographic data acquisition.

Specific hydrographic survey was designed in the northern offshore of the project area, in front of the power plant where the water depth was 8 m and some light buoys were installed, at which the bulk ore carrier operated berthing and deberthing only when its high tide. The objective was to improve their skills in digital hydrographic data acquisition, which was operated for 1 week, alternately. And, This was the request from MPWT. It was operated on Dec. 2014, and the digital acquisition was carried out accordingly following to the procedures stated in the above.

The above DHSDA was conducted only by C/Ps except ship operation according to the procedure described above 3 - 1 - 3 (1), (2) and (3). The technology transfer of DHSDAS thought by the study team did not proceed at the first hydrographic survey period in reason of all C/Ps being seasick because of first experience of sea work, rough sea, and the effect of cross-cultural for this mission, however it is considered that C/Ps have learned knowhow with a certain level of DHSDAS including installation work by the additional MB sounding at the second hydrographic survey period. The following Power Point screen is presented by C/P at the 4th Task force Meeting.

Supplemental knowledge and skills were replenished on the uncertainty operations and etc. by the study team during the extension project, although the basic operations were almost the same.

During the extension project, the C/Ps undertook a series of operations from the survey designing, rigging of equipment, bathymetric survey, de-rigging and maintenance of survey equipment. Study team also accompanied each operation and advised if necessary and induced trainees to be able to reach an appropriate solution by themselves once the operational issues and/or problems occurred even after the project.

3 - 1 - 4　(6) D) Tide observation and tidal measurement

The Tide observation point for the determination of the chart datum on sea area around SHV port and for correction of sounding raw data, and the current observation method for acquiring current information described in the nautical Chart and ENC were guided by OJT. Items of technology transfer are as follows.

(1) Theory of Tide and Tidal Current Observation

(2) Operation and Maintenance for Short and Long Term Observation for Tide Gauges

1) Installation of Short Term Type-Tide Gauge

Short Term Type-Tide Gauge was installed at the same station in order to compare the tidal records of tide gauge (RMD5225WL-B), hence the comparative observation of tides was carried out simultaneously.

Photo 3 - 14　Comparative Observation of Tides between “RMD5225WL-B” and “RT710”, Simultaneously

(3) Method of Simultaneous Tide Observation and Reduce-ratio Calculation

(4) Method of Tide and Tidal Current Harmonic Analysis

(5) Determination Method of Chart Datum (Lowest Low-water)

3 - 1 - 5　(6) E) Data Processing of DHS data

After finished data acquisition, DHSD and technology transfer have been carried out as the following step.

(1) Tidal correction and sound velocity correction have been done by the function of HYPACK with DHSDPS.

1) Creation of Tide Correction File

2) Creation of Sound Velocity Correction File

3) Creation of Patch Correction Data

C/Ps had experienced and finished these series of corrections above by themselves from the data acquisition to the respective processes using HYPACK.

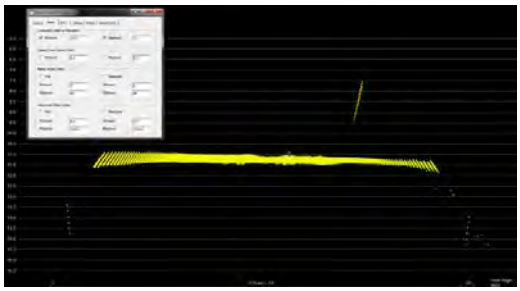
(2) Noise Reduction Processing

Processing of noise reduction, which took much time, was carried out as OJT in Cambodia and Japan by the following steps.

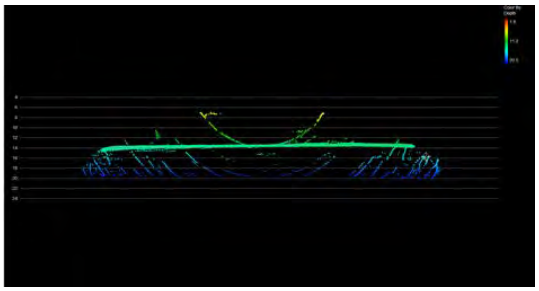
Applying automatic filter to delete noise/false data quickly and efficiently.

1) Manual editing using interactive processing to delete noise and false bottom was carried out by means of HYSWEEP EDITOR,

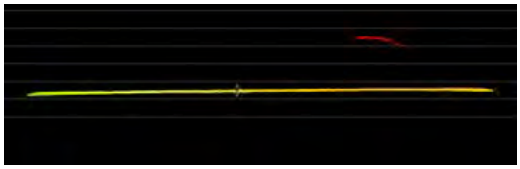
2) During the manual editing, as the trainees did not have enough knowledge and experience yet to identify noise and false bottom, study team made the noise sample sheet by using the screen capture for C/P.



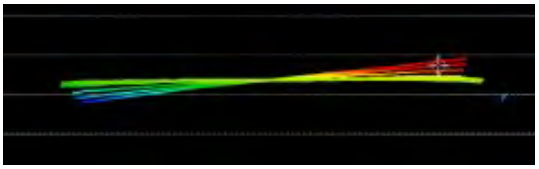
Normal noise



Fishnet tangled up in transducer



Fishing net or floating debris in water column



Errors of motion sensor due to rough sea

Figure 3 - 4　Samples of the noise data in the noise sample sheet

3) As the chart's important information, critical seafloor topology of outcropped rocky bottom or EO (Extraneous Object) were put the flag at the top to determine the minimum depths.

(3) Area Based Data Processing

After finishing the noise deletion in all of each survey line, area-based noise deletion was made by uniting the survey line data. Processing time can be reduced to some extent by applying the automatic filter used in the noise reduction on survey line. And then, manual deleting of noise/false data was undertaken considering the harmonization of depths with adjoining sounding lines and cross lines. C/Ps worked on the deletion of noise and false data processing on all the area-based profiles of each adjoining survey line.

(4) Data Processing Management

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.

(5) OJT and Feedback

On the data analysis, especially on depth data analysis, it was likely to waste the processing time during the OJT. C/Ps made the inspection mutually within the process of work. Feedback lecture was also made to C/Ps after they completed the inspection. Thanks to the mutual cooperation, OJT was complete as scheduled, whereas some of the member could not participate the training from time to time due to the other engagement and conferences.

An intensive training was scheduled to the younger generation of trainees, especially Mr. Sok Vannak, as the expert for data processing, considering the future project.

Attention for this intensive training was to aim at the development of his skills to other trainees in the Echo-Training. The assigned trainee for intensive training also participated in the JICA Collective Training, Hydrography for Charting and Disaster Management, for 6 months, from Jun. 2016 to Dec. 2016.

3 - 1 - 6 (7) Production of Chart and ENC

(1) The 1st ENC Training; Basic Knowledge

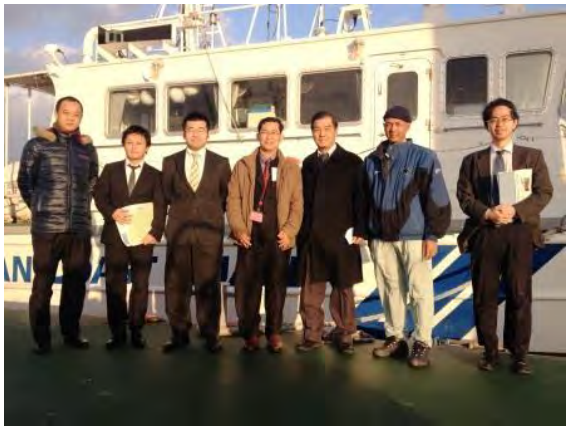
The 1st ENC training has been conducted to the 2 C/P as to the ENC contents, the method and the schedule at JICA Tokyo, for 27 days from 1st Dec. to 27th Dec. 2013. Following Table 3 - 3 shows the summary of the 1st ENC training:

Table 3 - 3 Schedule of 1st ENC Training in Japan

Date		Contents	Method	Instructor
		Shoichi Kokuta: Aero Asahi Corporation (AAC) Ichiro Nakagawa: Terra Corporation Katsutoshi Naijoh: Japan Hydrographic Association (JHA)		
30-Nov-13	Sat.	Two trainees travelled to Japan		
1-Dec-13	Sun.	Trainees arrived at Narita		
2-Dec-13	Mon.	Briefing / Skill Check /visit JCG	Lecture	S. Kokuta and I. Nakagawa
3-Dec-13	Tue.	Training ENC/Chart Knowledge (1)	Lecture	S. Kokuta and others
4-Dec-13	Wed.	Technical training of ENC	Lecture	S Kokuta and I. Nakagawa
5-Dec-13	Thu.	Training on S-57 standard	Lecture/Practice	I. Nakagawa
6-Dec-13	Fri.	Outline of ENC Designer / visited JHA	Practice/Visitation	I. Nakagawa/ S. Kokuta
7-Dec-13	Sat.	Day off		
8-Dec-13	Sun.	Day off		
9-Dec-13	Mon.	Training on ENC Reference	Lecture/Practice	I. Nakagawa
10-Dec-13	Tue.	Chart Knowledge (2) (3) (4), Datum Level	Lecture	K. Naijoh
11-Dec-13	Wed.	Cell and meta / convert Geo- Datum	Lecture/Practice	I. Nakagawa
12-Dec-13	Thu.	Feature and topology	Lecture/Practice	I. Nakagawa
13-Dec-13	Fri.	International ENC / Visit AAC	Lecture/Visitation	S. Kokuta
14-Dec-13	Sat.	Day off		
15-Dec-13	Sun.	Day off		
16-Dec-13	Mon.	How to digitize using ENC Designer	Lecture/Practice	I. Nakagawa
17-Dec-13	Tue.	How to digitize using ENC Designer	Practice	S. Kokuta and others
18-Dec-13	Wed.	How to create feature objects	Lecture/Practice	I. Nakagawa
19-Dec-13	Thu.	Quality management/use -Inspector	Lecture/Practice	I. Nakagawa
20-Dec-13	Fri.	6th JCG Headquarters(Hiroshima)	Visitation	S. Kokuta
21-Dec-13	Sat.	Training Tour (Kyoto)	Tour	S. Kokuta
22-Dec-13	Sun.	Return to Tokyo		
23-Dec-13	Mon.	Day off		
24-Dec-13	Tue.	How to update/distribute ENCs	Lecture	S. Kokuta
25-Dec-13	Wed.	Making exchange set / Install ENC	Lecture/Practice	I. Nakagawa
26-Dec-13	Thu.	Skill Check / Evaluation Meeting	Questionnaire	S. Kokuta and I. Nakagawa
27-Dec-13	Fri.	Trainees travelled back to Cambodia		

Lectures on ENC at JHOD on 2 rd Dec. 2013

Lectures on ENC at JHOD on 2 rd Dec. 2013



Visit 6th Regional HQ of JCG on 20th Dec. 2013

Lecture about ENC on 10th Dec. 2013

ENC Training at Terra Corp. on 25th Dec. 2013

Evaluation Meeting at JICA on 26th Dec. 2013

Photo 3 - 15 ENC Training on December 2013 in Japan

There were some uncertainties on the result of training for ENC at the beginning. But Mr. Long Bunlong, (one of the trainees) was familiar with diversified technologies of IT and GIS. He was expected to be an ENC expert and the chief of C/Ps to train the other C/Ps.

(2) The 2nd ENC Training; In-service Training

The 2nd ENC training has been carried out in Japan and the Philippines as to the following contents and schedule from 27th Jul. 2014 to 23rd Aug. 2014. At the beginning, the trainee had lectures on ENC in Japan for 1 week. Then, the training in the Philippines has been carried out under the "Third-Country-Training" at the National Mapping Resource Information Authority (NAMRIA), which had already obtained the high evaluation among the JICA technical cooperation projects that achieved the objective of "The project for supporting ENC Production of the Philippines", implemented in 2000 - 2004 (For more detailed information refer to Interim Report). Following Table 3 - 4 shows the summary of training in Japan and the Philippines:

Table 3 - 4 Schedule of Training in Japan and the Philippines

2nd ENC Training Schedule; in Japan and the Philippines				
Year/Month/Date		Summary of Activity	Training Contents	Lecturer
2014			Shoichi KOKUTA, AAC Ichiro NAKAGAWA, Terra Corp. Kittisak WANGKIJWORAKUL, AAC Dante, ENC staff in NAMRIA	
27th Jul.	Sun	Arrival of Trainee in Narita		
28th Jul.	Mon	Briefing, Visit JHOD	Courtesy call /Lecture	S. Kokuta
29th Jul.	Tue	Review on ENC knowledge	Lecture	S. Nakagawa
30th Jul.	Wed	Review on ENC knowledge	Lecture	S. Nakagawa
31st Jul.	Thu	Training on vectorization technique of digital data	Lecture/Training	S. Nakagawa W. Kittisak
1st Aug.	Fri	Training on ENC production adopting vectorized data	Training/Field trip	S. Kokuta S. Nakagawa
2nd Aug.	Sat	Travel from Narita to Philippines		
3rd Aug.	Sun	Day off		
4th Aug	Mon	Visit NAMRIA	Courtesy call/ Discussion	S. Kokuta
5th Aug.	Tue	Trial production of ENC near SHV	Training	S. Kokuta W. Kittisak Dante
6th Aug.	Wed	Lectures on ENC production using hydrographic survey results at NAMRIA	Lecture/Training	-ditto-
7th Aug.	Thu		Lecture/Training	-ditto-
8th Aug.	Fri		Field trip	-ditto-
9th Aug.	Sat	Day off		
10th Aug	Sun	Day off		
11th Aug	Mon	Visit NAMRIA Head Quarters. Trial production of ENC using part of the existing	Training	S. Kokuta W. Kittisak Dante
12th Aug	Tue		-ditto-	-ditto-

13th Aug	Wed	chart under the instruction of lecturers of NAMRIA.	-ditto-	-ditto-
14th Aug	Thu		-ditto-	-ditto-
15th Aug	Fri		Visit NAMRIA's survey vessel	S. Kokuta W. Kittisak
16th Aug	Sat	Day off		
17th Aug	Sun	Day off		
18th Aug	Mon	Evaluation of trial ENC produced in the previous week	Lecture/Training	S. Kokuta W. Kittisak Dante
19th Aug	Tue	Re-produce of trial ENC based on the review	-ditto-	W. Kittisak Dante
20th Aug	Wed	Preparation of ENC in SHV	-ditto-	W. Kittisak Dante
21st Aug	Thu	Discussion on ENC production with ENC staff of NAMRIA	Qs & As	S. Kokuta W. Kittisak Dante
22nd Aug	Fri	Evaluation Meeting Presentation of diplomas	Evaluation meeting	S. Kokuta JICA Philippines
23rd Aug	Sat	Trainees traveled from Manila to Phnom Penh		

ENC Training at NAMRIA

MPWT's executives visiting

Presentation of Diplomas by JICA Philippines; Lecturers of the Third-Country Training

Photo 3 - 16 Third-Country-Training on August 2014

What was worthwhile for the successful completion of the Third-Country-Training was the preliminary visit to NAMRIA by the Study Team Leader of JICA, and he requested the cooperation for ENC training to Deputy Director of NAMRIA and discussed on the arrangement with the technical staff of ENC. It was considered that it was effective to have them the Third-Country-Training given by the ex-trainees in the previous Technical Assistance Project of JICA. Following maps show the paper chart and ENC produced as the products of Third-Country-Training.

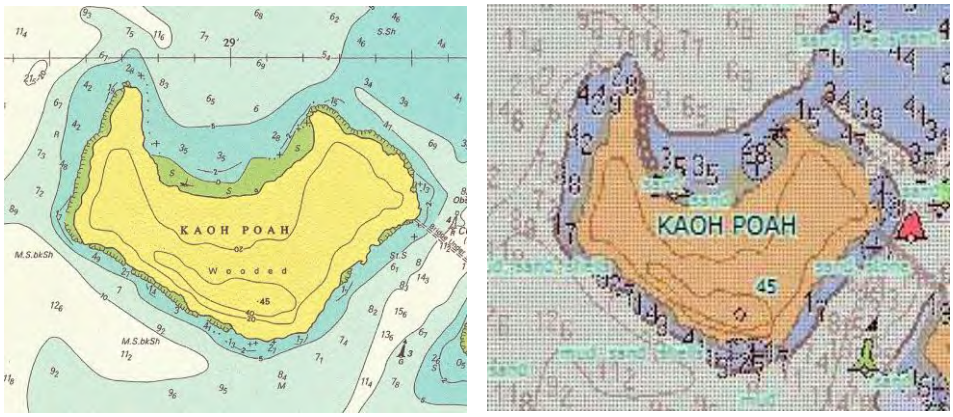


Figure 3 - 5 Paper Chart in left and ENC in right produced in the Third-Country-Training in Aug. 2014

(3) Implementation of Technical Visit and Leader Training

Technical Visit, recognizing the importance of institutional capacity building, aimed at being a member of IHO has been implemented by the visits of NAMRIA of Philippines and MSA of Singapore from 3rd Aug. 2014 to 8th Aug. 2014. H.E. Mr. LENG THUN YUTHEA; Under Secretary of States, Mr. ROS SOPHORNNA: Director of Waterways Department and Mr. MAK SIDETH, MSc; Director of Merchant Marine Department of MPWT have joined respectively in order to obtain know-how on management of ENC produced and build a cooperative relationship with the member countries of EAHC. The Philippines is the Chair country of EAHC and has published ENCs in the technical cooperation of JICA. Singapore is one of the leading countries to enlighten the importance of ENC (For more detailed information refer to Interim Report).

Leaders participated for the training from Cambodia made a courtesy call to NAMRIA and thanked their cooperation to the ENC training and exchanged the views on the ENC with the Director and Deputy Director of NAMRIA.

They also visited MPA in Singapore and made a tour of ENC production. Team Leader S. Kokuta and Project Coordinator K. Takashita accompanied their visit to Singapore.

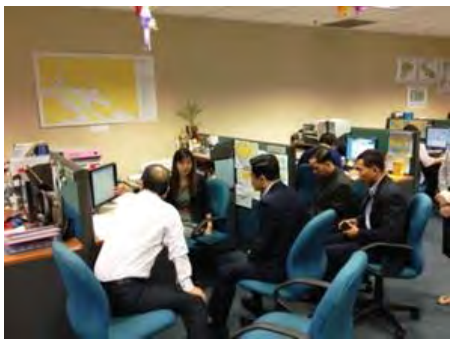
 Exchange of Views with the Leader of NAMRIA, 4th Aug. 2014	 Visit ENC Training Room of NAMRIA,4th Aug. 2014
 Exchanging Views with Director and the Leaders of NAMRIA, 5th Aug. 2014	 Exchange of Friendship Token between Director of NAMRIA and Under Secritary of MPWT, 5th Aug. 2014
 Visit ENC room of MPA, 7th Aug. 2014	 Courtesy Call to MPA Hydrographic Office, Under Secritary Yuthea, left, JICA Study Team Leader S. Kokuta, center, Director of MPA Hydrographic office Dr. Parry Oei, right, 7th Aug. 2014

Photo 3 - 17 Leader Training on August 2014

(4) ENC Administrative Training

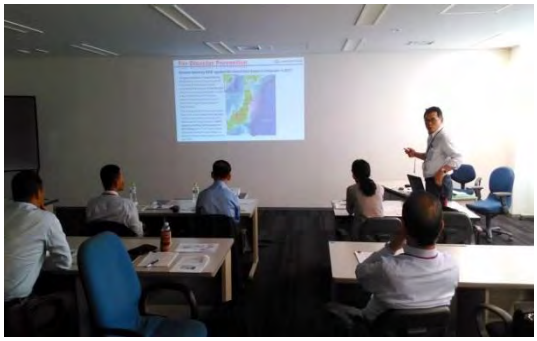
After the production of C & ENC, it is desired to be effectively used as the sailing purpose. However, it is difficult to distribute them for actual users because Cambodia is not a member of the IHO, which is required for the publication of the international chart. Therefore, MPWT's executives as described above visited the Hydrographic Department of Philippines and Singapore and exchanged views on international environment surrounding the C & ENC. Supporting assertion for the publication of charts produced in this project has been voiced of opinions from EAHC at the field of this exchange. There is a request of training for administrative ENC training as capacity building to build the publication and maintenance system of C & ENC for a week at Hydrographic and Oceanographic Department of JCG, where is EAHC permanent secretariat, from the Chief Hydrographer, Director of MPWT/WD, who is real responsible for C / P organization according to publishing C & ENC. Then the training was implemented in September 2015 when the trial version of ENC in this project had been completed. JHOD of JCG is the permanent secretariat of the EAHC required in the publication of the chart, including Cambodia in order to provide the necessary information to maintain the latest chart for Mariners in the Southeast Asia, East Asia together with an adjustment countries of the region (NAVAREA XI region).

Therefore, the most effective training was considered to be in the JHOD, Japan. ENC Administrative training was held in Japan for one week from 6th Sep. 2015 as shown below:

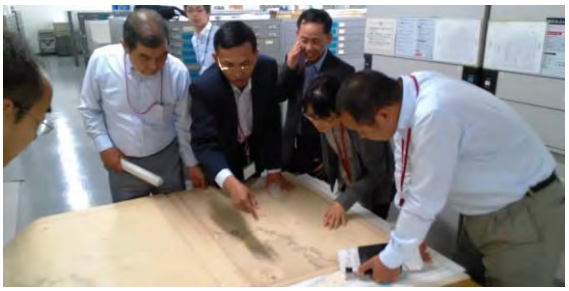
Table 3 - 5 Schedule of ENC Administrative Training in September 2015

ENC Management Training Schedule in Japan

D/ M / Y			Contents	Method	Place	Lecturer & Explanation
13.Sep 2015	Sun		Arrival at NARITA			
14.Sep	Mon	Before noon	Briefing	Visitation	Aero Asahi Corporation	Person in charge of JICA
		Afternoon	International situation about ENC	Lecture		Kokuta / Nakagawa
15.Sep	Tue	Before noon	Courtesy call to the Director General of HOD Introduce Activities of Hydrographic and Oceanographic Department	Lecture & Explanation	JHOD	JHOD's officer / Kokuta
		Afternoon	Visit Cartographic Office: Charting ENC Visit Notices to Mariners Office Visit Environmental and Oceanographic Research Division Visit Oceanographic Data and Information Division Visit Marine Pollution Research Laboratory Visit Pavilion of HOD			
16.Sep	Wed	Before noon	Chart and Navigational Information Division : Outline of International Standard of ENC Production and International framework according to the distribution/update	Lecture	JHOD	JHOD's officer / Kokuta
		Afternoon	Chart and Navigational Information Division : Series of challenges according to ENC Production Technology Planning and International Affairs Division : Hydrographic and Oceanographic Services related laws in Japan			
17.Sep	Thu	Before noon	Presentation of Marine Information Services in Cambodia The role of the IHO and EAHC	Presentation & Discusssion	JHOD	JHOD's officer / Kokuta
		Afternoon	Exchange of views opinions relating to future cooperation			
			Vistation in Tokyo Bay	Vistation	Tokyo Bay	Takashita/
18.Sep	Fri	Before noon	Suggestion about ENC of Cambodia	Discusssion	Aero Asahi Corporation	Kokuta /Takashita
		Afternoon	Evaluation			
19.Sep	Sat		Trainees leave to Phnom Penh			

Explanation of Chart Management and Mechanism of IHO at JHOD of JCG




Explanation of the oldest BA chart of Cambodian Jurisdiction water

Courtesy Visit to AAC

Photo 3 - 18 ENC Administrative Training in Japan

(5) Trainee's Level on the Data Processing Technique

As to the publication of ENC actually, it should be desirable to own the publication technology of a paper chart. The computer science and operation should be the minimum requirements and the knowledge of the vector graphics and of the geographic coordinate systems should also be needed for the smooth implementation of the technology transfer. It was found that the comprehension varied apparently from each other despite the same contents of training. In order to acquire the ENC production technology for a short period of time, it might be essential that the trainees should be well prepared for it along with having a high level of techniques on computer science, of course.

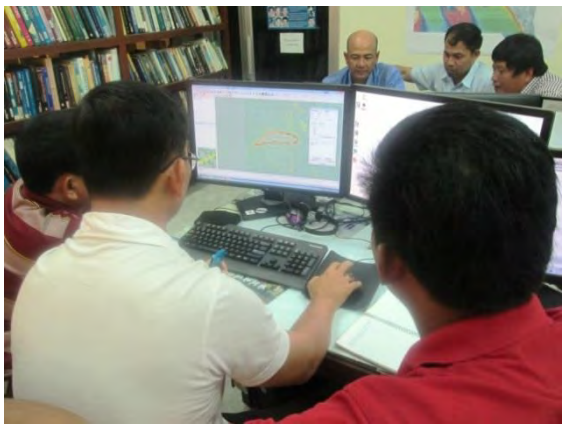



Photo 3 - 19 Production ENC trainees C/P

Following Table 3 - 6 shows the rating of technical proficiency on ENC of trainees at 6 grades in terms of before and after the trainings as of Dec. 2016:

1: 0 ~ 10 % State of being having neither knowledge nor practical experience.
2: 10 ~ 20 % State of being having a basic theory and knowledge only.
3: 30 ~ 40 % State of being an initial stage of technical learning and skills based on basic theory.
4: 50 ~ 60 % State of being an intermediate stage of technical learning based on practical skills and theory.
5: 70 ~ 90 % State of being the advanced stage of technical learning based on practical skills and theory.
6: 90 ~ 100 % State of being proficient in practical skills and theory and possible for the further sustainable development by oneself.

Table 3 - 6 Rating of Technical Proficiency on ENC Production

		Before Training	After training
1	**Creating ENC Dataset**		
	Initial Set up of country Code and Cell Naming.	1	5
	Datum Conversion	1	5
2	**Topology Correction**		
	Correct the topology before encoding ENC, understanding of Chain Node	1	4
	Digitize isolated node, connected node, and edge, digitizing Methodology	1	4
	Remove redundant topology, Understanding of Redundancy	1	3
3	**ENC Encoding**		
	Understanding feature objects in S-57	1	4
	Understanding attributes in S-57	1	3
	Relationship between paper chart and symbolization and ENC symbolization	1	4
	Mandatory objects in ENC	1	3
	Mandatory attributes for each objects.	1	4
	Understanding the concept of Mask and Data limit	1	3
	Understanding the concept of Group-1	1	5
	Examine the use of object catalogue while encoding ENC	1	4
4	**Quality Assurance**		
	Understanding errors/warnings message by ENC Analyzer	1	4
	Correct errors/warnings	1	4
5	**Computer Engineering**		
	Operate the hardware	5	5
	Operate Operating System	5	5

In the original project, ENC production by way of the hydrographic survey of all the project area followed by the production of vector fair sheet was executed, and at the same time, the technical training for ENC production was also carried out during the project period. In the extension project, ENC/Paper Chart productions were carried out following to the rasterizing process of existing paper chart scanned. And, the technology to update the ENC based on the limited data acquired by the hydrographic survey was technically transferred by the study team

3 - 2 **Issues Raised during Technology Transference and its Challenges in the Future**

Initially, during the 1st phase of hydrographic survey period, from October 2013 to May 2014, most of the C/Ps were suffered by the seasickness since they did not have any experience at all to get on board the survey boat for hydrographic survey activity. Although they got to know the hydrographic survey and basic technologies of operation/maintenance of DHSDAS somehow, it was difficult for them to manage the "Echo-Training" originally planned. However, the trial for phase 1 ended up to failure, "Echo-Training" system came to be established gradually because the hydrographic activity was favored by rather a good weather condition at the latter part of the 2nd term hydrographic survey. In addition, they could have the opportunity of using DHSDAS by themselves for one week.

Having the Extension Project shifting toward further offshore, more severe weather condition was anticipated in advance. Half of the C/Ps already became unconcerned about the seasickness at the beginning of Extension Project. And, the C/Ps were entrusted rigging and data acquisition process as much as possible by themselves. Among them, one C/P already became independent operator using data acquisition system. Therefore, it should be believed that "Echo-Training" system within their office has almost established having the completion of fieldwork of the Extension Project, June 2016.

As for the technical transfer on the knowledge and methodology of data processing of digital hydrographic survey and compilation of Navigational chart and ENC, it was realized through the "Echo-Training" system operated by the 8 C/Ps divided by 2 parties on the data processing over the total number of 53 months data derived by the initial project.

Further, on the Extension Project, personnel that have not involved for the ENC training so far also emerged in the ENC production, as a result that the training policy was taken to establish sustainable system for nurturing human resources letting them to recognize the importance on the collection of reference materials for the charting project, especially on the accumulation of empirical knowledge for bathymetric data acquisition in digital format.

OJT on the rigging and installation was performed to C/Ps as in the following manner:

- To show a good example of rigging and installation of each equipment,
- To repeat its operation to each trainee,
- To point out mistakes and advised its remedies, if necessary, and to further repeat its method for them to memorize in the future.

However, unexpected incident of poor connection occurred in the connector of SVP, Sound Velocity Profiler, which was to be lowered in the water for measurement, because the plug was connected and disconnected every time the measurement of sound profiling was performed.

Which was the major defective portion of the instrument though, the connector for plugging was so tight that the operator moved it back and forth to widen its connector, which was inferred to cause the poor connection of the plug.

Photo 3 - 20 Sound Velocity Profiler Plug and Connector

Following countermeasures were taken:

- To practice pulling out the connector vertically,
- To use fresh water for washing the instrument after its use,
- To use the dummy plug during the wash so that the connector should not affected by water,
- To make it dried and stored avoiding the direct sunlight,
- To add the warning in the operational manual,
- To enlighten the importance of maintenance of the survey equipment, which was scheduled to transfer to WD for their management and maintenance after the project.

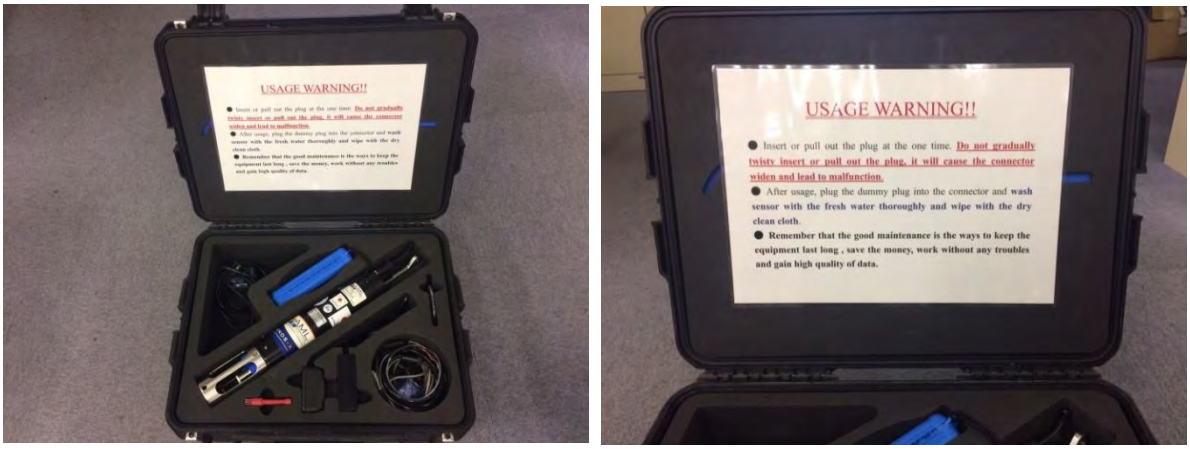


Photo 3 - 21 Operational Warning attached back of the Instrument Box of SVP

Summary:

The C/P got to know and acquired its technology gradually by the repeated trainings even for the complicated operations in the hydrographic related activities, varying from hydrographic survey to editing and compiling of navigational chart. Actually, the C/P had already become the ENC expert, but they might require some technical advice, after the 3-year training accumulating various technologies and skills for the production of paper chart and ENC, which was the initial major objective of the project, by the Technology Transfer including OJT, and now they already have relevant capability of producing ENC by their own effort. And, it was also considered that C/P had relevant responsibility and already prepared to update the ENC by them in the future.

After the project, C/P would work on the ENC training of younger generation in accordance with the respective job assignment and with relevant budget by having more accumulation of empirical knowledge of hydrographic survey and ENC production.

Chapter 4 REPORTING

4 - 1 (2) Preparation of Inception Report, (3) Explanation and Discussion

Inception Report had been prepared for summarizing the basic execution policy, methodology including technology transfer, individual tasks and its contents, implementing organization and plan of work. Study Team submitted it to JICA for comments and approval. After the approval of the Inception Report by JICA, the report had been presented to the 1st Joint Coordination Committee, hereinafter referred to as JCC, held at MPWT. Study Team explained its basic execution policy and overall survey framework and discussed with MPWT representatives. Record of Discussion was summarized in the Minutes of Meeting and approved by the personnel concerned. Minutes of Meeting of Meeting was submitted to JICA on 20th Nov. 2013.

4 - 2 (8) Preparation of Progress Report, Explanation and Discussion

Survey activities and the results were summarized in the Progress Report on the geodetic and leveling surveys carried out in Oct. 2013 and the 1st hydrographic survey commenced from the end of Feb. 2014 together with the evaluation results of 1st ENC training. Approved by JICA, the Progress Report had been submitted to the 2nd JCC Meeting and study team explained about its data acquired and the progress. Then, the study team discussed on the framework of the 2nd-term hydrographic survey after the explanation about the scope of work and its policy for the upcoming survey activity. Discussion was summarized in the Record of Discussion and approved by the personnel concerned. Minutes of Meeting including its R/D was submitted to JICA at the completion of the 1st-term hydrographic survey, i.e. 23rd July 2014.

4 - 3 (8) Preparation of Interim Report, Explanation and Discussion

Interim Report was prepared by summarizing the progress of survey work, evaluation of achievements and the procedures for upcoming project work inclusive of survey activities on the 1st-term hydrographic survey and the 2nd-term hydrographic survey as well as the 2nd ENC training undertaken in Aug. 2014.

Interim Report was submitted to JICA for approval. Then, the contents were explained at the 3rd JCC Meeting held in 22nd Apr. 2015. During the Meeting, the scope of work designed to produce ENC of Navigational Purpose 5, Harbour, by the end of Aug. 2015 was explained and discussed on the upcoming procedures and methodology.

Further, on the occasion, a request for the production of ENC for Navigational Purpose 3, Coastal navigation, in and around SHV port was proposed extending the present project for another 1 year by the MPWT. R/D was summarized in the M/M and approved by the personnel concerned. Also, the M/M was submitted to JICA at the completion of 2nd -term hydrographic survey, 21st May 2015, for approval.

4 - 4 (8) Preparation of Interim Report 2, Explanation and Discussion

Interim Report 2 was compiled, as to the progress, results and evaluation, summarizing the following tasks as shown below:

- Survey activities executed from Sep. 2013 to end of 2015,
- Scope of work for the Extension Project, for another 1 year up to the end of 2016, officially approved in the M/M, based on the revised R/D held in 10th Nov. 2015, between the Minister of MPWT and the Chief Representative of JICA Cambodia Office.

Following to the approval by JICA, a reporting of outputs of original project and an explanation on the framework and its executing policy was made at the 4th JCC Meeting held on 11th Mar. 2016. During the discussion on the Meeting, necessary procedures, expected to complete its production by the end of Aug. 2016, for the ENC of Navigational Purpose 3 near the SHV were explained and further discussed on the survey activity. R/D was summarized in the M/M and approved by the attendees. The M/M was submitted to JICA at the completion of the Extension Project, 18th May 2016.

4 - 5 (9) Preparation of Draft Final Report, Explanation and Discussion

Overall project activities, inclusive of the original project and the extension project, and results as well as the evaluation were summarized in the draft final report, and it will be submitted to JICA for approval. It will also presented to the 5th JCC Meeting to be held on the 13th Dec. 2016, and discussion will be held on the outputs of original and extension projects and on the proposal of the future development of ENC process in Cambodia. Discussion will also be made on the "Workshop on ENC Enlightenment" by the personnel concerned. Following to the mutual agreement on the R/D, M/M will be submitted to JICA for comments and approval.

4 - 6 (10) Preparation of Final Report

Draft final report will be revised based on the results of 5th JCC Meeting. Also, together with the results of Workshop on ENC Enlightenment as well as the provision of equipment that used in the project will be added to the Draft Final Report. Final Report will be compiled that includes the CD-ROM or DVD-ROM containing the files of large and medium scales ENCs scaled at 1/20,000 and 1/150,000, which are accessible on the PC.

Chapter 5 OTHER ACTIVITES

5 - 1 Procurement of Survey Equipment

Survey equipment used in this project was procured both by the open tender by JICA Headquarters and the tender performed by the Consultant contracted. Following photographs show the equipment required essentially to execute this project such as DHSDAS and DHSDPS as well as the hardware and software necessary to produce ENC.

Survey equipment was provided for wet-test before the equipment was transported to Cambodia from Japan. JICA study team witnessed the wet-test about the function and its performance carried out at Hota port in Chiba pref. on 16th Dec., 2013, The 2 Cambodian C/P trainees participated to the 1st ENC Training of JHOD witnessed this wet-test for the future project in Cambodia. Although a part of the equipment, SIM; synchronizing function of data acquisition timing, showed an improper performance, hardware and software comprising DHSDAS and DHSDPS worked properly. A defective SIM was replaced by the supplier and checked its function by the dispatched technician. Equipment provided by JICA Headquarters when arrived at SHV and all of them at Table 5 - 1

Table 5 - 1 List of Equipment Procured By JICA Headquarters

JICA No.	Equipment	Equipment Model	Acquisition Date	Storage Place	Remark
13-3-002206	Single Beam Echo sounding System	PDR-1300	2014/1/20	MPWT/WD	For Shallow area survey
13-3-002207	Multi-Beam Echo sounding System	SONIC2020	2014/1/20	MPWT/WD	Including spare parts
13-3-002208	GNSS positioning System	SPS361	2014/1/20	MPWT/WD	Including spare parts
13-3-002209	Surface SVP Profiler	Micro･X SV	2014/1/20	MPWT/WD	Including spare parts
13-3-002210	ADCP System	ADP 500khz, SPS351	2014/1/20	MPWT/WD	Including spare parts
13-3-002211	Motion Sensor	DMS-10	2014/1/20	MPWT/WD	Including spare parts
13-3-002212	SVP Profiler	Minos･X SV･P	2014/1/20	MPWT/WD	Including spare parts
13-3-002213	Hydrographic Survey Software	HYPACK MAX and HYSWEEP	2014/1/20	MPWT/WD	
13-3-002214	Hydrographic Survey Software	HYPACK MAX and HYSWEEP	2014/1/20	MPWT/WD	
13-3-002215	Note computer	ThinkPad T430	2014/1/20	MPWT/WD	For Data Acquisition
13-3-002216	Note computer	ThinkPad T430	2014/1/20	MPWT/WD	For Data Acquisition
13-3-002217	Note computer	ThinkPad T430	2014/1/20	MPWT/WD	For Data Acquisition
13-3-002218	Desktop computer	ThinkPad M72E	2014/1/20	MPWT/WD	For Data Acquisition
13-3-002219	Desktop computer	ThinkPad M72E	2014/1/20	MPWT/WD	For Data Processing
13-3-002220	Desktop computer monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Data Processing
13-3-002221	Desktop computer monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Data Processing
13-3-002222	Desktop computer monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Data Processing
13-3-002223	Desktop computer monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Data Processing
13-3-002224	Survey Navigation monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Survey Navigation
13-3-002225	Survey Navigation monitor	LENOVO LS2223	2014/1/20	MPWT/WD	For Survey Navigation
13-3-002226	External HDD	HD-PCT1TU3	2014/1/20	MPWT/WD	For Data Backup
13-3-002227	External HDD	HD-PCT1TU3	2014/1/20	MPWT/WD	For Data Backup
13-3-002228	USB-Serial port convertor	Edgeport/8	2014/1/20	MPWT/WD	For Data Converting
13-3-002229	USB-Serial port convertor	Edgeport/8	2014/1/20	MPWT/WD	For Data Converting
13-3-002230	Junction Box	J-BOX-1G(200)	2014/1/20	MPWT/WD	For Data Synchronization
13-3-002231	CAD Software	AutoCAD MAP2014	2014/1/20	MPWT/WD	For DTM editing
13-3-002232	GIS Software	ArcGIS Desktop Basic	2014/1/20	MPWT/WD	For GIS
13-3-002233	GIS Software	ArcGIS Desktop Basic	2014/1/20	MPWT/WD	For GIS
13-3-002234	A0 Plotter	DesignJet T920	2014/1/20	MPWT/WD	For Map Plotting
13-3-002237	CAD Software	AutoCAD MAP 2014	2014/1/20	MPWT/WD	For DTM editing

5 - 2 Equipment Procured by Study Team

As of Dec. 2016, all the equipment procured at the commencement of the project is working properly with no problems. Other than the equipment procured, consumables, such as generator, battery, air-conditioner for the survey boat and etc., were procured on site by the study team. Following Table 5 - 2 shown the equipment the study team procured:

Table 5 - 2 List of Equipment Procured by Study Team

JICA No.	Equipment	Equipment Model	Acquisition Date	Storage Place	Remark
13-3-002235	Tide Gauge	5225WLB-2	2013/9/11	PAS; SHV Port	Purchased in Japan For Tide Station
13-3-002236	Tide Gauge	RT710-W	2013/8/23	MPWT/WD	Purchased in Japan For Temporary site
13-3-002238	UPS	GXT-2000MTPLUS230	2014/1/23	MPWT/WD	Purchased in Cambodia For Hydrographic Survey
13-3-002239	UPS	GXT-2000MTPLUS230	2014/1/23	MPWT/WD	Purchased in Cambodia For Data Processing
14-3-002739	ENC Production Desktop computer	DELL PRECISION T1700	2014/5/16	MPWT/WD	Purchased in Cambodia For ENC Production
14-3-002740	UPS	GXT-2000MTPLUS230	2014/5/16	MPWT/WD	Purchased in Cambodia For Data Processing
14-3-002741	NAS Desktop computer	DELL OPTIPLEX 9020	2015/2/11	MPWT/WD	Purchased in Cambodia For NAS Server
14-3-002742	NAS HDD	D-Link ShareCenter	2014/6/9	MPWT/WD	Purchased in Cambodia For Data Backup
15-3-002128	Tide Gauge	RT710-W	2016/2/23	MPWT/WD	Purchased in Japan For Temporary site
15-3-002129	ENC Production Software	SevenCs, FME	2016/2/23	MPWT/WD	Purchased in Cambodia For ENC Production
15-3-002130	Unmanned Aerial Vehicle	PHANTOM3	2016/3/10	MPWT/WD	Purchased in Cambodia For Remote Photo Taking

5 - 3 Site Visits

(1) Site Visit by the Chief Representative of JICA Cambodia Office

Photo 5 - 1 Site Visit by the Chief Representative of JICA Cambodia Office and his Party

The Chief Representative of the JICA Cambodia office, Mr. IZAKI and Mr. YOKOI visited the Project site on 8th Apr. 2014. The site visit was made having the introduction of C/Ps and the inspection of the patrol boat of PAS, which was to be used as a survey boat, and the seafarer room, which was to be used as the data processing room. The systems of the DHSDA equipped in the survey boat and the DHSDP were also explained, respectively. The chief representative encouraged C/Ps to learn the hydrography and advised the survey team of good taking care of the health. The duration of site visit was for about one hour.

(2) Site Visit by the Minister of Embassy of Japan in Cambodia and Member of the Legation Staff

Photo 5 - 2 Site Visit by the Minister of Embassy of Japan in Cambodia and Member of the Legation Staff

The Minister of Embassy of Japan in Cambodia, Mr. HIGUCHI and Second Secretary, Mr. IIZUKA visited the project site on 10th Dec. 2014. The site visit was made having the introduction of C/Ps and the inspection of the patrol boat of PAS, which was to be used as a survey boat, and the seafarer room, which was to be used as the data processing room. The systems of the DHSD equipped in the survey boat and the DHSDPS were also explained, respectively. The Minister encouraged C/Ps to learn the hydrography and advised the survey team of good taking care of the health. He had an interest to operate the boat.

(3) Site Visit by the Deputy Representative of JICA Cambodia Office


Photo 5 - 3 Site Visit by the Deputy Representative of JICA Cambodia Office

The Deputy Representative of JICA Cambodia office, Mr. ITO and Mr. WATANABE were visited at the project site on 11th Dec. 2014. The site visit was made having the introduction of C/Ps and the inspection of the patrol boat of PAS, which was to be used as a survey boat, and the seafarer room, which was to be used as the data processing room. The systems of the DHSDA equipped in the survey boat and the DHSD were also explained, respectively. The deputy representative encouraged C/Ps to learn the hydrography and advised the survey team of good taking care of the health. The duration of site visit was for about one hour.

(4) Courtesy call to "SHIRAYUKI", the Escort Ship of Squadron of Maritime Self-Defense Force of Japan.

The squadron of the Maritime Self-Defense Force of Japan consisting of 3 escort ships sailed into the SHV port on the mid-February 2014. The leader of the Study team made a courtesy call to "SHIRAYUKI", one of the three escort ships, in order to get the information on the navigation route leading to the SHV port on 17th Feb. 2014, and met with the chief mate at the bridge. He said that the position of one Navigational Aids on the way to the port was different compared with the existing chart (BA2103). ENC had not been used at "SHIRAYUKI" at that time.

(5) Courtesy call to "KOUYO-MARU", Training Ship of National Fisheries University of Japan

Training ship "KOUYOU-MARU" belonging to the Fishery Academy sailed into the SHV port at the beginning of December 2014. The leader and member of the Study team visited "KOUYOU-MARU", in order to obtain the information on the navigation route to SHV port on 3 December, and met the captain Mr. SIMOJOU and the chief navigation officers Mr. FUGAMI at the bridge. Their objectives were both on investigation of the fish catch and for the navigational training for about 50 trainees. They pointed out that the positions of isolated islands located in the Thailand Bay were different compared with the chart (BA2103 and 3967). They said that the difference in its location ranged half miles from the chart information. ENC had not been used in "KOUYOU-MARU" at that time. The following scan overlapped with radar imagery on Electric Chart System (ECS) of TRANSAS shows two isolated islands named "KOH POULO WAI" (N 9°55'13" E120°54'39": the position is in-between two islands) located in the southern edge of the Cambodian territorial water. It can easily be seen the difference on the imagery.

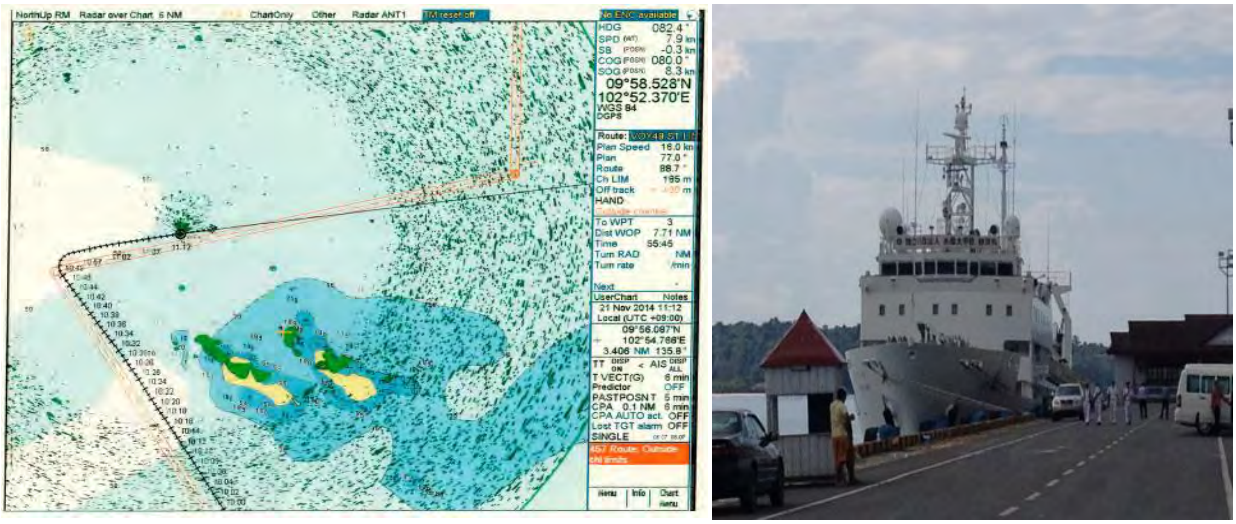


Photo 5 - 4 ECS Display, manufactured by TRANSAS, overlapped by Radar Image on the left, and Courtesy Call to “KOUYOU-MARU” on the right

(6) Visiting to Koh Poulo Wai and Kas Tang, Maritime Defense Party Base

Study Team visited the Maritime Defense Party Base in Koh Poulo Wai and Kas Tang on 23rd Mar. 2016. Because the study team had a planning to operate the hydrographic survey activities in and around the Koh Poulo Wai and advanced information should be necessary for the Party. Study member lead by the Team Leader together with C/Ps guided by the PAS pilot visited the base to salute the Party and explained the hydrographic survey information.

(7) Exchange of view with PAS pilot team after ENC Workshop

Prior to the ENC Workshop held at the PAS of SHV, The briefing and exchange view regarding the ENC WORKSHOP was carried out for PAS pilot officers (16 people joined) at 19th Dec. 2015. After explain how to create the ENC in the Study team, was exchanged views in order to confirm whether the ENC produced fits the needs of end-users for the future issues. Their opinion will be reflected in the extension project. We also have committed for good cooperation and feedback to the extension project as well. Further, a detailed depths map was provided in response to the request made by the Pilot Team of PAS.

Photo 5 – 5 Meeting on Hydrographic Survey Results by Pilot Team of PAS and Study Team

(8) Exchange of view and Practical Usage with PAS pilot team after ENC Seminar

After finished ENC Seminar, Study team was carried out the explanation of completed Chart and ENC for PAS officer (PAS Harbour Master, PAS Pilot Team Members 15 people and PAS information Technology Staff)

The explanation main content was caution from completed Chart and ENC As request from PAS, to utilize (install and maintenance) new completed ENC data with the existing equipment in PAS (VTMS AIS and ECDIS in the new tug boat).

By the way, the AIS of The Vessel Traffic Management System: VTMS room could not compatible with completed new ENC data. Study team suggested to use ENC viewer in another PC together with AIS computer. For the tug boat "KOH TAKIEV", Study team showed how to install, utilize the new completed ENC data in tug boat's ECDIS to tug boat crew and PAS information technology staff. And hoped that new completed ENC data will be useful to for PAS functions.

Photo 5 - 6 New completed ENC data usage at PAS VTMS room

Photo 5 - 7 New completed ENC data installation and usage at PAS's Tag boat "KOH TAKIEV"

5 - 4 Joint Coordination Committee

1st Joint Coordination Committee:

- Date and Time: 08:30, 22nd Sep. 2013
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: JCC Joint Chairs: H.E. TRAM IV TEK, Minister, Ministry of Public Works and Transport
  Hiroshi IZAKI, Chief Representative, JICA Cambodia Office
- Attendees: Officials of MPWT, JICA personnel, Study Team

The Inception Report was distributed to all the attendees and presentation was made on the principal policy of study work and its methodology by the study team. Minutes of Meeting was prepared summarizing the result of the meeting, and it was approved by the chair, H.E. TRAM IV TEK.

Photo 5 - 8 1st JCC Meeting

2nd Joint Coordination Committee

- Date and Time: 08:30, 22nd May 2014
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: JCC Joint Chairs: H.E. TRAM IV TEK, Minister, Ministry of Public Works and Transport
  Hiroshi IZAKI, Chief Representative, JICA Cambodia Office
- Attendees: Officials of MPWT, JICA personnel, Study Team

The Progress Report, summarizing the 1st -term hydrographic survey including geodetic and leveling surveys the 2nd -term hydrographic survey as well as 1st ENC training, was distributed and a presentation was made on the progress of study work and its results by the study team. Minutes of Meeting was prepared summarizing the result of the meeting, and it was approved by the chair, H.E. TRAM IV TEK.

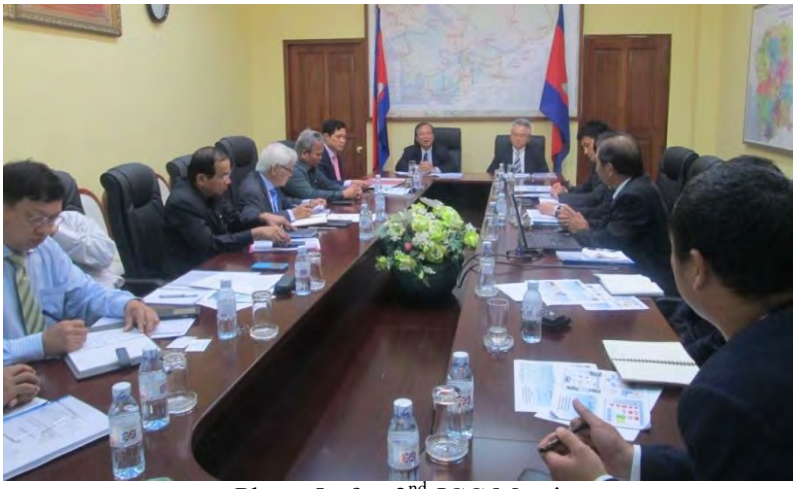


Photo 5 - 9 2nd JCC Meeting

3rd Joint Coordination Committee

- Date and Time: 08:30, 22nd Apr. 2015
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: JCC Joint Chairs: H.E. TRAM IV TEK, Minister, Ministry of Public Works and Transport
  Itsu ADACHI, Chief Representative, JICA Cambodia Office
- Attendees: Officials of MPWT, JICA personnel, Study Team

The Interim Report, summarizing the 1st -term hydrographic survey and the 2nd -term hydrographic survey including the progress of large-scale ENC production, was distributed and a presentation was made on the progress of study work and its results by the study team. Minutes of Meeting was prepared summarizing the result of the meeting, and it was approved by the chair, H.E. TRAM IV TEK.

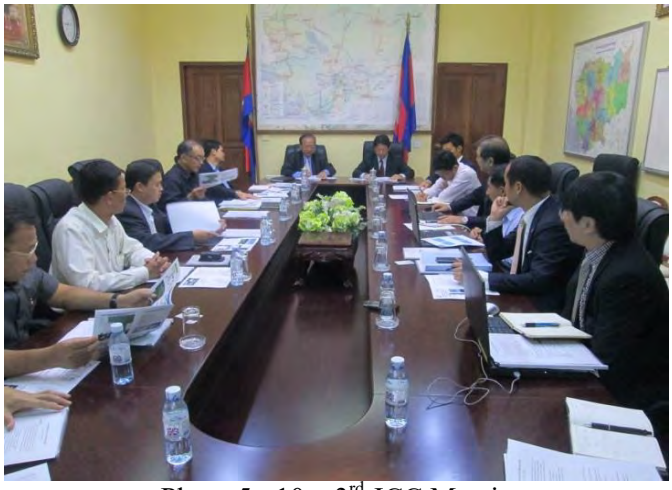


Photo 5 - 10 3rd JCC Meeting

4th Joint Coordination Committee

- Date and Time: 08:30, 11th Mar. 2016
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: JCC Joint Chairs: H.E. TRAM IV TEK, Minister, Ministry of Public Works and Transport
  Itsu ADACHI, Chief Representative, JICA Cambodia Office
- Attendees: Officials of MPWT, JICA personnel, Study Team

The Interim Report-2, summarizing the 1st -term hydrographic survey and the 2nd -term hydrographic survey including the final output of large-scale ENC production, the progress for 1st ENC Workshop and the principal policy of Extension Project and its methodology, was distributed and a presentation was made on the progress of study work and its results by the study team. Minutes of Meeting was prepared summarizing the result of the meeting, and it was approved by the chair, H.E. TRAM IV TEK.

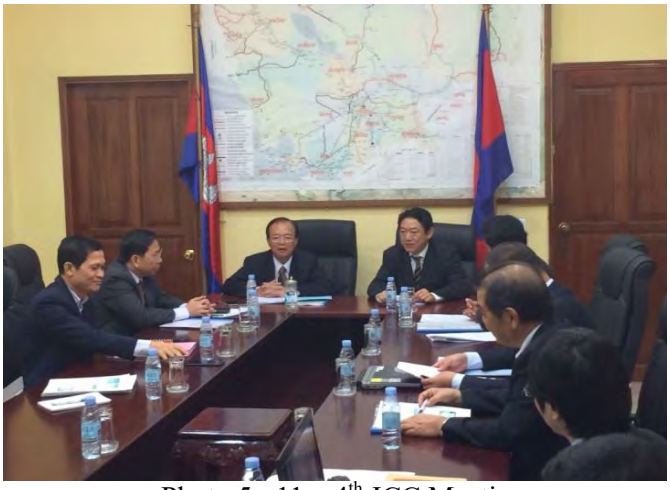


Photo 5 - 11 4th JCC Meeting

5th Joint Coordination Committee

- Date and Time: 14:30, 8th Dec. 2016
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: JCC Joint Chairs: H.E. TAUCH CHAN KOSAL, Secretary of State, Ministry of Public Works and Transport
  Itsu ADACHI, Chief Representative, JICA Cambodia Office
- Attendees: Officials of MPWT, JICA personnel, Study Team

The Draft Final Report, summarizing the final output of Original Project and Extension Project and its all methodology for producing C & ENC, was distributed and a presentation was made on the progress of study work and its results by the study team and C/D discussed about future vision of WD tasks and responsibilities of maritime management in Cambodia. Briefed about preparation for holding ENC Seminar in 13th Dec. 2016 and its schedule. Minutes of Meeting was prepared summarizing the result of the meeting, and it was approved by the chair, H.E. TAUCH CHAN KOSAL.

Photo 5 - 12 5th JCC Meeting

5 - 5 Taskforce Meeting

1st Taskforce Meeting:

- Date and Time: 08:30, 8th Oct. 2013
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: H.E. LENG THUN YUTHEA, Under Secretary of State, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

Photo 5 - 13 1st Taskforce Meeting

2nd Taskforce Meeting:

- Date and Time: 08:30, 13th Jan. 2014
- Venue: Conference Room in 2nd Fl., MPWT
- Chair: H.E. LENG THUN YUTHEA, Under Secretary of State, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

3rd Taskforce Meeting:

- Date and Time: 09:00, 13th Nov. 2014
- Venue: Conference Room in 2nd Fl., Waterways Department, MPWT
- Chair: ROS Sophornna, Director, Waterways Department, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

4th Taskforce Meeting:

- Date and Time: 14:30, 2nd Dec. 2015
- Venue: New Beach Hotel, SHV
- Chair: ROS Sophornna, Director, Waterways Department, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

5th Taskforce Meeting:

- Date and Time: 09:00, 5th Aug. 2015
- Venue: Conference Room, 2nd Fl., Waterways Department, MPWT
- Chair: ROS Sophornna, Director, Waterways Department, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

6th Taskforce Meeting:

- Date and Time: 09:30, 15th Dec. 2015
- Venue: Conference Room, 2nd Fl., Waterways Department, MPWT
- Chair: ROS Sophornna, Director, Waterways Department, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

7th Taskforce Meeting:

- Date and Time: 09:00, 16th Aug. 2016
- Venue: Conference Room, 2nd Fl., Waterways Department, MPWT
- Chair: H.E. LENG THUN YUTHEA, Under Secretary of State, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

8th Taskforce Meeting:

- Date and Time: 09:30, 5th Dec. 2016
- Venue: Conference Room, 2nd Fl., Waterways Department, MPWT
- Chair: ROS Sophornna, Director, Waterways Department, Ministry of Public Works and Transport
- Attendees: Member of Taskforce Meeting and Study Team

5 - 6 ENC Workshop

ENC Workshop was held at the conference room of PAS on 21st Dec. 2015. Cambodia Domestic Maritime For specialty.

- Date: 21st Dec. 2015
- Place: PAS Conference Room
- Participant: PAS's pilot team, Domestic Maritime Organization, Shipping Company
- Content : Present about ENC basic information from C/Ps and Study team. After presentation had Q&A section about ENC usage and WD introduction. Due to Domestic attendee, ENC Workshop mainly used Cambodian language for presentation and discussion.

Photo 5 - 14 ENC Workshop at PAS

Photo 5 - 15 Attendees to the ENC Workshop

5 - 7　ENC Seminar

The objectives for the Seminar were to enlighten on ENC information to the public and enhance the application of ENC effectively in many fields. Having invited the International Organization; IHO, UKHO and other related maritime organization, held the ENC Seminar in SHV. ENC Seminar was held under the auspices of MPWT/WD as shown below:

- Date: 13rd Dec. 2016: 8:30-15:00
- Place: Sokha Beach Resort Hotel、Sokha Beach Conference Center, Function Room I
- Participant: Total around 75 people from Cambodia Government and Private port, Private shipping companies, and around others 20 organizations including International Organization (IHO, UKHO, JHOD).
  These result showed the high interest on ENC in Cambodia.

Photo 5 - 16　ENC Seminar

Content:

1) Opening Ceremony and Opening Address
   - Opening Address by JICA Cambodia Office Chief Representative: Itsu ADACHI
   - Opening Address by First Secretary, Embassy of Japan in Cambodia: Naoki MITORI
   - Opening Address by Senior Secretary of State, MPWT: H.E. TAUCH CHAN KOSAL

Photo 5 - 17　Opening Address by JICA Cambodia Office Chief Representative: Itsu ADACHI

Photo 5 - 18 Opening Address by First Secretary, Embassy of Japan in Cambodia: Naoki MITORI

Photo 5 - 19 Secretary of State, MPWT: H.E.TAUCH CHAN KOSAL

2) Organizer Presentation

- Project Introduction and Briefing Presentation by Under Secretary of State, MPWT: H.E.LENG THUN YUTHEA

Photo 5 - 20 Under Secretary of State, MPWT: H.E.LENG THUN YUTHEA

3) Invitation Guest Presentation

- Presentation by IHO Representative: Commander Azrul Nezam bin Asri (EAHC)
- Presentation by UKHO Representative: Rob WHEELER (ENC Expert)
- Presentation by Japan Coast Guard, Hydrographic and Oceanographic Department, Chart and Navigational Information Division, Chart Quality Assurance Office Chief: Toru KAJIMURA

Photo 5 - 21 IHO Representative Commander Azrul Nezam bin Asri

Photo 5 - 22 UKHO representative Rob WHEELER

Photo 5 - 23 Japan Coast Guard, Hydrographic and Oceanographic Department, Chart and Navigational Information Division, Chart Quality Assurance Office Chief : Toru KAJIMURA

4) Study Team Progress Presentation
- Study Team Member from Aero Asahi Corporation: Kittisak WANGKIJWORAKUL
- MPWT/WD: Huon RATH

Photo 5 - 24 Study Team's Project Process Presentation

5) ENC Exhibition and ENC Cruising

ENC Seminar aims to promote the importance of ENC for the maritime safety, international trading, fishery, tourism and the other related section.

After the presentation and dissemination activity on ENC in the morning, and in the afternoon, the ENC cruising was scheduled to demonstrate using the ENC data on board.

By importing the created ENC data to AIS and displayed into the monitor on board the vessel. While sailing, AIS showed information from ENC data (depth and nearby obstruction and etc.) and also alerted by sound if there were any approaches to the danger or obstruction. As each of the attendee knew the practical ENC usage, participants could widely exchange the points of views with each other on ENC.

It was considered that all the attendees understood the usefulness of ENC application and were encouraged to use ENC for their navigational safety and preservation of natural environment.

Photo 5 – 25 ENC Seminar's exhibition

Photo 5 - 26 ENC data usage demonstration on ENC Cruising

Photo 5 - 27 Attendees to the ENC Seminar

Chapter 6 SURVEY RESULTS

6 - 1 Survey Report

Reports submitted at various milestones are shown as in the following Table 6 - 1.

Table 6 - 1 List of Reports

No.	Report	Japanese	English	No. of Reports addressed to Cambodian government
1	Inception Report	5	15	10 including in 15
	Date submitted	On the commencement of Project Work		
2	Progress Report	5	15	10 including in 15
	Date submitted	On the completion of 1st-term hydrographic survey; 12 months after the commencement of the study		
3	Interim Report	5	15	10 including in 15
	Date submitted	On the completion of 2nd -term hydrographic survey; 20 months after the commencement of the study		
4	Interim Report 2	5	15	10 including in 15
	Date submitted	March 2016		
5	Draft Final Report	5	15	10 including in 15
	Summary of Report	5	15	10 including in 15
	Date submitted	December 2016		
6	Final Report	5	15	10 including in 15
	Summary	5	15	10 including in 15
	Date submitted	March 2017		

6 - 2 Survey Results

Following outputs are the survey results as shown in Table 6 - 2:

Table 6 - 2 List of Survey Results

No.	Survey Results			
	Result	Unit	Q'ty	Remarks
1	Vector Fair Sheet	set	1	
2	Paper Chart	set	1	
3	ENC in CD-ROM	set	1	

Chapter 7 RECOMMENDATIONS

7 - 1 Maintenance Work of ENC

7 - 1 - 1 Importance of Update on ENC Information

SOLAS, 1974, hereinafter referred to as “the Convention”, requests on all merchant ships to install Nautical Charts and Nautical Publications in the sailing vessels. The Convention shall recognize that meets the requirement is to install the ECDIS in addition to the conventional Paper Chart and Nautical Publications. The system that displays the information of Nautical Chart is called ENC. ENC is the vector electronic navigational chart published by the respective governments or officially recognized organizations complying to S-57 and S-63, standard displaying format, specified by IHO.

ENC produced in this project will be entrusted to UKHO, which has the international sale market, to publish since there is not any effective mechanism in Cambodia to provide ENC to the vessels in service internationally, at this moment. ENC should provide the users with the latest information in terms of the safety at sea. Therefore MPWT/WD has the mandatory obligation to update the information of the ENC produced in this project. Hence, it will be important to carry out the updating hydrographic survey at an appropriate timing on the updated shoreline lineation of multi-purpose wharf and water depth changes along the passage due to dredging work in the PAS, and to send the necessary information to renew the ENC to UKHO.

7 - 1 - 2 Public Relations and Application of ENC

In this project, finished ENC data , SHV Port management relative in SHV port to enlighten the usage by applying to VTMS. And installed to use in Tug boat’s ECDIS. After that PAS’s Pilot will schedule to install into the other PAS boat.

For International vessel, when C&ENC start to has been publishing by UKHO, the international vessel which berthing and deberting need to install as duty.

For the enhancement of sustainability for ENC management in Cambodia, “ENC Workshop” (Dec. 2015) and “ENC Seminar”(Dec. 2016) was guided to be held. By inviting stakeholders of ENC users and the representatives from IMO, IHO and the officers of overseas Hydrographic Offices were asked to make presentation on the international maritime relation and significance of ENC.

7 - 1 - 3 Recommendations and Promotion of ENC Application

ENC and Navigational Chart is expected to be effectively used for vessel sailing and secured for safety at sea. However, Cambodian government has not the member country of IHO, International Hydrographic Organization. Therefore, in order to let them aware the ENC arena in the world, 2 leaders of Taskforce Team were dispatched to the hydrographic offices of Philippines, which is the Chair country of EAHC, East Asia Hydrographic Commission, and Singapore, which is one of the most developed countries in terms of ENC.

On Aug. 2015, ENC training was implemented at JHOD, which is the Permanent Secretariat of EAHC, in order for MPWT officials to have management training on the publication and maintenance of ENC for about 1 week. JHOD itself is working as the coordinating country in order to provide updated navigational information as the Notices to Mariners in Southeast Asian Countries and East Asian Countries, corresponding to NAVAREA XI Area, including Cambodia, and at the same time, acting as a coordinator for Cambodia to entrust the publication of ENC to UKHO, which is working to assist the publication of ENC of other countries.

Study Team hereby strongly recommends joining IHO as early as possible having good coordination with and necessary advice from JHOD in order to facilitate the application of ENC. Also recommended is for the MPWT, which is the observer country to EAHC, to attend various committees of EAHC and recognize the significance of involvement in IHO.

7 - 2 Issues on Technology Transfer and Recommendations

7 - 2 - 1 Issues on Technology Transfer

C/P organization MPWT/WD assumes the responsibility of hydrographic activity in Cambodian waters. It seems that the Cambodian government was groping for systematizing of hydrographic activity and nurturing human resources in the 1970's because 2 ex-MPWT/WD personnel were dispatched to Japan to have the Collective Training of Hydrographic Survey Course organized by JICA. Since then, the systematization had been at a deadlock together with a loss of human resources due to a national crisis.

In the latter half of 1990's, it is considered that the present organization of hydrographic services was organized to secure the navigational safety and to maintain the shipping lane along the Mekong River having the assistance from EU. However, the hydrographic survey technology they had was not too much to say that it was the level of 30 years ago.

In this project, an emphasis was placed not only on the technology transfer for production of ENC near SHV port but also for the enlightenment of importance on the maintenance of survey equipment. C/Ps have been encouraged for their devotion to the project training and contribution on the hydrographic services, i.e. maintenance and updating of Chart and ENC. Based on the principal project policy, their hydrographic survey technology had been strengthened through the 1st - term hydrographic survey, from Oct. 2013 to May 2014, and the 2nd -term hydrographic survey, from Nov. 2014 to Mar. 2015. Further, the editing and compilation technology of Navigational Charting have been upgraded through the 1st Training in Japan, for one month, and 2nd Training in Japan and the Third Country, for one month.

Although the practical experience of hydrographic activity is not enough at this moment, all the C/Ps have improved their knowledge and techniques for hydrographic survey considerably. On the other hand, ENC leader training was executed in Philippines and Singapore on Aug. 2014 for one week, and the ENC management training was carried out in Japan on Sep. 2015 for 1 week, in order for the C/Ps and their management staff to recognize the importance on the hydrographic services and the requirement of navigational safety to upgrade the credibility of Cambodia though, it seems that it's still on the half way in terms of systematization of hydrographic services and its management and planning in the MPWT/WD.

Followings explain some of the issues on the Technology Transfer at site:

(1) During the SW monsoon season from February through March, the offshore of SHV becomes rather a rough sea with the swell of about 1m, and is also being affected by the winds and waves going around the southern coast of Vietnam due to the stormy weather in the South China Sea. It was a hard time for all the C/Ps to have the OJT satisfaction because of their first encounter with the seasickness. An experience and tolerance against maritime activity should be one of the issues for them to overcome.
Although the C/Ps have sufficient experience of bathymetric survey in the Mekong River, the equipment and the methodology they utilize have already been outdated and the gap between the modern technology and their conventional one became far enough as the result. As of December 2014, they came up to the level of SBES survey techniques by themselves somehow. Moreover, it is envisaged that the C/Ps should accumulate more experience of the MBES survey under the instruction of the survey expert. Since then, some of the C/Ps could operate the DHSDAS independently even under sea rough condition.

(2) Some of the C/Ps seemingly lack of enthusiasm sometimes for the acquisition of modern technology especially on the sea. All the trainees should be aware of the fact that knowing the field conditions during the data acquisition period should be far more important than the deskwork. Completely different from the normal office work, a certain extent of flexibility and concentration should be desired for the C/Ps to acquire new technology and skills in this project.

(3) It is envisaged that C/Ps need more consciousness initially on the maintenance of survey equipment procured by JICA for this project. However, a certain improvement had evidenced by the study team.

Taking into account the present situation, Study Team summarizes the possible issues for MPWT/WD to cope with in the near future, as shown below:

Issue 1: Statutory Arrangement for Supporting Hydro-Oceanographic Services

MPWT/WD has acquired the technology to produce ENC. However, there is no relevant laws and/or regulations nor the supporting legal systems and/or structures pertaining to the hydrographic and oceanographic services, hence MPWT/WD will encounter the difficult time in the upcoming age where MPWT/WD will face the increasing demand for updating of ENC and/or data acquisition and ENC production for port development in the other area. And, on the other hand there are no supporting legal systems for data compilation and dissemination including relevant budgetary allocation for its purposes. It is envisaged that the necessary information for updating/revision on maritime construction work and any other changes different from the present information of the navigational chart such as the information on navigational aids and etc. would certainly be informed to MPWT/WD, so that the navigational chart could promptly updated.

=> **Arrangement of relevant laws and regulations for supporting the hydro-oceanographic services.**

Issue 2: Accumulation of Empirical Knowledge to Strengthen the Organizational Capabilities

Given the appropriate steps to familiarize the ENC world along with the timely OJT and off-site training by the study team, the trainees from MPWT/WD could get to know the basic knowledge on ENC, and further they could attain the working-level on the empirical knowledge on ENC and its production capability. It is envisaged that these 8 trainees could more accumulate the working-experience and strengthen their capability for the time being to the production and updating skills on ENC in order for them to perform the hydro-oceanographic services for the development of Cambodia.

=> **Strengthening the organizational capabilities for supporting the hydro-oceanographic services.**

Issue 3: Application of ENC Technology on various Fields

Although the ENC in SHV port has been produced for the vessels engaging the international voyages, it should be essential to secure the budgetary allocation and to have the survey boat in order to cope with the increasing demands of hydro-oceanographic services for the navigational safety of the domestic vessels, port development projects in other part of the region, fishery activity and preservation of ambient natural environment. And, also the important things are the maintenance of navigational aids, especially the lighthouse, monitoring of sea level fluctuation and the CDL, measures against storm surges and extreme high tide and etc. MPWT/WD is well recognized these urgent issues and requested for further assisting to develop the countermeasures for these matters at the 5th JCC meeting because Cambodia is totally incompetent and scarce knowledge in these urgent matters.

Since all the survey equipment was transferred to MPWT/WD on February 2017 from JICA, JICA study team discussed with MPWT/WD on the insurance coverage of the survey equipment after March 2017.

Originally, the overall plan of operation for hydrographic survey inclusive of updating work of ENC due to the dredging work was scheduled to complete by the end of 2016. However, there happened a different situation than expected before. Namely, the completion of dredging operation for the passage of PAS was unexpectedly postponed to June 2017, which was reported on the 5th JCC meeting. Therefore, the updating work of ENC using the survey equipment should be necessitated from June 2017 onward, which would already be after the ENC project and also be the exclusion period from application of insurance for the survey equipment. Therefore, MPWT/WD urged on JICA the need for assistance of providing them with the insurance coverage for the survey equipment, even after March 2017, for another one year up to the end of February 2018. And, moreover, they pleaded that it's

difficult for them to allocate the relevant budget for the insurance immediately. MPWT/WD also defined clearly that they would ask for necessary budget to the Cambodian government to cover the survey equipment with the insurance starting from the beginning of March 2018, as their own liability even if the exemption amount would be raised.

Actually, they had a will to expand the insurance coverage to a wider area, covering all the Cambodian waters than the present limited area because they were planning to enlarge the hydrographic services to the regional ports and harbors.

According to the information from the insurance company, the insurance amount would not be changed should the coverage area were expanded. However, the amount for exemption of the policy would be raised to some extent. But, MPWT/WD preferred this condition as their management policy for hydrographic services even if the exemption amount would be raised.

Taking into account the situation MPWT/WD faced, JICA accepted their request to insure the survey equipment for another one year from March 2017 to the end of February 2018. Accordingly, MPWT/WD will take the insurance coverage over from JICA after March 2018.

=> Securing the navigational safety and budgetary allocation

7 - 2 - 2 Proposal on Technical Transfer

Strengthening of hydrographic survey capability for 8 C/Ps through the 1st and 2nd terms of hydrographic surveys has been carried out mainly by OJT using digital data acquisition and its data processing systems. Among the C/Ps, 2 officers were selected to dispatch to the training in Japan and the Third Country to further acquire editing techniques of ENC. Study team also dispatched Japanese ENC expert to Cambodia from time to time to undertake OJT of Technology Transfer on the production of ENCs for Navigational Purposes of 5 for Harbour in and around the SHV port.

Next issues after the completion of navigational charting near SHV should be rested on their effort how they could strengthen the updating capability and maintenance management, which will open the door for publication of ENC officially. Therefore, Study Team designed the ENC management training aiming at strengthening of ENC management capability for the Cambodian officials. Further, ENC updating technology had been transferred during the extension project, which was to produce the medium scale ENC of Navigational Purpose 3 for Coastal Navigation.

However, strengthening of ENC management and servicing system together with the improvement of empirical knowledge and its accumulation should be indispensable processes to cope with the international standard and requirements as MPWT/WD are not necessarily independent in terms of management ability and systematic services on ENC.

Unless the data processor knows the site operation how the data are acquired, it's difficult to process the data in order and appropriately. And, it should know that even a small defective part could lead to a fatal system shutdown. Accordingly, all the surveyors should further improve their knowledge and skills to accommodate the difficulty and to detect the solution. It's not an easy job to understand the in-depth function and performance of DHSDAS and DHSDPS in a limited period of times though, it should be envisaged that C/Ps would give all-out their effort to improve their skills and knowledge for the updating and maintenance of ENC they produced.

7 - 3 Comments and Remarks on Production of ENC by the Team Leader of JICA Study Team:

Refer to former report, the Kingdom of Cambodia was the only one country that had not produced nor published navigational chart, not to mention ENC, among the ASEAN countries at the time of being examined on the feasibility of this project as the technical cooperation project by JICA around 2012. Due to the national crisis experienced from 1970's to 1980's in Cambodia, maritime security services including search and rescue, maintenance of navigational aids and hydrographic survey service became vulnerable seriously. Especially, accumulation of empirical knowledge essential to train the human

resources that handled the hydrographic survey as well as the compilation of navigational chart was extremely deficient.

Under such circumstances, technical assistance services by JICA had been tailed off in more than 10 years ago. However, a concerted action by the then staff of JICA Cambodia Office, Embassy of Japan and the then JICA expert had realized this project considering the significance of this technical cooperation project in Cambodia.

Under the circumstances and understanding, JICA study team carried out various types of technical trainings including OJT and technical transfer, and as a result, joint study team produced the ENCs of medium scale and large scale, which were naturally acceptable for the international ENC arena.

Further, C/Ps themselves carried out the hydrographic survey both for the practical purpose and for their self-training, and now they are on the process of producing the vector fair sheet complying with the ENC format and the paper chart. However, there still exists a little uneasy about the capability of using the DHSDAS for updating the current ENC including the weak structural supporting system within the MPWT/WD.

Moreover, JICA study team tried to enlighten the importance of equipment maintenance and sound operation and management as stated in the 'Issues on Technical Transfer and Proposal' above.

In the manner stated above, JICA study team strived for the development of hydro-oceanographic services that MPWT/WD would be able to catch up with the other ASEAN nations primarily. However, there still exist many other factors to be addressed in building up the harmonization and cooperative relation with the international hydrographic services such as 1) arrangements of the laws and regulations for supporting the hydro-oceanographic services, 2) strengthening the organizational capability and 3) securing the navigational safety and preservation of ambient natural environment.

There are naturally the limitations to change the present status as a private consultant in other country. In addition, there was the request by MPWT to JICA at the 5th JCC meeting for 1) construction of permanent Tide station, 2) renovation of old lighthouse, 3) provision of survey boat and pick-up trucks for transportation of precious survey equipment and 4) long-term expert for statutory arrangement. JICA study team considers that it requires the broadening consciousness and renewing themselves for the beginning of new era.

For the time being, MPWT is expected to strive for the broadening consciousness on the necessities for arrangements of laws and regulations, strengthening of organizational capability and securing the navigational safety and preservation of ambient natural environment and etc., having the long-term experts dispatched by JHOD to have the understanding on their request of further assistance by JICA.

Finally, JICA study team would like to emphasize that MPWT/WD should have the perception that it would be utmost essential to strengthen the organizational capabilities and accumulate the empirical knowledge on the ENC in order for MPWT/WD to have the capabilities to maintain the hydro-oceanographic services worthy of the international standard.

RECORD OF DISCUSSIONS

ON

THE PROJECT FOR PRODUCTIONS OF INTEGRATED DIGITAL TERRAIN MODEL AND ELECTRONIC NAVIGATIONAL CHART

IN

THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF PUBLIC WORKS AND TRANSPORT

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Phnom Penh, 15 March, 2013

Izaki Hiroshi *Chief Representative* *Cambodia Office* *Japan International Cooperation Agency* *Japan*	*H.E. Tram Iv Tek* *Minister* *Ministry of Public Works and Transport* *The Kingdom of Cambodia*

In response to the official request of the Government of Cambodia (hereinafter referred to as "GOC") to the Government of Japan (hereinafter referred to as "GOJ"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") held a series of discussions with Ministry of Public Works and Transport of GOC(hereinafter referred to as "MPWT") and relevant organizations to develop a detailed plan of the Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart (hereinafter referred to as "the Project").

Both parties agreed the details of the Project and the main points discussed as described in the Appendix 1 and the Appendix 2 respectively.

Both parties also agreed that MPWT, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Cambodia.

The Project will be implemented within the framework of the Note Verbales exchanged on 11th June, 2012 between GOJ and GOC.

Appendix 1: Project Description
Appendix 2: Main Points Discussed

Appendix 1

PROJECT DESCRIPTION

I. BACKGROUND

One of the mission of MPWT (Department of Waterways) is to ensure the safety of navigation on the main trading routes. This commitment includes ensuring the availability of the adequate coverage on major ports and trade routes with ENCs, Electronic Navigational Charts, for the safety of navigation approaching the main ports. MPWT is of the view that it is necessary to update the present outdated bathymetric data and oceanographic information on the currently used chart with lots of uncertainties. After all, the ambient conditions in terms of the available geographic information are still be the same as it was in the '70s, exposing the incoming and outgoing vessels to danger. However, MPWT has neither the hardware nor the software and the necessary technical know-how, which are needed for production of ENC through the digital hydrographic survey and data processing. While the Sihanoukville Port is being gradually improved in management and operation through various stages via the assistance of development partners, especially Japan; and due to its vital role as the Cambodia's main international maritime gateway to the world, it is urgently required to improve the programs of disaster management and conservation of the environment, all of which should be based on the updated geospatial terrain model.

The direction of Japanese assistance to Cambodia for the program of social and economic infrastructure development is partially focusing on the development and expansion of port sector from both sides of software and hardware. ENC is important and urgently needed part of software for Cambodian port sector.

Given these situations, "The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart" has been conceptualized in order to contribute to safety, effectiveness, efficiency and competitiveness of the Sihanoukville port.

II. OUTLINE OF THE PROJECT

1. Title of the Project

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart

2. Expected Goals which will be attained after the Project Completion

2-1. Goal of the Proposed Plan

- Strengthening the navigation safety in and around the Sihanoukville Port.
- Enhancement of international credibility of the Sihanoukville Port.

2-2. Goal which will be attained by utilizing the Proposed Plan

- Capacity building (Transfer of Technology) on the planning and hydrographic and oceanographic surveys
- Capacity building for development of and skills for publication of ENC and dissemination system of navigational information
- Capacity building on the ENC management and operation skill for the technical officers
- Development of the ENC of the proposed area

3. Outputs

- Knowledge and ability improvement of relevant technical staffs of MPWT and other relevant organizations for hydrographic and oceanographic survey techniques, such as data acquisition, data processing including updating skills for sustainability, and capacity to assimilate its procedures/outputs.
- Enhancement of the skill for establishment of Database of Integrated Digital Geospatial Terrain Model of Land and Sea (DTM).
- Production of hydrographic and oceanographic data in Sihanoukville coastal area.
- Enhancement of management and operation skill for technical staffs on ENC.

4. Activities

- Coordination of survey party and mobilization of equipment to site.
- Collection and analysis of the existing data
- Acquisition of sonar images, hydrographic images seabed image and sounding data at Sihanoukville harbor area
- Collection of satellite images for lineation of coastline and land information
- Collection of bottom samples for anchorage purpose and study for biotope identification
- Measurement of tides and currents
- Data processing and analysis of oceanographic data for tide table and current prediction
- Data processing and production of DTM for ENC and paper chart in the Sihanoukville Port
- On-the-job trainings of hydrographic and oceanographic surveys to the Cambodian trainees
- On-the-job training and lectures for data analysis, processing and assessment, inclusive of overseas training in Japan, for future maintenance of digitalized geospatial information by the Cambodian personnel in charge
- Conduct seminar/workshop for dissemination of the product and confirmation of social impacts induced by the project
- Technical visit to Japan and neighboring countries on the operation and management of ENC

5. Input

5-1. Input by JICA

i. Dispatch of Missions

ii. C/P training both in and outside of Cambodia

iii. Necessary Equipment for the implementation of the survey

Input other than indicated above will be determined through mutual consultations between JICA and MPWT during the implementation of the Project, as necessary.

5-2. Input by MPWT

MPWT will take the following necessary measures to provide at its own expense.

i. Services of MPWT's counterpart personnel and administrative personnel as referred to in II. 6
ii. Suitable office space with necessary equipment
iii. Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA (including Survey Ship for operating bathymetric surveys works)
iv. Information as well as support in obtaining medical service
v. Credentials or identification cards
vi. Available data (including maps and photographs) and information related to the Project
vii. Expenses necessary for transportation within Cambodia of the equipment referred to in II. 5-1 as well as for the installation, operation and maintenance thereof
viii. Necessary facilities to members of JICA missions for the remittance as well as utilization of the funds introduced into Cambodia from Japan in connection with the implementation of the Project

If there arise other expenses necessary for implementing the project, MPWT will make the best effort to cover it and in case there is any difficulty, both sides will discuss the solution.

6. Implementation Structure

In order to implement the project, the following mechanisms will be established by Prakas of the Minister of Public Works and Transport:

6-1. Joint Coordinating Committee

I. Function: Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to supervise the project and to facilitate inter-organizational coordination. JCC meeting will be held

every six months and whenever deems it necessary.

II. Chairperson:

1) Chairperson: Minister of MPWT and Chief Representative of JICA Cambodia Office
2) Vice-Chairperson: Secretary of State
3) Vice-Chairperson: Chairman and CEO of PAS

III. Members:

Cambodian Side

- Members of Task Force
- Any other person concerned to be decided by MPWT

Japanese Side

- Chief Representative of JICA Cambodia Office as Co-Chairperson
- JICA missions
- Any other person recommended by JICA Cambodia Office

6-2. Task Force

I. Function: to manage and implement the project and discuss practical matters. The Task Force should meet once every three months or whenever it deems necessary.

II. The Task Force is led by:

1. Project Director: Under Secretary of State
2. Deputy Project Director: Deputy Director General of Transport
3. Deputy Project Director: Director of Department of Waterway
4. Members: Officials from General Department of Public Works (Department of Waterway) and General Department of Transport (Department of Marine Merchant and Department of Inland Waterway Transport) of MPWT and PAS.

6-3. Practical Counterpart Persons for Technical Transfer: Staffs including the four (~~4~~) staffs of participating departments who participated in JICA Group Training Course (Marine Information Management for Navigation Safety, Disaster prevention and Environment Protection) for 6 months in 2011 and 2012 fiscal year.

6-4. Cooperating Agency: Sihanoukville Autonomous Port (PAS)

6-5. JICA Missions

Members of JICA missions will give necessary technical guidance, advice and recommendations to MPWT and other relevant organizations including PAS and Phnom Penh autonomous Port (PPAP) on any matters pertaining to the implementation of the Project.

7. Project Site(s) and Beneficiaries

The project sites will be "From 10°34' N to 10°45' N, From 103°24' E to 103°34' E" which is in and around Sihanoukville Port as shown in Annex-1. The beneficiaries extend to wide range of fields, such as incoming and outgoing vessels to and from the Sihanoukville Port, contractors of development and rehabilitation project of the port, etc.

8. Duration

The duration of the Project will be carried out for approximately twenty (24) months as shown below from the date of arrival of JICA missions. Duration and timing of submitting reports may change according to the progress of the project.

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Project																								
JCC																								
Report	▲ ICR							▲ PRR								▲ ITR						▲ DFR		▲ FR

Notes: JCC: Joint Coordinating Committee, ICR: Inception Report, PRR: Progress Report, ITR: Interim Report, DFR: Draft Final Report, FR: Final Report

9. Reports

JICA will prepare and submit the following reports to MPWT in English.

I. Thirty (30) copies of Inception Report at the commencement of the first work period in Cambodia.

II. Thirty (30) copies of Progress Report at the time about eight (8) months after the commencement of the first work period in Cambodia.

III. Thirty (30) copies of Interim Report at the time of sixteen (16) months after the commencement of the first work period in Cambodia.

IV. Thirty (30) copies of Draft Final Report at the end of the last work

period in Cambodia.

V. Thirty (30) copies of Final Report within one (1) month after the receipt of the comments on the Draft Final Report

10. Environmental and Social Considerations

MPWT agreed to abide by 'JICA Guidelines for Environmental and Social Considerations' in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF MPWT AND GOC

MPWT and GOC will take necessary measures to:

I. ensure that the technologies and knowledge acquired by the Cambodian nationals as a result of Japanese technical cooperation contributes to the economic and social development of Cambodia, and that the knowledge and experience acquired by the personnel of Cambodia from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

II. grant privileges, exemptions and benefits to members of JICA missions referred to in II. 5-1 above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Cambodia.

III. update the ENC produced by the project in a timely manner after the project by cooperating within the relevant organizations, so that the credibility of ENC will be maintained.

IV. EVALUATION

JICA will conduct the following evaluations and surveys to mainly verify sustainability and impact of the Project and draw lessons. MPWT is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle
2. Follow-up surveys on necessity basis

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting its support for the Project, MPWT will take appropriate measures to make the Project widely known to the people of Cambodia.

VI. MUTUAL CONSULTATION

JICA and MPWT will consult each other whenever any major issues arise in the course of Project implementation.

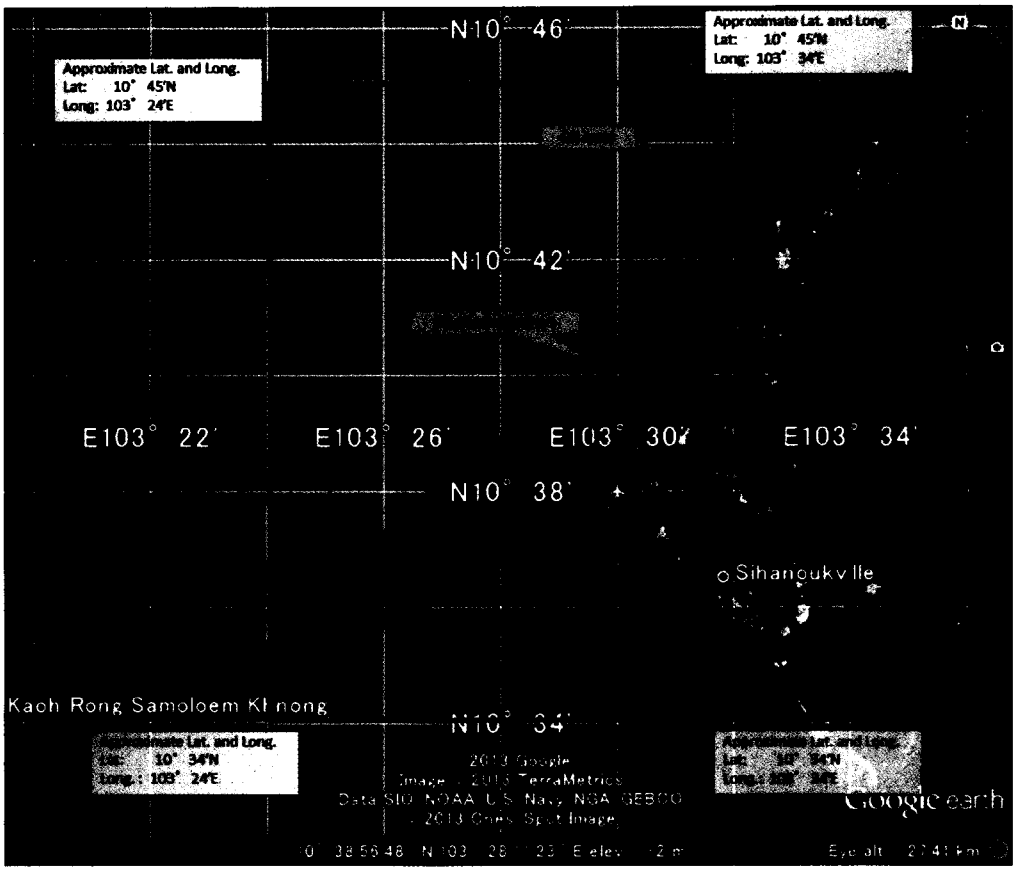
VII. AMENDMENTS

The record of discussions may be amended by the minutes of meetings between JICA and MPWT.

The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the record of discussions.

Annex-1 ENC Coverage Area of Sihanoukville port and its Adjacent Waters

Annex-1



ENC Coverage Area of Sihanoukville port and its Adjacent Waters

Appendix 2

MAIN POINTS DISCUSSED

- Both sides had a discussion regarding the area of ENC to be covered by the project and agreed to extend the area to the further west up to 103°24' E from 103°26' E which is proposed in the original application form. Thus, the area to be covered by the project is changed to "From 10°34' N to 10°45' N, From 103°24' E to 103°34' E".

- Both sides also discussed whether to extend to north or south, but agreed that further extension should be executed by the Cambodian side's own after the necessary techniques and knowledge are transferred by the project.

- The team explained the importance to update the ENC produced by the project in a timely manner after the project by the Cambodian side's own effort, so that the credibility and value of ENC will be maintained. MPWT replied to make full effort for the update of ENC by coordinating the related departments, authorities etc.

- Tentative list of Equipment which will be procured in the project is shown in Table 1. Purchased equipment by JICA will be handed over to MPWT, while the procurement method will be determined by June 2013 by JICA taking into consideration the budget and necessity for the equipment to be used for maintaining and updating ENC by MPWT.

Table1 Tentative list of Equipment

Type of Survey System	Name of Survey Equipment (Quantity)
Sea Positioning and Navigation System	SBAS DGPS system (2)
	Helmsman display for vessel navigation (2)
	Navigation software (2)
	Laptop PC for vessel navigation and control (2)
Depth Sounding System	Single-beam echo sounder (1)
	Swath sounding system with side scan function (1)
	Under water sound speed measuring system (1)
	Motion sensor for correction of vessel posture (1)
	USB cables and serial port with multiple sockets(2)
	Data acquisition and processing software: HYPACK (2)
	Bar-check bar, Generator, Converter, Mount (2)
	Laptop PC (2)
	Desktop PC (2)
	External hard disks and ancillary systems (2)
Seabed Imaging	Side Scan Sonar Is used to examine the riverbed(1)
Oceanographic Measure-System	Water level recorder (Tide gauge) (2)
	ADCP current meter with bottom tracking (1)
Production of ENC & Paper Chart	Software for production of ENC & Paper Chart (1)
	Hardware for ENC production (1)
	CAD mapping software for analysis of sounding data and production of survey sheet (2)
	A0 plotter (1)
	UPS （To balance the use of electricity） (3)

MINUTES OF MEETINGS

BETWEEN

JAPAN INTERNATIONAL COOPERATION AGENCY

AND

MINISTRY OF PUBLIC WORKS AND TRANSPORT

FOR AMENDMENT OF THE RECORD OF DISCUSSIONS

ON

THE PROJECT FOR PRODUCTIONS OF INTEGRATED DIGITAL TERRAIN MODEL AND ELECTRONIC NAVIGATIONAL CHART

Phnom Penh, November 10th, 2015

Mr. Itsu Adachi
Chief Representative
Cambodia Office
Japan International Cooperation Agency
Japan

H.E. Tram Iv Tek
Minister
Ministry of Public Works and Transport
The Kingdom of Cambodia

The Japan International Cooperation Agency (hereinafter referred to as "JICA") and Ministry of Public Works and Transport hereby agree that the Record of Discussions on The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart (hereinafter referred to as "the Project") signed on March 15th , 2013 will be amended as follows;

1. Amendment Contents

(1) Project Site(s) and Beneficiaries

Before	Amended Version
The project sites will be "From 10°34' N to 10°45' N, From 103°24' E to 103°34' E" which is in and around Sihanoukville Port as shown in Annex-1.	The project sites will be "From 10°13' N to 10°56' N, From 102°50' E to 103°43.5' E" which is in and around Sihanoukville Port as shown in Annex-2.
Reason: In addition to the original coverage area of the large scale (1:20,000) Electronic Navigational Chart (ENC), there is an urgent demand for the middle scale (1:150,000) ENC of approach route to the Sihanoukville Port from the maritime stakeholders as well as the pilots and the personnel concerned in the port.	

(2) Duration

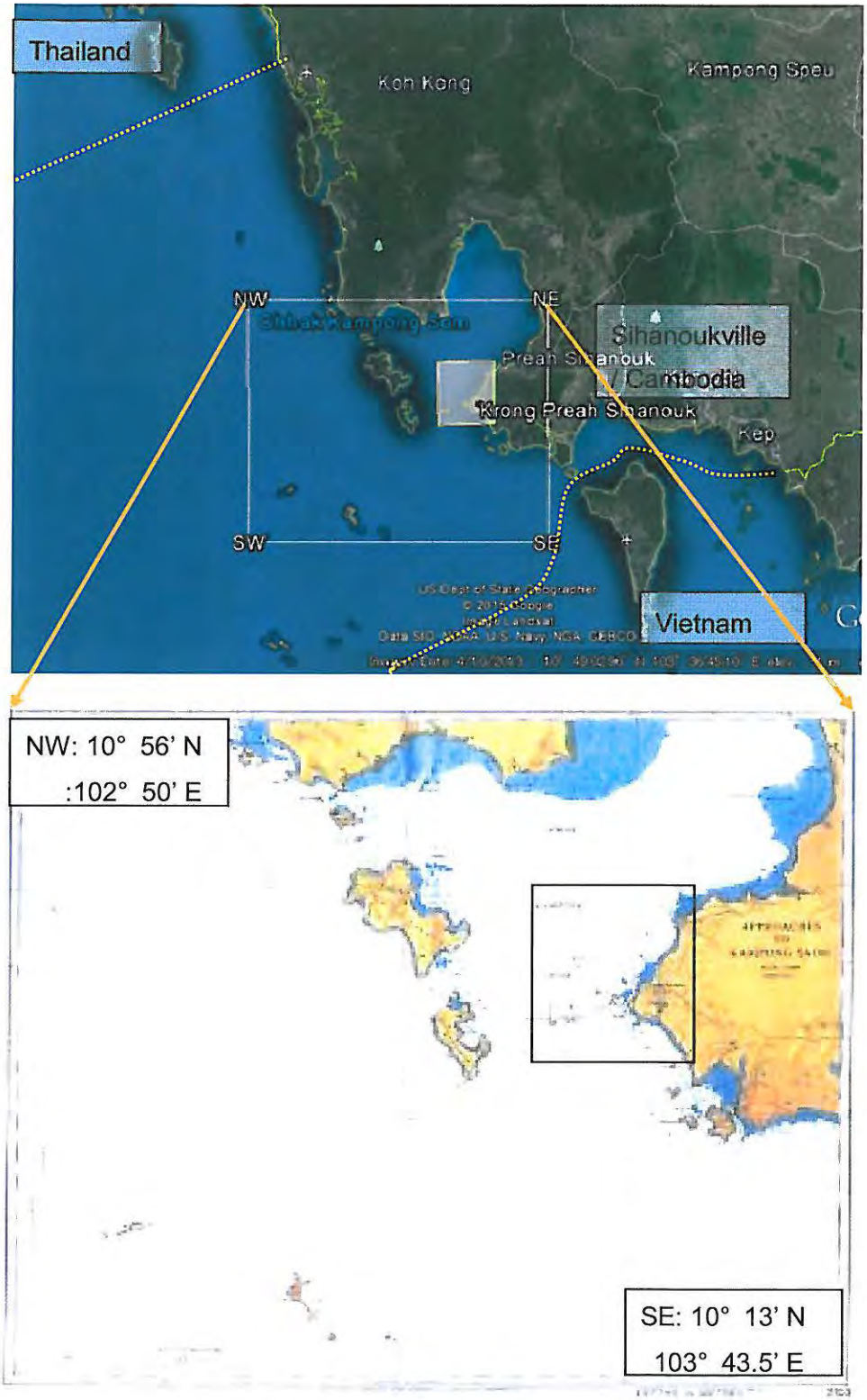
Before	Amended Version
The duration of the Project will be carried out for approximately twenty-four (24) months as shown below from the date of arrival of JICA missions.	The duration of the Project will be carried out for approximately forty (40) months as shown in Annex-3 from the date of arrival of JICA missions.
Reason: The Project site (coverage area of ENC) will be expanded, therefore the duration of the Project has to be extended.	

2. Effectuation Date

This amendment will become effective as of November 10th , 2015.

Annex 1 : Record of Discussions (signed on March 15, 2013)
Annex 2 : ENC coverage area (Amended)
Annex 3 : Duration of the Project (Amended)

Annex 2



ENC coverage area (Amended)

Duration of the Project (Amended)

2013-						2014-																		2015-																		2016-											
7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
JCC			▲							▲												▲										▲										▲
Report		△ IC /R							△ PR /R												△ IT/ R (1)										△ IT/ R (2)								△ DF /R	△ F/R

MINUTE OF MEETING

of the First Meeting of Joint Coordinating Committee

for

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart in the Kingdom of Cambodia

Following the RECORD OF DISCUSSIONS BETWEEN THE JAPAN INTERNATIONAL COOPERATION AGENCY AND AUTHORITIES CONCERNED OF THE ROYAL GOVENRMENT OF CAMBODIA ON THE PROJECT FOR PRODUCTIONS OF INTEGRATED DIGITAL TERRAIN MODEL AND ELECTRONIC NAVIGATIONAL CHART IN THE KINGDOM OF CAMBODIA signed on March 15th, 2013 hereinafter referred to as "The Project"}, The First JCC Meeting for the said Project was held on September 26th, under the Chairmanship of **H.E Mr. Tram Iv Tek**, Minister for Public Works and Transport, and **H.E Mr. Izaki Hiroshi,** JICA Chief Representative, Phnom Penh. The list of attendants is attached.

At the meeting, the Inception Report including the work plan of the Project was presented by the JICA Expert Team.

JCC discussed intensively the Inception Report and Work Plan and noted that the methodology and technology applied are clear, accurate and universal applicable despite it is introduced first time in the world (Production of ENC before Paper Chart).

JCC recognizes the importance of an Integrated Digital Terrain Model and Electronic Chart. JCC and JCC agreed on the importance of obtaining ground control points for Sihanuokville bay.

JCC and the expert team also expressed interest of the importance of understanding port management and chart datum as well as the importance of the MPWT to carry out a technical visit in a relevant third party country and/or international organizations to obtain and review international standards and norms as well as the lessons learnt.

JCC endorsed the work plan and urge all stakeholders for full cooperation for the project implementation.

Phnom Penh, September26th, 2103.

H.E Tram Iv Tek

Chairperson of JCC

The Minister of public Works and Transport

MINUTE OF SECOND MEETING

of the Joint Coordinating Committee

for

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart in the Kingdom of Cambodia

In accordance with the work plan of the ***PROJECT FOR PRODUCTIONS OF INTEGRATED DIGITAL TERRAIN MODEL AND ELECTRONIC NAVIGATIONAL CHART IN THE KINGDOM OF CAMBODIA***, hereinafter referred to as "***The Project***", and as a follow up to the progress of the implementation of the Project, the Second Meeting of the Joint Coordinating Committee (JCC) for the said Project was held on May 22nd, 2014, under the Chairmanship of **H.E Mr. Tram Iv Tek**, Minister for Public Works and Transport, and **H.E Mr. Izaki Hiroshi,** JICA Chief Representative, Phnom Penh. Mr. KOYANAGI Yoshimoto, Deputy Director of Transportation and ICT Division of JICA Headquarter in Tokyo, was also in attendance. The list of attendants is attached.

The JICA Expert Team together with the Task Force Team presented the Progress Report on the Implementation and achievement of the Project Phase 1; that is the Hydrographic Survey including Geodetic and Tidal Observation; and the Activity Plan to be implemented at the Phase 2 of the Project. The progress of the Knowledge and Technology Transfer was also presented by the Task Force Team.

JCC discussed intensively the Progress Report and noted that the purpose of the Phase 1, the Hydrographic Survey, was almost completed and the capacity or Technology Transfer is progressed gradually. JCC also praises the accomplishment made by the study team despite it has faced a number of difficulties during the project implementation.

JCC also agreed with the activity plan for the Phase 2 and urge the study team to work closely together to conclude this phase 2 timely. JCC also encourages the Task Force to digest knowledge and technology from the Expert Team.

Phnom Penh, May 22nd, 2014

H.E Mr. Tram Iv Tek
Chairperson of JCC
The Minister for Public Works and Transport

MINUTE OF THIRD MEETING

of the Joint Coordinating Committee

for

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart

in the Kingdom of Cambodia

In accordance with the work plan of the ***PROJECT FOR PRODUCTION OF INTEGRATED DIGITAL TERR MODEL AND ELECTRONIC NAVIGATIONAL CHART IN THE KINGDOM OF CAMBODIA,*** hereinafter referred to as ***"The Project"*** and as a follow up to the progress of the implementation of the Project, the Third Meeting of the Joint Coordinating Committee (JCC) for the said Project was held on April 22nd 2015 under the Chairmanship of **H.E. Mr. Tram Iv Tek**, Minister for Public Works and Transport, and **H.E. Mr. Itsu Adachi,** Chief Representative of JICA Cambodia Office. The list of attendants is attached.

The JICA Study Team together with the Task Force Team presented the Interim Report on the implementation and achievement of the Project Phase 2; that is the supplementary Hydrographic Survey including Tidal Observation and Tidal Current Measurement; and Data Processing for enormous acquisition data of the Phase 1; starting to produce ENC; and the Activity Plan to be implemented until the end of the Project. The progress of the Knowledge and Technology Transfer was also presented by the Task Force Team.

JCC discussed intensively the Interim Report and noted that the purpose of the Hydrographic Survey including enormous Data Processing was almost achieved, and is ongoing to produce ENC and Technology Transfer is progressed gradually. JCC also praises the accomplishment made by the study team despite it has faced a number of difficulties during the Project implementation.

JCC also agreed with the activity plan until the end of the Project and urge the Study team to work closely together to conclude the Project timely. JCC also encourages the Task Force Team to digest Knowledge and technology from the Study Team.

Phnom Penh, April 22nd 2015

H.E Tram Iv Tek

Chairperson of JCC

The Minister of public Works and Transport

MINUTE OF FORTH MEETING

of the Joint Coordinating Committee

for

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart

in the Kingdom of Cambodia

In accordance with the work plan of the *PROJECT FOR PRODUCTION OF INTEGRATED DIGITAL TERR MODEL AND ELECTRONIC NAVIGATIONAL CHART IN THE KINGDOM OF CAMBODIA*, hereinafter referred to as "The Project" and as a follow up to the progress of the implementation of the Project, the Forth Meeting of the Joint Coordinating Committee for the said Project was held on March 11 2016 under the Chairmanship of H.E. Mr. Tram Iv Tek, Minister for Public Works and Transport, and H.E. Mr. Itsu Adachi, Chief Representative of JICA Cambodia Office. The list of attendants is attached.

The JICA Study Team together with the Task Force Team presented the Interim Report 2 on the implementation and achievement of the original Project up to December 2015; that is the Hydrographic Survey including Tidal Observation and Current Measurement; and Data Processing for enormous acquisition data; Production ENC; and the Activity Plan to be implemented in the extension Project until the end of December 2016. The progress of the Knowledge and Technology Transfer was also presented by the Task Force Team. (The Project has been extended for a year because of producing a middle scale ENC by requesting of the Third JCC.)

JCC discussed intensively the Interim Report 2 and noted that the purpose of the Hydrographic Survey including enormous Data Processing and the Cartography including ENC Production was achieved as of the original plan, and Technology Transfer is progressed gradually. JCC also praises the accomplishment made by the study team despite it has faced a number of difficulties during the Project implementation.

JCC also agreed with the activity plan for the extension Project and urge the Study Team to work closely together with Task Force Team to conclude the Project timely. JCC also encourages the Task Force Team to digest Knowledge and Technology from the Study Team.

Phnom Penh, March 11 2016

H.E Tram Iv Tek

Chairperson of JCC

The Minister of public Works and Transport

MINUTE OF FIFTH MEETING

of the Joint Coordinating Committee

for

The Project for Productions of Integrated Digital Terrain Model and Electronic Navigational Chart

in the Kingdom of Cambodia

In accordance with the work plan of the *PROJECT FOR PRODUCTION OF INTEGRATED DIGITAL TERRAIN MODEL AND ELECTRONIC NAVIGATIONAL CHART IN THE KINGDOM OF CAMBODIA,* hereinafter referred to as "The Project" and as a confirmation of completion of the Project implementation, the Fifth Meeting of the Joint Coordinating Committee for the said Project was held on December 8 2016 under the Chairmanship of H.E. Mr. Tauch Chan Kosal, Acting Minister for the Ministry of Public Works and Transport, and H.E. Mr. Itsu Adachi, Chief Representative of JICA Cambodia Office. The list of attendants is attached.

The JICA Study Team together with the Task Force Team presented the Draft Final Report on the implementation, achievement and results of the original and extensional Project over three years; that is the Hydrographic Survey including Tidal Observation and Current Measurement; and Data Processing for enormous acquisition data; Production ENC until the end of December 2016. The progress of the Knowledge and Technology Transfer was also presented by the Task Force Team. (The Project has been extended for a year because of producing a middle scale ENC by requesting of the Third JCC.)

JCC discussed intensively the Draft Final Report and noted that the purpose of the Hydrographic Survey including enormous Data Processing using GIS technology such as practical use of satellite imagery and the Cartography including ENC Production has been achieved as of the original / extensional plan, and Technology Transfer is progressed gradually. JCC also praises the accomplishment made by the study team despite it has faced a number of difficulties during the Project implementation.

JCC also agreed on the summarization of the Draft Final Report for the whole Project and urge the Study Team (JICA mission) to advise effectually on the continuity of the ENC management system and urge to have a strong will to continue the ENC management system in the Task Force Team of MPWT, and expected for JICA's support for strengthening the organization on maritime safety.

At Phnom Penh, December 8 2016

H.E. Mr. Tauch Chan Kosal

Chairperson of JCC

The Acting Minister of Ministry public Works and Transport