INLAND ELECTRONIC NAVIGATION CHARTS FOR ENHANCING THE EFFICIENCY OF NAVIGATIONAL WATERWAY IN THE NILE RIVER: CASE STUDY- EL-WASTA REACH

Noha Kamal

Researcher, Nile Research Institute, National Water Research Center,
E-mail:Noha_kamal2002@hotmail.com

ABSTRACT

The Nile River is characterized by numerous natural phenomena and human interventions represented in multiple qualities of the islands characteristics and the spread of many activities on the stream which could be solved by utilizing an interactive Inland Electronic navigational charts (IENC). The IENC play an important role for the optimization of the development and preparation of the waterway between Cairo and Aswan and its branches. This paper introduces new electronic navigation charts, for improving the safe navigation of the Nile River in Egypt at El-Wasta reach, by using the modern navigational aids and tracking systems. The El-Wasta reach was selected as a case study. It extends from km 878 to km 901 downstream Aswan dam with a length of about 23 km. This region has been exposed to many morphological changes as a new island was formed and the area of permanent island was increased. This, in turn, negatively affected the efficiency of the navigational path. The author developed an application tool linking between these IENCs and Geographic Information System (GIS). This application tool illustrated the morphological changes that affecting the navigational path location, by monitoring and analyzing the navigation path from the hydrographic survey at 2005 up until now using the recent hydrographic survey data at 2016. These electronic navigation charts follow International Hydrographic Organization (IHO) standards for hydrographic survey. The charts are considered more accurate, quick, and easy to update, compared to traditional navigation (the navigational marks or Buoyage System), which are more expensive to operate and maintain. Moreover, the user gets the latest navigational information simultaneously to avoid any navigational bottlenecks and reduce the workload. New INECs for El-Wasta region proved to be technically feasible and efficient for safe inland navigation, and the developed tool linkage between IENCS and GIS has provided an effeicent tool to solving navigation problems.

Keywords: Nile River, GIS, IENC, FME , SevenCs, Navigation Efficiency

1 INTRODUCTION

The Nile has been considered as a navigable channel throughout Egypt history. Around 3 million tons of cargo is transported over the Nile River between Alexandria, Cairo, and Aswan yearly. This transport is expected to increase considerably when the planned container terminal projects and other infrastructure projects in the Nile Delta are completed. Also, It is of great concern to the responsive authorities are the more than 290 Nile Cruise ships (Floating hotels) with a total capacity of 26,673 passengers, operating between Luxor and Aswan [Rasslan, 2001]. Therefore, the Egyptian government has declared a high priority to the improvement of safety of navigation on the Nile River. The main condition is that the transport companies have certainly about the depth of the river and the draft for the ships, independent of time of the year and for both day and night navigation. The reduction in fright costs, increased safety and certainly of water depth will cause positive effect and has been proven world-wide to increase the amount of traffic. The main outcome of this paper is the highly recommended demand on IENCs to be applied in navigation and tracking systems in the Nile in Egypt, which introducing enormous economic gain in terms of Nile transportation services; contribute to solving overcrowding, the traffic problems, and reduce accident roads. After executing these steps it will be impossible to construct any berths unless the main navigable channel is established and connected to other routes to facilitate berthing and departure of vessels. It was clear that several

researchers addressed in the field of navigation waterway and application of GIS in water resources and navigation. Among them are:
(Kamal & Rasslan, 2015) determines the navigable routes in the Nile River using Geographic Information System in Nile River (Greater Cairo region). Based on stage discharge relationship, flow stage corresponding to maximum, minimum, and average discharge were determined. These flow stages were used along with recently developed bathymetric charts to determine the location of navigation channel. Geographic Information System was used to locate most suitable navigation channel corresponding to discharge.(CHRIS,2001) report provides a status for Australia’s ENC production, 320 cells is the number of produced cells for Australia’s area which is covered until now . (Abdel-Aziz, 2004) describes the main steps that should be followed to achieve safe navigation in the Nile River based on IHO standards for hydrographic survey. (Mohamed, 2004) Another application using GIS technique, study the Rashid Tributary, developed GIS model studied sedimentation and erosion rates at different senarios with the urbanization of surrounding areas as results of the increase in the density of population.

2 PROBLEMS OF NAVIGATION IN THE NILE RIVER

Recently, Nile river transportation cannot take part in solving the transportation requirements. The most threaten problem in the Nile River navigation is the shortage of enough navigational water depth and as a result the tourism industry. Also, continues change of the water level, along the River Nile from old Aswan Dam to Delta Barrages, where the irrigation supplies throughout the year effect on the water level in the Nile River. Through July and August, the irrigation water rations are high. While in December and January, the water requirements are low. According to that, water level in the Nile during December and January is the lowest and navigation form a real problem during this period unless Aswan High Dam released additional water. On the other hand, the absence of the landmarks and suitable navigational aids, lack of experience among boat navigators, change in the level of the river bed, the navigational information of the channels is not well defined are the significance problems that faces the navigation in river Nile, those problems were evaluated during the period 1995 to 2009 (Raslan, 2001). Accordingly, the aims can be identified with respect to the development of inland water transport by means of producing new electronic navigation maps , since the maps are accurate , quick and easy update which ensures the user get the latest navigational information, which increases the efficiency of the navigational path and purpose.

3 INLAND WATERWAY TRANPORT IN EGYPT

Inland Waterway Transport (IWT) is the traditional transportation in Egypt, operated since ancient the Egyptian dynastic period, which is commonly advantageous to mass transportation. According to table1 which show the rapidly increasing in the traffic of cargo transportation, which increased from 82.6 million tons in the year 1979 to 570 million tons in the year 2007, and it reached 872 million tons by the end of the year 2014. Therefore, the Nile River navigation development has major importance by reducing the load on road transportation with the enormous increasement of population, also to reduce the motorways crowding and a decrease in the overall transport costs. (Saber, 2011).

Table1. Nile’s river working units fleet of different type and operators, (Saber, 2011)

Type of Units	Number of working units
Passengers	2899
Single cargo units	1247
Double cargo units	111
Research units	48
Sounding boats	3
Service units	40
Towing units	357

Tourist Service boats	296
Floating winches	2
Total units	**5003**

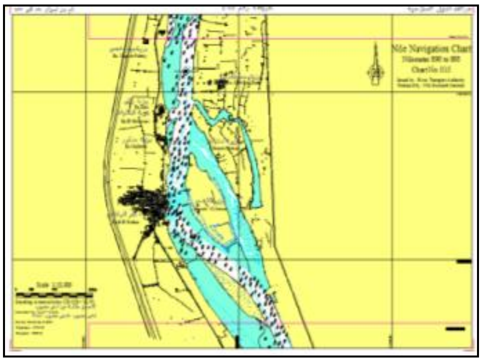

Figure 1: Navigational Charts

4 CURRENT INLAND NAVIGATION SITUATION

In order to achieve safe navigation on Nile River, day and night, many steps had achieved to obtain the most suitable and safe navigation path as shown in the following:

4.1 Navigational Charts

On 2003 to 2010, The (X-Y-Z) data will be used for producing contour maps of 0.5 m interval. The chart size will be 70 x 50 cm at scale 1:15000 as shown in figure 1, suitable firm paper enabling to make frequent annotations and erase them again without damaging the image. A harmonious colour scheme will be adopted (NRI, 2003)

4.2 Bathymetry Charts

The scale of these charts is 1: 10,000. With Datum of Spheroid Helmert 1906, Transverse Mercator Projection. There is no water depths indication on these charts. All heights on these maps are relative to Lowest Low Water Spring in Alexandria, Mediterranean Sea. Nile Research Institute executed the hydrographic surveys, over a total length of 25 km out a total length of 953 km (Cairo- Aswan).

4.3 Buoyage System

There is no marking system or any positioning system for vessels have been done on the Nile. Only floating markers have been located near dredging operations, to mark underwater obstacles and anchors.

4.4 Radio Communication

The RTA (River Transport Authority) vessels have VHF channel 12 on board. The communication between Nile Cruise Ships has been done by on one channel under the responsibility of the Ministry of Interior for security reasons only [AbdelAziz, 2004].

5 OBJECTIVES

At this time no aids of navigation and no vessel traffic information service is available on the Nile. Therefore, the production of standard navigation maps for Nile River has to be basic and according to decision maker accepted and applied systems. In addition, it should improve the quality of shipping in general. This research introduces new electronic navigation charts production follow IHO standards for hydrographic survey, recommended for safe navigation improvement in the Nile River, by using the modern tracking systems and navigational aids. Moreover, the auother developes an application tool linking between GIS and IENCs. This tool illustrate the morphological changes that affecting on the navigational path location in a 23 km reach of the Nile River. The study reach extends from km 878 to km 901 downstream Aswan dam during the period from 2005 to 2016, by monitoring and analyzing the navigation path using Geographic Information System (GIS) spatial analyst from the hydrographic survey maps at 2005 up until now.

6 STUDY AREA DESCRIPTION

Data was accumulated and analyzed in order to perceive a complete data picture to the study area. A sub-reach of about 23 km of River Nile Reach four at El Wasta area extends from km 878 to km 901 downstream Aswan dam. It is considered an optimum case study for many reasons, it is exposed to many morphological changes as new island was formed and the area of Permanent Island increased. It has many navigation bottlenecks, consequently effect on the efficiency of navigational path and a result changing the path. That hinder the passage of the navigational traffic, this region had enough data to start the present investigation. This sub-reach is shown in Figure 2.

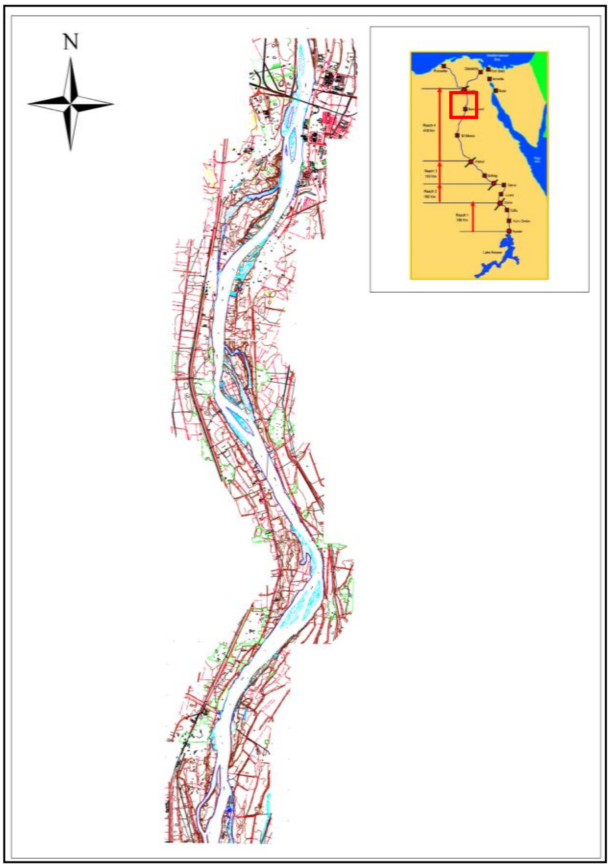

Figure 2. Study Area

7 METHODOLOGY

A research methodology was planned in order to achieve the objectives as shown in figure 3, the methodology includes the following steps:

(7.1) Source Data Collection and Transmission

- Produce ENC Bathymetry contours.
- Data capturing and editing.

(7.2) Source Data Evaluation

- Data Optimization, Quality Assurance, and Approval Process .

(7.3) Data Compilation

- IENC file database.
- Using FME from Safe Software for S-57 conversion.

(7.4) IENC Chart Production (S-57 Encryption)

- ENC Designer ENC Optimizer ENC Analyzer

(7.5) Quality Assurance

(7.6) Final IENC Product

(7.7) Developing an application tool linking between IENCs and GIS.

(7.8) Morphological changes Analysis for study reach.

(7.9) Monitoring and analyzing path changes from the hydrographic survey maps at 2005 up till now using the recent hydrographic survey data at 2016.

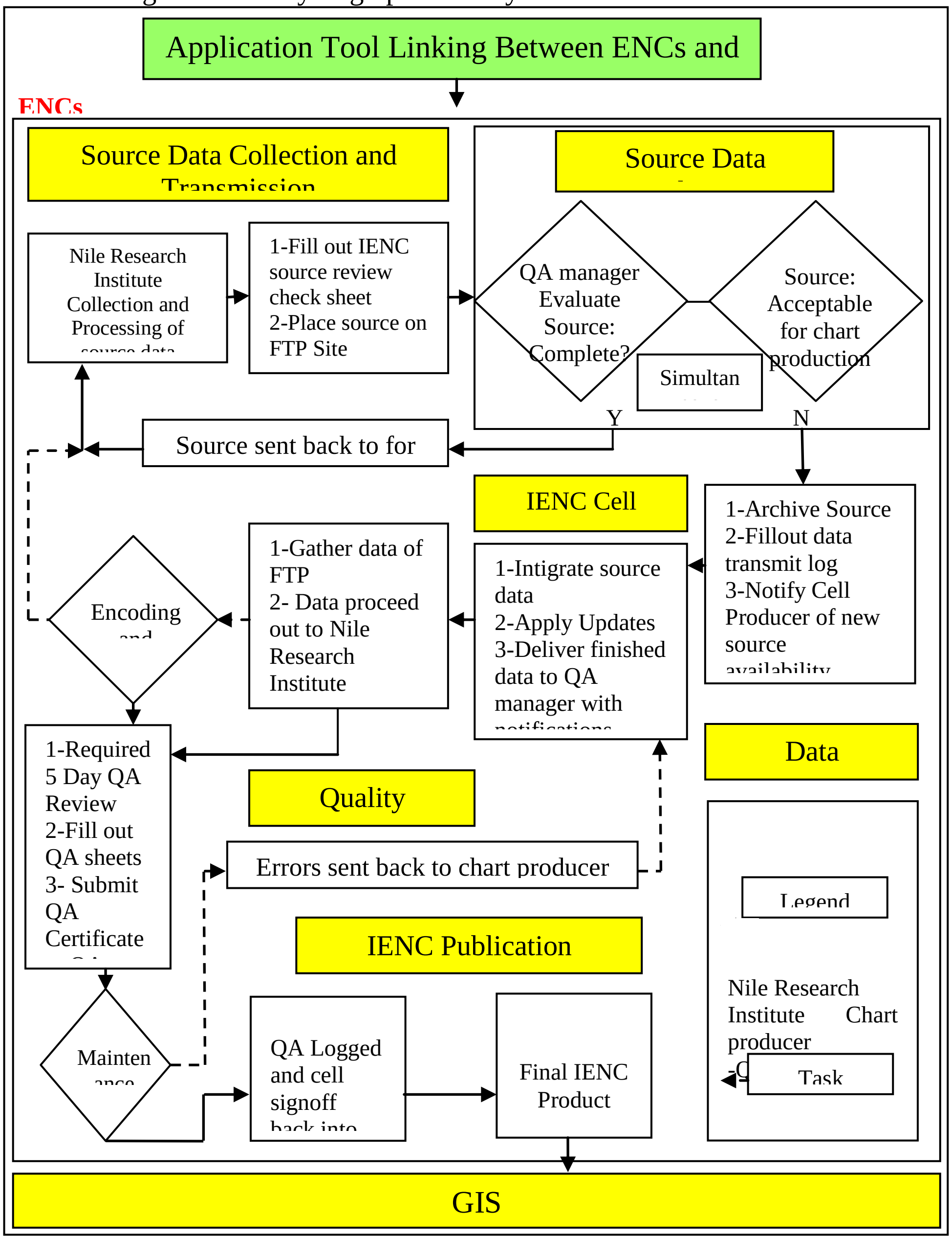

Figure 3. The flow chart of Methodolgy

7.1. DATA COLLECTION

The data required to monitored and analyzed the navigational path changes include the following:

7.1 .1 IENC BATHYMETRY CONTOURS

River bathymetry (bed topography) plays a critical role in producing IENCs. Conventional way of measuring river bathymetry is through cross-sectional surveys where ground profiles are collected at certain locations along the river. A recent technological development was used in bathymetry measurement to give a series of (x, y, z) bathymetry points. Along each cross section bathymetry will be measured continuously, using the echo sounder. The horizontal positioning of the locations will be controlled by DGPS with the on-line PC Hydrographic survey software on board. For the DGPS positioning there are beacons every 5 km along the river with X and Y co-ordinates in WGS 84. Water levels will be recorded from 56 staff gauges available along the Nile River and interpolated for the surveyed stretches in between. In addition, tidal corrections will be carried out for the measured bathymetric data. The depth will be plotted in the form of bathymetric map in UTM co-ordinates (WGS 84) according to RTA (River Transport Authority) of Egypt. The actual survey has to be updated continuously, depending on the stability of the river stretch. Every ten years the whole stretch of the river has to be re-surveyed. The survey work is a continuous operation, the charts have to be updated accordingly and will be renewed on a regularly basis. The vessels need to be obliged by law to have up to date charts on board of the stretch in which they operate.

7.1.2 Data collection from Topographic maps and ortho photos

Based on Collection of topographic maps [NRI,2005] for study area and ortho photos (2005 and 2016) as shown in figure 4 and figure 5, many new features are found , table2 show the features at 2005, table3 show the new features at 2016. The study reach is characterized with many hydraulic structures and human interventions that increase the impacts of different low and high flows. This affected the morphological characteristics. Consequently, it affected the drinking water intakes and river navigation route along the fourth reach during low discharge periods. The chosen reach was recently surveyed by the Nile Research Institute. The gauging stations produced recent data for both low and high flows. It is to be noted from table3 that the number of hydraulic structures increased, and affecting on navigation waterway.

Figure 4. Topographic Map for Study Area

Figure 5. Ortho Photo for Study Area

Table 2. Features in 2005

No.	Type of Structure	Name of Structure	Km	Bank
1	Bridge	Maraziq	900.8	-
2	Water Intake	Tebeen	898.7	East
3	Port	Petrol Company	898.2	East
4	Permanent Island	Elshobak Elsharki	894.8-898	West
5	Port	El Haded We Elsolb	896.7-897.2	East
6	Permanent Island	El Amir	890.7-892	East
7	Reformed Island	-	889.8-891	-
8	Ferry	-	889	East
9	Ferry	-	888.2	West
10	Reformed Island	-	883.4-884.8	East
11	Reformed Island	-	883-884.5	West
12	Permanent Island	-	876-878	West

Table 3. features in 2016

No.	Type of Structure	Name of Structure	Km	Bank
2	Water Intake	-	899.8	East
3	Water Intake	-	899.6	West
4	Water Intake	-	898.5	West
5	Water Intake	-	894.4	West
6	Water Intake	-	892.4	West
7	Bridge	El Ekhsas	888	-
	Water Intake	-	884.5	East
8	Water Intake	-	878.7	West
9	Water Intake	-	879.5	West

In order to achieve IENC navigation Charts, data capturing and editing from Topographic maps as the following features: shore line, Contour lines, River Center line and Km from Aswan, Bridges and Bridges piers, Break Factories, Building areas, Dikes, Mosques and Church, Electric Cables and towers, Ferry terminal and its rout, Power and water stations, Berths , and Gas, Telephones lines.

7.2. Source Data Evaluation

7.2.1. Data Optimization, Quality Assurance, and Approval Process.

Every IENC product has established identity, precision, high efficiency, safety. The Quality by Design concept is based on the clear fact that a high level of quality of final products cannot be achieved by testing the products but needs to be excuted into the products by intelligently designing the whole manufacturing process.

7.3. Data Compilation

7.3.1. IENC file database.

In ENC the data is divided into chart cells, these cells are characterized by defined limitation and data amounts. The individual cells are characterized by a unique cell number. The data is updated continuously through the distribution of revised files.

In accordance with S-57 rules, each cell of data is contained in a physically separate, uniquely identified file on a transfer medium, known as a data set file. The geographic extent of each IENC cell was designated when the program began to ensure that each data set file contains no more than 5 Megabytes of data.
(1) Cells are rectangular (i.e., defined by 2 meridians and 2 parallels).
(2) The area within the cell which contains data is specified by data objects. These data objects, known as M_COVR, and are encoded by the Cell Producer.
(3) As specified by IHO S-57, the features within the cells do not overlap. This ensures that adjacent cells do not have duplicate or conflicting data.
(4) Feature objects (Point or line) which are at two IENCs border are part of only one cell. North and east borders of the cell are part of the cell, south and west borders are not.
(5) The naming convention for each IENC cell is CCPRCMMM.VVV, in which:
CC = international Producer Code; USACE = U3 (all IENCs), P = navigational purpose; all IENCs have a purpose of "7," which means navigating within inland waterways, RC = river code, MMM = river mile at lower end of the cell, VVV = version of the base chart, beginning with "000," "001" for the first update, "002"for the second update, etc.

7.3.2. Using FME from Safe Software for S-57 conversion

According to table 4 Using FME from safe software to convert AutoCAD features to S-57 format.

Table 4. FME feature code

Item	ENC Feature Code	Attributes
Cell boundary	M_COVER	
Land Area	LNDARE	
Contour Line	DEPCNT	VALDCO = contour depth
Contour Area	DEPARE	DRVAL1 = min depth DRVAL2 = max depth
Shore Line	COALNE	
Building Area	BUAARE	OBJNAM = Area Name
Mosque	LNDMRK	CONVIS = 1 FUNCTN = 26
Church	LNDMRK	CONVIS = 1 FUNCTN = 20
Silo	SILTNK	CATSIL = 1
Water Tank	SILTNK	CATSIL = 4
Bridge	bridge	CATBRG = 1 OBJNAM = Bridge name VERCLR = vertical clearance
Bridge piers	PYLONS	CATPYL = 5
Electric Tower	PYLONS	CATPYL = 1
Electric Cable	cblohd	catcbl = 1 VERCLR = vertical clearance
Dikes	DYKCON	
Ferry Rout	FERYRT	
Ferry terminal	termnl	Cathaf = 2
River center line	wtwaxs	
Kilometer	dismar	CATDIS = 1 hunits = 3

		wtwdis = kilometer
Depth Spots	SOUNDG	

7.4. S-57 Production

S-57-IHO Transfer Standard for Digital Hydrographic Data describes the standard to be used for the exchange of digital hydrographic data between national hydrographic offices and for its distribution to manufacturers, mariners and other data users. To produce Inland Electronic Navigation Maps, SevenCs ENC software is using, which consists of three core programs:

1- ENC Designer 2- ENC Optimizer 3-ENC Analyzer

The core combination of three software provides all the software tools required to create a wide range of digital nautical chart products, including IENCs.

7.4.1 ENC Designer

E NC Designer is the essential tool of S-57 production. This tool is used to produce electronic charts in IHO S-57 format fast and efficiently. In addition, it is characterized by a wide variety of functions enables to capture, edit, modify, and control the quality of ENC data as shown in figure 6.

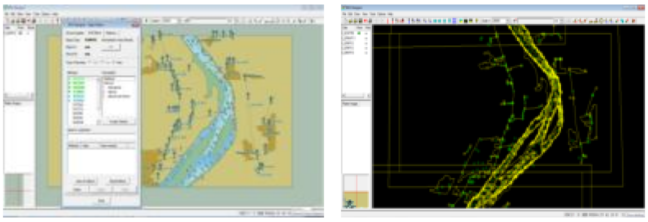

Figure 6. ENC Designer Interface

7.4.1. ENC Optimizer

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ENC Optimizer is the checking tool, which has powerful checks to detect and eliminate errors of topology and provides automated functions.

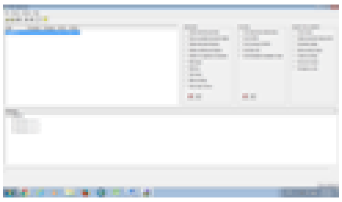

Figure 7. ENC Optimizer

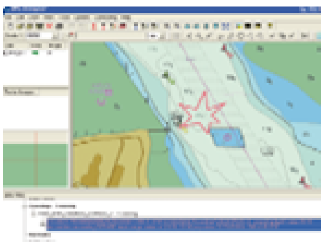

Figure 8. Interactive Logfile reviewed in ENC Designer

7.4.2. ENC Analyzer

The most importatnt and critical part in the production and maintenance of Electronic Navigational Charts (ENC) is quality control. These charts must be validated for obligation to standards, accuracy, and consistency. ENC analyzer is the validation component of the SevenCs ENC Tools suite. ENC analyzer is performing an extensive series of checks to clarify the wide variety of errors that can occur during the initial production step, and subsequent maintenance cycles.

7.5. Quality assurance

Quality assurance aims to prevent defects on the product, which linked to system that guarantee that all procedures that have been designed and planned to produce quality of a certain level are followed. In addition, quality assurance acts on a meta-level and continually surveys the effectiveness of the quality of IHO (International Hydrographic Organization) standards for hydrographic survey.

7.6. Final IENC product

The final product of IENCs is shown in figure 9. Morover, these electronic charts recommended to be presented by Inland ECDIS; this system presents electronic inland navigation charts and additional information. Its persistence is to provide to the safety and inland navigation efficiency and to the environment protection. The importance of Inland ECDIS which it is used simultaneously to decrease the workload when navigating the ship as compared to traditional navigation, and for information methods. It is either software running on a standard personal computer or an autonomous device. The produced electronic inland navigation chart issued for use with ECDIS. It contains all chart information necessary for safe navigation and additional supplementary information that may considered necessary for safe navigation.

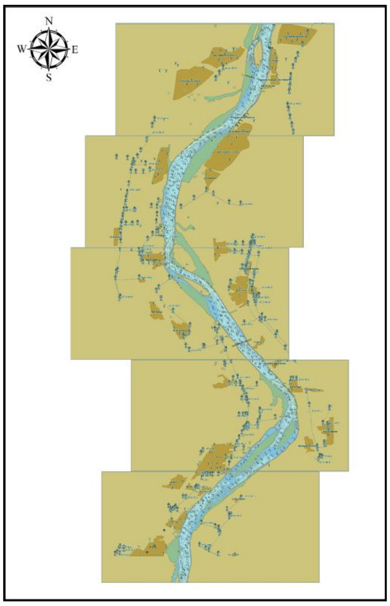

Figure 9. Final Product of IENCs for El-Wasta region

7.7. Developing an application tool linking between ENCs and GIS

The application tool was developed by the author with the intention to link the produced electronic navigation chart with GIS for enhancing the effecincy of navigation waterway by analyzing the morphological changes in the study area according to navigational depths on ENCs. The application tool was developed by means of the Visual Basic language representing a flexible interface as shown in figure 10 that operates with FME from safe software, Seven Cs ENC software which is used to produce ENCs for the study reach, and GIS which analyzed the morphological changes.

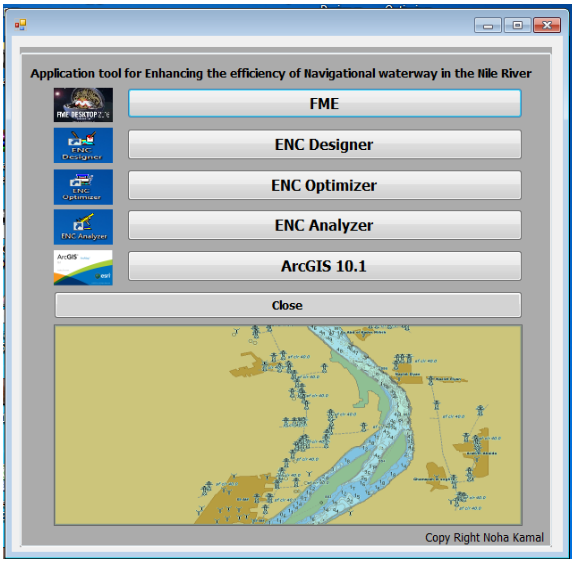

Figure 10 . The Interface of developed application

7.8. Morphological changes Analysis using GIS

Morphological changes analysis of river streams is highly important for many reasons such as navigation safety, efficiency of navigation path, allocation of intake structures and scour calculations at bridges. It also plays an important rule in planning of the area on the river sides for sustainable development. According to Table 5 the number of new features in the year 2016 was increased compared to that of the year 2005, which effect on navigation path efficiency.

Table 5. Comparison between old and new features at 2005, and 2016

Name of Structure	2005	2016
Water Intakes	1	8
Ports	2	2
Bridges	1	2
Permanent Islands	2	2
Reformed Islands	2	4
Ferry	2	2

This part of research presents Geographic Information Systems (GIS) spatial analyst application as a tool for morphological analysis. For this reason, a study area with a length of 23 km from 906 to 910 km, downstream Aswan dam, was selected. The Morphological changes analysis is divided into three main parts:-

1- Calculate the morphological changes by developing Digital Terrain Models (DTM).
2- Study and analyze the morphological changes of the study area during the period from 2005 to 2016.
3- Calculate the results with the DTM approach for the calculation of erosion and deposition volumes in the study area.

7.8.1 Digital Terrain Models (DTM)

The calculation of the morphological changes could be predicted in a river bathymetry if the data about bed surface for different time periods is available. By comparing these data sets and calculating the difference in volumetric changes between them, the morphological changes, can be monitored. GIS is used as the first main step to obtain a three dimensional bathymetry for the study reach. Two data sets were obtained from the Nile Research Institute (NRI). These data sets were in form of contour lines and spot level points and were available for the year 2005 and 2016. Nile bed level and the flood banks at the reach study are formed from The contour lines then used to generate scatter points that will be used to form a triangles irregular net (TIN) using an interpolation method, figure 11. The digital terrain model (DTM) that represents the bathymetry is formed from the raster file which is converted from the generated TIN, figure 12; all DTM files generated had the same cell size of (10m x 10m). This type of files was used in the analysis calculations in the next stages.

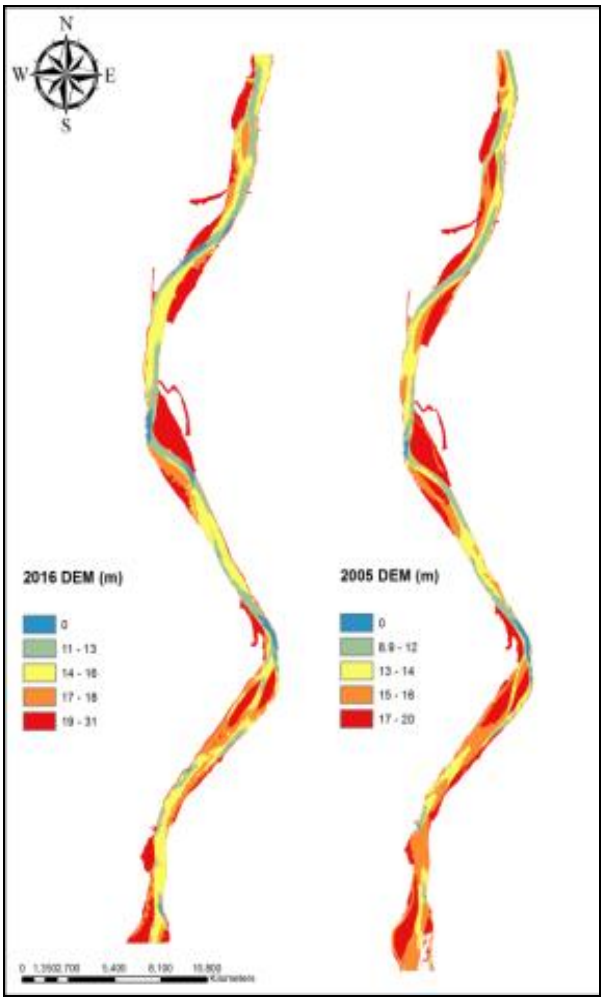

Figure 11. The Interpolated TINs for 2005 and 2016

Figure 12. The generated DTMs for 2005 and 2016 bathymetry

7.8.2 Analyze the morphological changes of the study area during the period from 2005 to 2016 by Spatial Analysis

The analysis of morphological changes concentrates on a small study area with length of 7 km from km 881 to km 888 downstream Aswan. This area is suffering from obvious morphological changes. In the west side of the river, the area of the reformed island from km 883 to km 884.5 downstream Aswan was increased in 2016 than 2005. In addition, the area of the reformed island in the east side from the river was decreased. Also, new hydraulic structures were built, as a new bridge (El Ekhsas Bridge) that was built on 2015 crossing the Nile River, at a site located 888 km from D/S Aswan, also two water stations was constructed after 2005 at km 879.5 and km 884.3 ds Aswan which all affected on navigational path location. The two DTM files generated for selected small study area had the same cell size of (10m x 10m) as shown in figure 13.The two generated raster files were then used to calculate erosion and deposition volumes. To locate the areas where erosion and sediment occurs, the two bathymetric DTMs of 2005 and 2016 were subtracted from each others.

Morphological changes Raster = [2016 DTM - 2005 DTM]

According to this equation the morphological changes in period 2016 and 2005 was shown in figure 14.

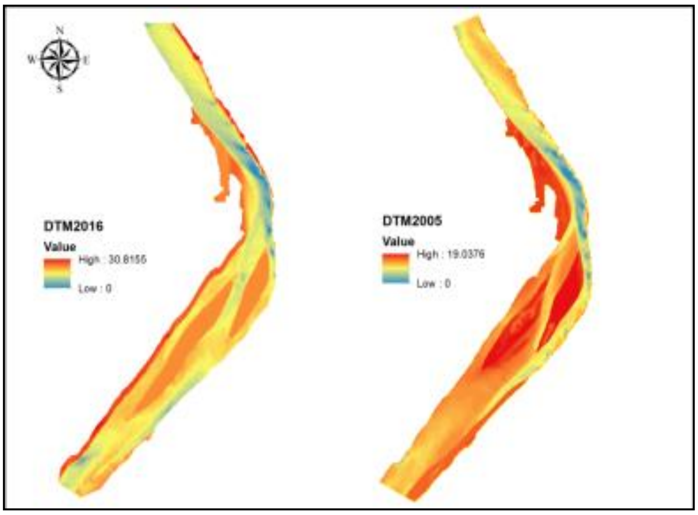

Figure 13. DTMs files generated for selected small study area with a length of 7 km

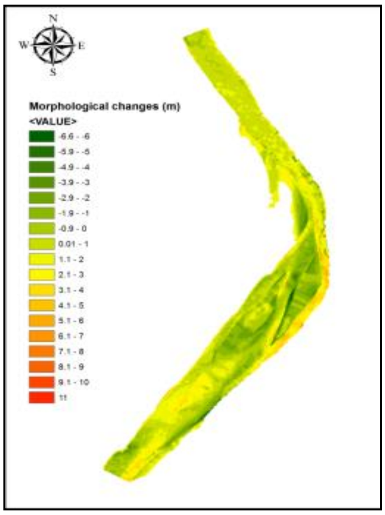

Figure 14. Morphological changes between 2005 and 2016

It was obvious that the bed level was changed especially in the region between km 883to km 884.5. The bed level in the eastern side of outer curve from the river was increased and it decreased in the middle of the stream and western side which effect on the navigational path that passed in this area in 2016 than 2005.

7.8.3 Erosion and Deposition Volumes using DTM

The resulted raster file, Figure 14 shows the changes that occurre to the bed during the period from 2005 to 2016. Yet, the resulted raster can be used to calculate the volume of the erosion and the volume of deposition. However, it can be helpful to detect and locate the locations that were subjected to serious morphological changes. In order to calculate the volume of bed changes occurred during the period from 2005 to 2016, the following tables 6 and 7 show the volume of deposition and erosion respectively. From these tables, it can be concluded that the deposition is more frequent than the erosion at the study period.

Table6: the volume of deposition (m^3) occurred during the period from 2005 to 2016

Table

dep

Dataset	Plane_Height	Reference	Z_Factor	Area_2D	Area_3D	Volume
..rcGIS\Default.	0	ABOVE	1	1924770.321737	1929819.218049	2472709.782939

(0 out of 1 Selected)

ero dep

Table7: the volume of erosion (m^3) occurred during the period from 2005 to 2016

ero

Plane_Height	Reference	Z_Factor	Area_2D	Area_3D	Volume
0	BELOW	1	1267276.19396	1270881.702804	1593599.08257

(0 out of 1 Selected)

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7.9 Monitoring and analyzing Navigational path changes

It is clear from morphological analysis that, the river shifted its navigational path from the east side of river in 2005 to the middle of navigational waterway, ,especially from km 883 to km 885 downstream Aswan. As shown from DTM in figures 15

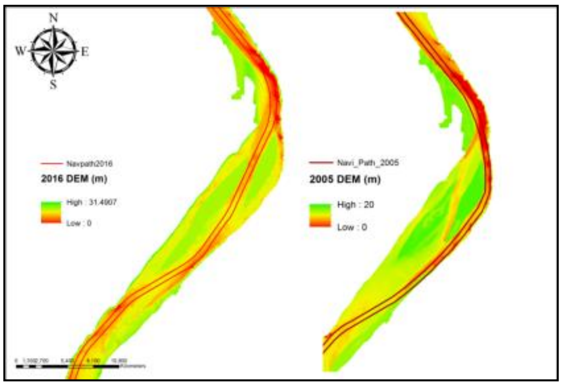

Figure 15. Navigational path changes between 2016 and 2005

8 CONCLUSIONS AND RECOMMENDATIONS

This paper presents the characteristics and the designed unique standards and specifications of production of inland electronic navigational charts. It is anticipated that this charts will improve the reliability, availability, and integrity of the inland navigation, and have a great economical impact on surveying and mapping activities in Egypt, particularly for water resources management. Testing new charts for El-Wasta region indicated that IENCs is technically feasible and efficient to satisfy safe inland navigation. The charts are considered more accurate, quick, and easy update, compared to traditional navigation (as the navigational marks or Buoyage System), which are more expensive to operate and maintain. The IENCs production will increase the safety of the cruise vessels sailing the Nile. It will enable them to sail for a longer period per day and thereby increase the efficiency at the river's bottlenecks, such as the locks and moorings berths. These electronic charts are designed according to Nile Research Institute research plan.

The developed application linkage between IENCS and GIS through this work has provided an effeicent tool to solving navigation problems and supporting the decision maker on river navigation by developing a flexible interface that linked between these charts and the morhplogical analysis. This linkage helps in evaluation of the volume of ottleneck and erosion, and predicting the locations of ottleneck on navigation waterway. The conducted analysis showed that the morphological changes for the reach under study were significant. The deposition has more significant effect. The setected 7 km as a study reach became shallower and smaller in its eastern part of the outer curve of the river Nile than it was on 2005. The river shifted its navigational path from the east side of river to the middle of navigational waterway (Figure 15). The digital terrain models proved to be accurate and fast tools to be used in the calculation of the morphological changes. On the other hand, it was recommended that, the government of Egypt should establish the legal justification for the compulsory use of up-to-date inland electronic navigation charts, The compulsory use of specified equipment, which will allow for vessel tracking. In addition, it is recommended to investigate the dredging negative impacts (erosion and sedimentation process) in the study reach at new hydraulic structures at 2016 by using numerical modeling.

REFERENCES

Abdel-Aziz .T, (2004),” Safe Visual Navigation on the Nile River.” 9th International Symposium on River Sedimentation (9ISRS). At Yichang- China.

CHRIS, (2001). Report provides a status for Australia’s ENC production.

G. Mohamed, “Analysis of the Behavior of the River Nile (Rosetta Barrage) Using GIS, (2004), A Thesis for Maser Degree, Civil Engineering, Faculty of Engineering, Cairo University, Egypt.

Inland Waterway Transport Sector, (March 2012), TRANSPORT PLANNING AUTHORITY (TPA), TECHNICAL REPORT 3. Inland Waterway Transport in Egypt.

Kamal .N & Rasslan.Y, (2015).” Locating the Navigation Route along the Nile River by Using GIS (Case Study: Greater Cairo Region – Fourth Reach). Regional Conference on Surveying & Development, Sharm El-Sheikh, Egypt. 3-6 October 2015.

Mohsen Fekry, Sameh K. Rashed, (2014),” GNSS Applications for Safe Navigation in Egypt's”, Alexandria, Egypt.

Moustafa A. Moussa & Ashraf M. Elmoustafa.(2010). ” Morphological Changes Analysis for Nile Bed at Aswan Bridge Area Using GIS”, Ain Shams Journal of Civil Engineering (ASJCE) ,Vol. 1. March, 2010, pp. 599-610.

Raslan.Y & Rafeek .M Abdelbary, (2001). “Economical and Environmental Aspects of Navigation Development in the Nile,” Sixth International Water Technology Conference, IWTC 2001, Alexandria, Egypt.

R. Li, D. Su, T. Sun, J. Zhang, (2011). “Research on Three-dimensional Water Resources Information System Based on ArcGis,” China Institute of water Resources and Hydropower Research, World largest online library of Satellite and aerial images.

Saber, M. Mohamed (2011). Improving River Transport Productivity by Improving the River Ports Performance Quality, PQI, AASTMT, Alexandria, Egypt.