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

Main Report

March 2017

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

AERO ASAHI CORPORATION

EI
JR
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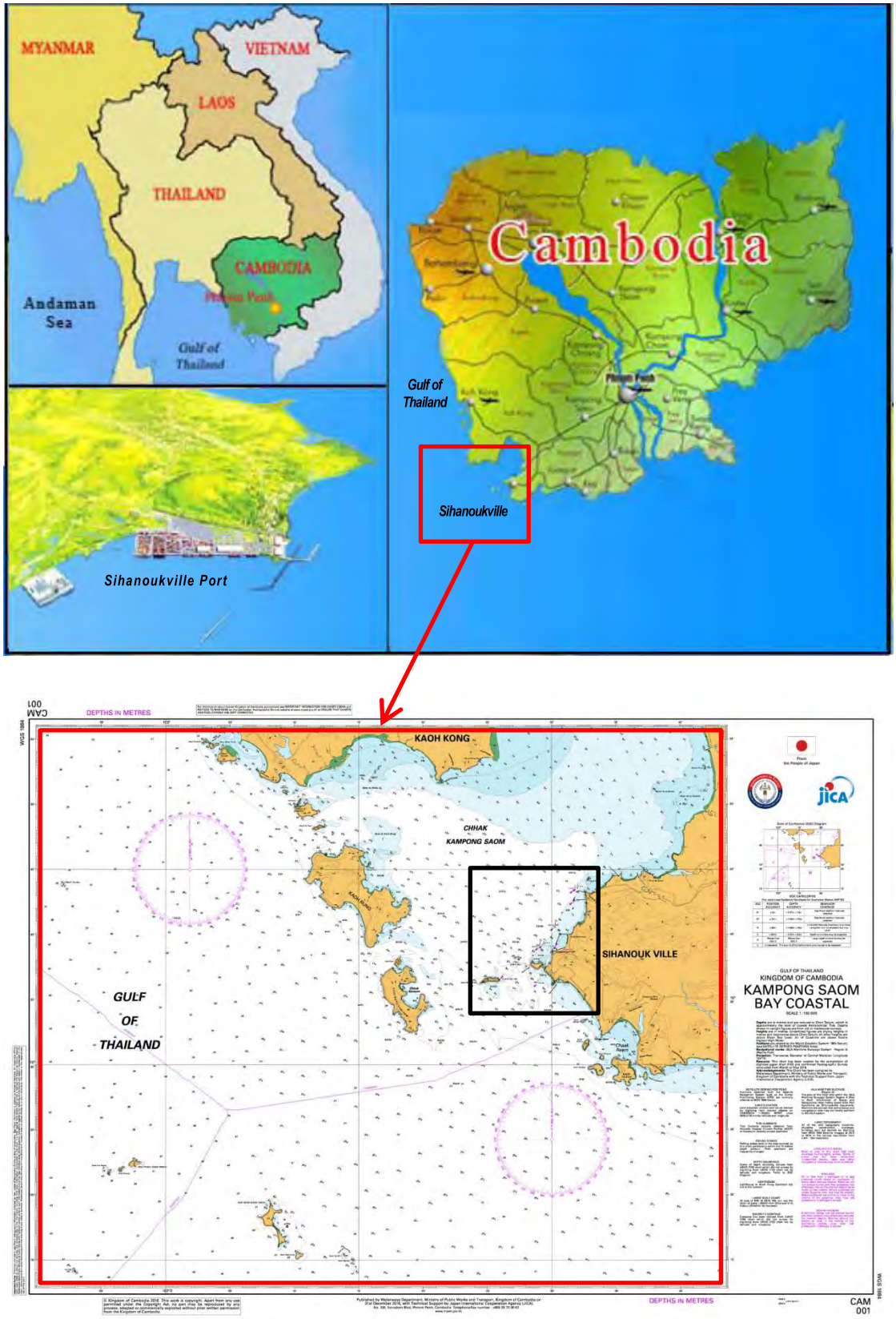
Study Area Map



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

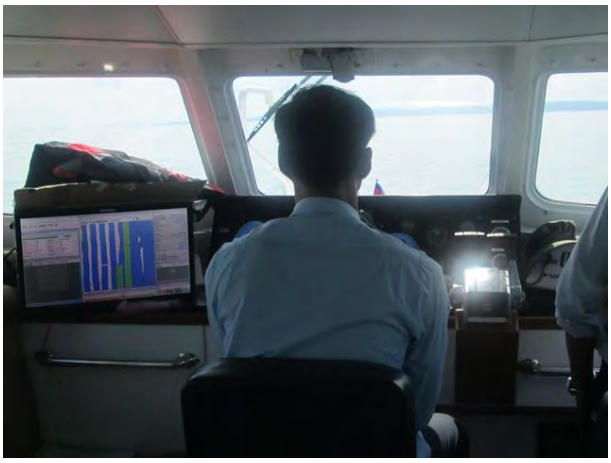
GNSS Antennas Installation

MBES Hydrographic Survey System

Navigation and Data Acquisition Computer

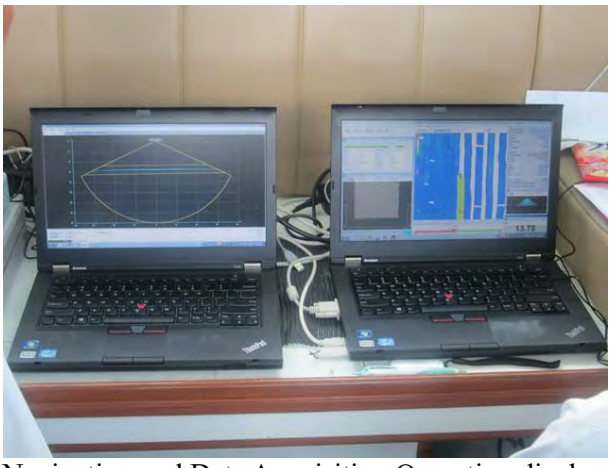
MBES Hydrographic Survey

MBES Transducer during Hydrographic Survey



Navigation Monitor with Survey Boat Operator

Snapshot of Hydrographic Survey operation



Navigation and Data Acquisition Operating display

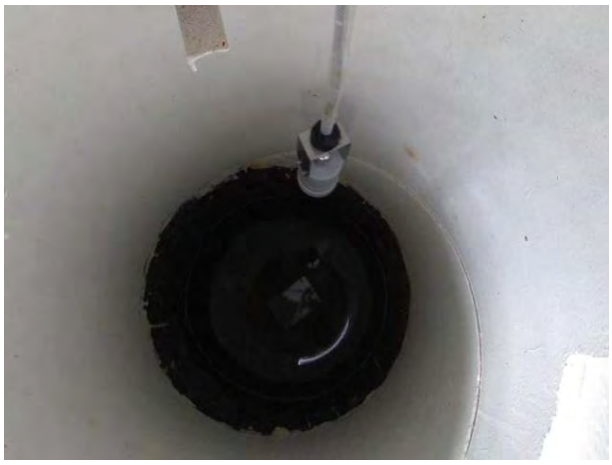
MBES hydrographic Survey Operation

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.)

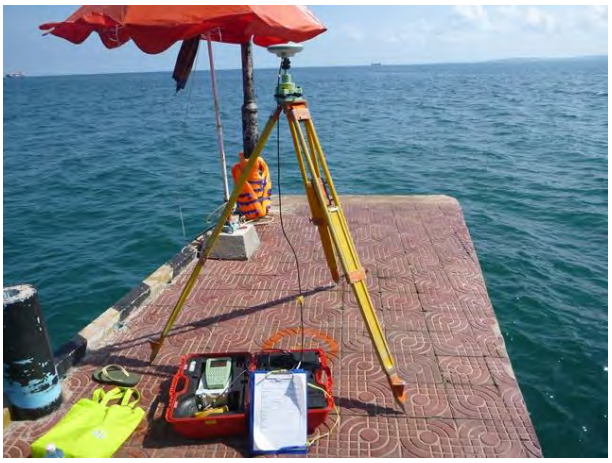
Tide Pole.

Saving of Tidal data
and Check of the Tide Gauge.

GNSS Ground Control Point Survey

Observation at GCP3 point

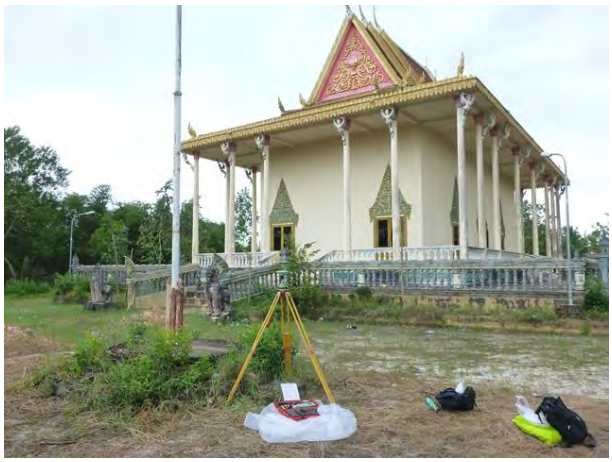
Observation at GCP4 point



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

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Chapter 1 IMPLEMENTATION POLICIES OF THE STUDY

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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.

Following photos show large size of international passenger cruises that visited SHV port.

CRYSTAL SYMPHONY

SEVEN SEAS VOYAGER

AEGEAN ODYSSEY

HANSEATIC

Photo 1 - 1 International Passenger Cruises visited to SHV Port

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.

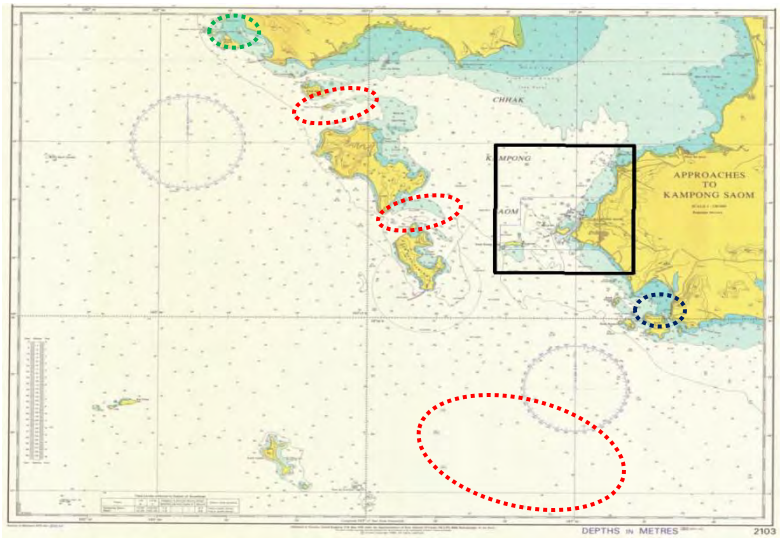

Figure 1 - 1 Study Area

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.

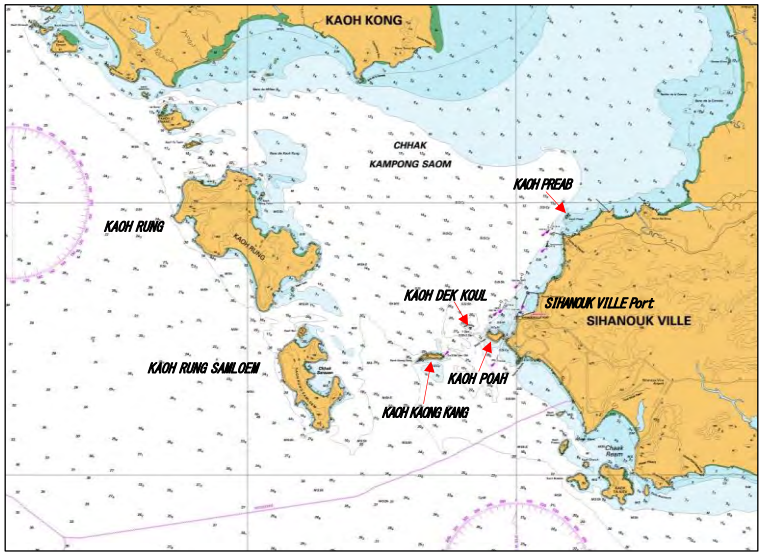

Figure 1 - 2 The Outskirt of the SHV Port

Photo 1 - 2 Overall Scenery of SHV port from the east side hill viewing;

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.

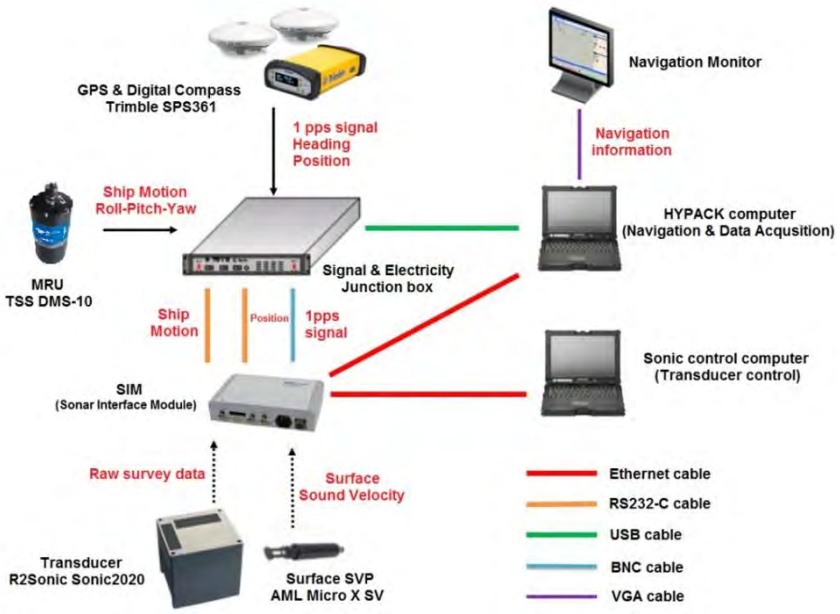

Figure 1 - 3 Digital Hydrographic Survey Data Acquisition System (DHSDAS)

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 - 3 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.

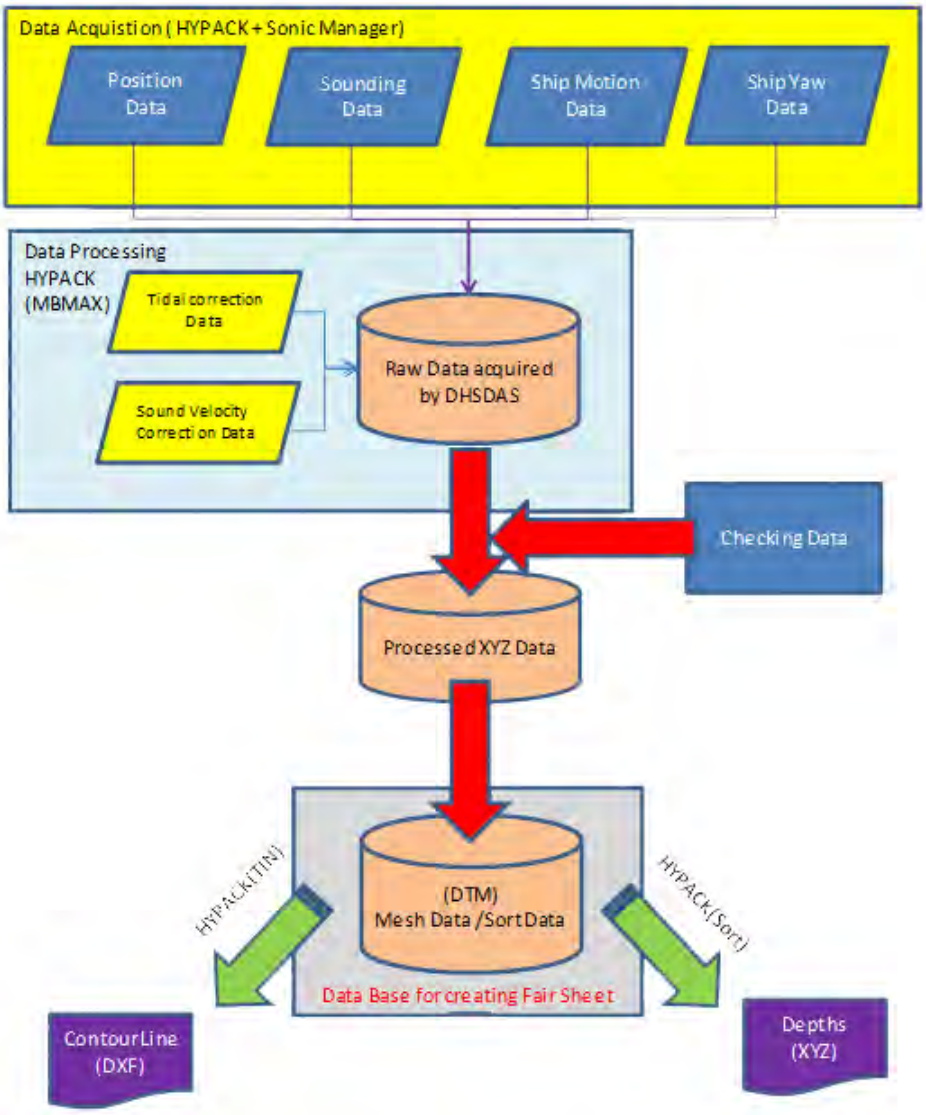

Figure 1 - 4 Flowchart of MBES Data Processing by “HYPACK”; DHSDPS

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.

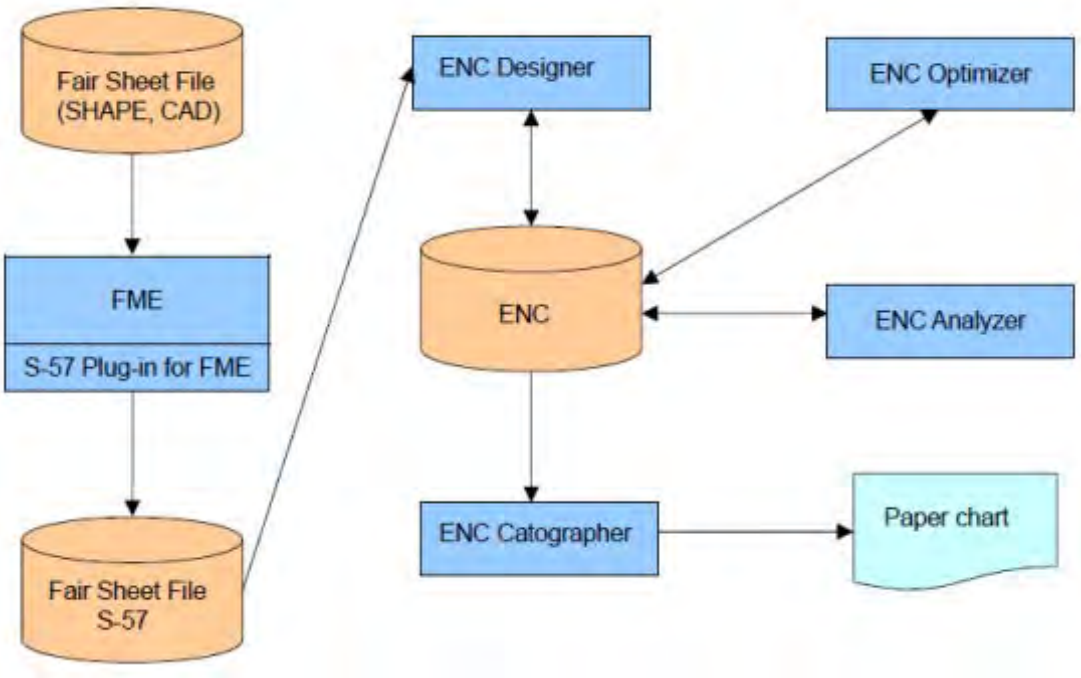

Figure 1 - 5 Flowchart of ENC Production

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.

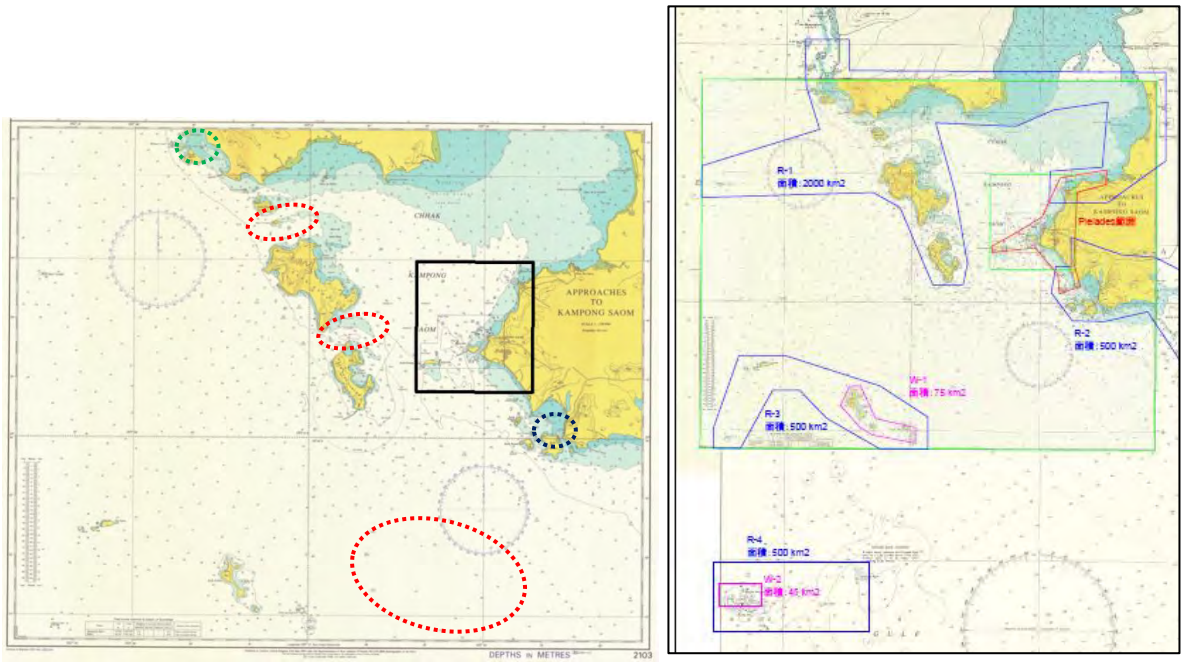

Figure 1 - 6 Area for Extension Project

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