2018

Heterogeneous Integrated Dataset for Maritime Intelligence, Surveillance, and Reconnaissance

Integration of Nautical Charts in 10.5281/zenodo.1167595

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2/21/2018

HETEROGENEOUS INTEGRATED DATASET FOR MARITIME INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

Integration of Nautical Charts in 10.5281/zenodo.1167595

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Abstract. For an efficient and advanced spatio-temporal analysis, reported information of vessels locations and behaviours must be cross checked with others and cartographical data. Amongst cartographical information, the International Hydrographic Organisation (IHO) defined a vector interchange format used for maritime charts. From this format (S-57 or its revision S-100) ensues the ENC (Electronic Nautical Chart) product specification use in electronic chart display and traffic control visualisation. It provides a data structure and format that are used to implement a data model and characterises spatial entities and geometrical primitives. The dataset labelled 10.5281/zenodo.1167595 contains ships' information collected though the Automatic Identification System (AIS), prepared together with a set of related data having spatial and temporal dimensions aligned. This technical note provides additional information for the integration of S57 nautical charts in this dataset.

1. Digital Cartographic Data

Due to its obvious benefits for navigation safety, electronic charting has been fully supported, and encouraged, by the International Maritime Organization (IMO), International Hydrographic Organization (IHO) and member state regulators. A standard for Electronic Chart Display Information System (ECDIS) has been developed to display onboard the relevant chart and navigational information and to automatically present the ship in this context. The final objective is to replace maritime maps on the decks of ships with automated and electronic charts. An ECDIS system comprises the official nautical chart data [1] stored in standardized vector (Electronic Navigational Chart, ENC) formats produced by national hydrographic offices (Figure 1).

Taking the geographic information into account is of paramount interest in processing an AIS (Automatic Identification System) database. Apart from the information already embedding in AIS signals, complementary information can be obtained from official maritime vector charts. IHO S-57 (and its revision S-100) is the current IHO standard for digital hydrographic data. It defines a data model, and a data structure and format used to implement this data model [6]. This standard describes entities in the real world that are of relevance for hydrography (nautical information, landmarks and features use to navigation, restricted area….). The model defines these real-world entities as a combination of descriptive and spatial characteristics. It assumes that real world entities can be categorized into a finite number of types, such as lights, coastline, restricted areas etc. They are defined in terms of feature objects and spatial objects (spatial objects may have descriptive attributes and must contain a geometry). An object is related with an identifiable set of information and attributes (location, physical properties…), and may be related to other objects. Objects are modelled as vector, implemented with geometrical primitives (nodes, edges or/and faces), according to their used as nautical information. These primitives are located from geographical coordinates of nodes. Relations between objects are defined by a topological model based on relations between geometrical primitives that compose objects: chain-node topology.

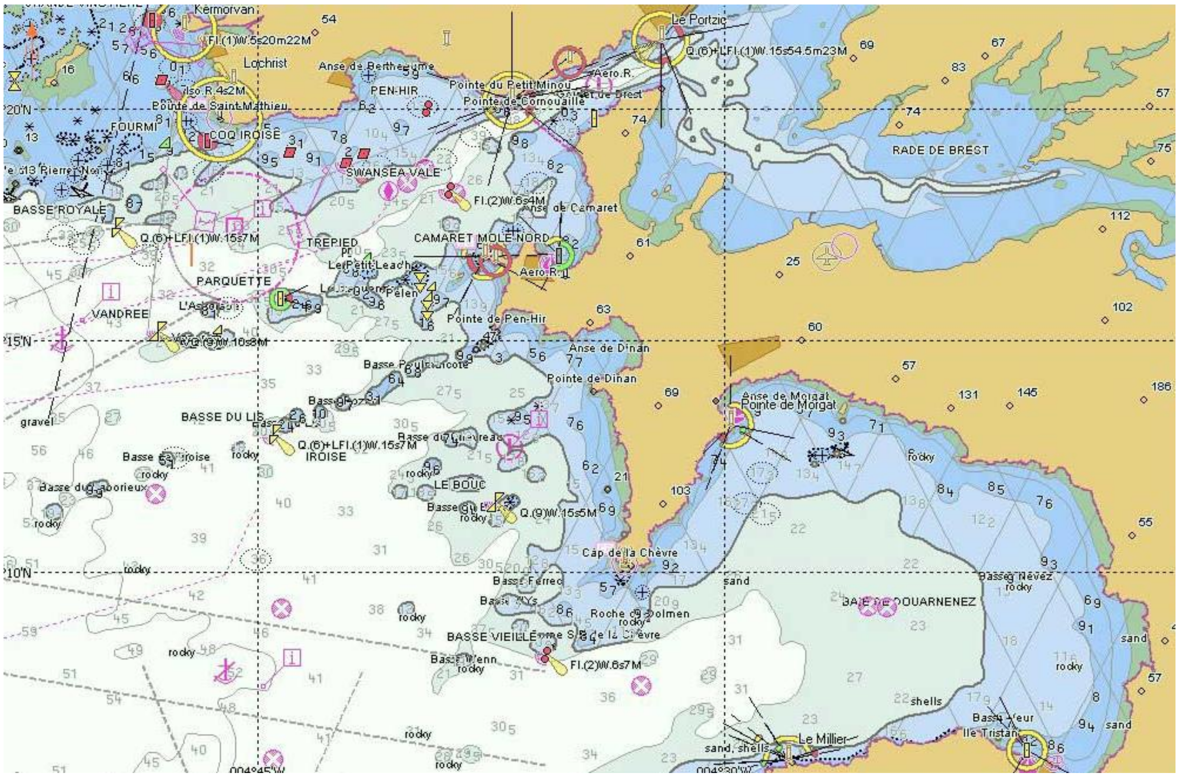

Fig. 1. Example of 2D Electronic Navigational Chart (Brest bay) [1]

The real world is represented by 159 geo-object classes (entities). Each of them is associated with a definition, which details the role of the object in the real world, and a list of attributes (up to 30), which give information for the representation on a map and the maritime use (language, scale, geometry, height, colour …). A list of 403 attributes is available.

Nautical charts are organized in six categories of different scale. These scales and associated levels of details aim to provide needed information depending on the navigation context. For instance, category 1 give a wider view (> 96 NM) but with less detailed navigation features. Category 6 is dedicated to port access and berthing and provides a spatial extent limited to 0.25 NM while giving much accurate details. Table 1 summarizes map scales.

Category	Name	Scale Range	Nautical Miles	Kilometers
1	Overview	< 1 : 1 499 999	> 96 NM	> 177.792 km

[1] Courtesy of Service Hydrographique et Océanographique de la Marine (SHOM)

2	General View	1 : 350 000 - 1 : 1 499 999	24 NM – 96 NM	44.448 km – 177.792 km
3	Costal View	1 : 90 000 - 1 : 349 999	6 NM – 24 NM	11.112 km - 44.448 km
4	Approach View	1 : 22 000 - 1 : 89 999	1.5 NM – 6 NM	2.778 km – 11.112 km
5	Harbor View	1 : 4000 - 1 : 21 999	0.25 NM – 1.5 NM	0.463 km – 2.778 km
6	Berthing View	> 1 : 4000	< 0.25 NM	< 0.463 km

Tab 1. Map categories

2. Selected Charts for 10.5281/zenodo.1167595

The dataset 10.5281/zenodo.1167595 comes from with several geographical features based on open licenses. However, S57 nautical charts are not publicly released and require to be acquired by dataset users. In an enriched 10.5281/zenodo.1167595, many features and spatial objects extracted from S-57 format have been considered. Similarly, interested users of the dataset should proceed in two steps to integrate these S-57 vector maps. First it requires to select useful nautical charts considering the level of category and the spatial extent of the analysis (and to acquire them). The following table (Tab. 2) lists all nautical charts intersecting the spatial extent of 10.5281/zenodo.1167595 dataset.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
FR166230	FR200010	FR368570	FR401270	GB510110	FR67095A
	GB200000	FR369410	FR401310	FR57133C	FR673990
		FR369660	GB410100	FR573410	FR601135
		FR369300	GB410200	GB510210	FR602190
		FR366800	GB410400	GB510310	
		FR370660	GB410300	GB510330	
		FR370670	FR471570	GB510320	
		FR302060	FR471610	FR570920	
		FR302010	FR401330	FR573410	
			FR401380	FR501090	
			FR401500	FR570950	
			FR401530	FR570940	
			FR471490	FR571220	
			FR401620	FR501150	
			FR401580	FR574010	
			FR471470	FR571230	
			FR471460	FR502190	
			FR402320	FR571410	
			FR402300	FR571420	
			FR402310	FR502220	
			FR402280	FR502231	
			FR402220	FR574100	
			FR402150	FR574110	
			FR473940		
			FR474020		

Tab 2. IHO Nautical charts linked to the dataset 10.5281/zenodo.1167595

3. Selected Layers for 10.5281/zenodo.1167595

The second step concerns geographical features composing each chart. The objective is to integrate these data in 10.5281/zenodo.1167595 relational database in order to query them (typically spatial join with AIS data). A list of interesting objects [3] from a navigation point of view is suggested in the following table (Tab. 3):

Object	Type	Description
AIRARE (Airport/airfield)	[P|A]	An area containing at least one runway, used for landing, take-off, and movement of aircraft.
RESARE (Restricted Area)	<A>	A specified area designated by an appropriate authority within which navigation is restricted in accordance with certain specified conditions (adapted from IHO Dictionary, S-32, 5th Edition, 4366).
TESARE (Territorial Sea Area)	<A>	The territorial sea is a belt of water of a defined breadth but not exceeding 12 nautical miles measured seaward from the territorial sea baseline (IHO Dictionary, S-32, 5th Edition, 5360).
MIPARE (Military Practice Area)	[P|A]	An area within which naval, military or aerial exercises are carried out. Also called an exercise area (adapted from IHO Dictionary, S-32, 5th Edition, 1722).
DMPGRD (Dumping Ground)	[P|A]	A sea area where dredged material or other potentially more harmful material, e.g. explosives, chemical waste, is deliberately deposited (Derived from IHO Chart Specifications, M-4).
SEAARE (Sea area / named water area)	[P|A]	A geographically defined part of the sea or other navigable waters. It may be specified within its limits by its proper name.
FAIRWY (Fairway)	<A>	That part of a river, harbour and so on, where the main navigable channel for vessels of larger size lies. It is also the usual course followed by vessels entering or leaving harbours, called ship channel (International Maritime Dictionary, 2nd Ed.).
ISTZNE (Inshore Traffic Zone)	<A>	A routing measure comprising a designated area between the landward boundary of a traffic separation scheme and the adjacent coast, to be used in accordance with the provisions of the International Regulations for Preventing Collisions at Sea (IHO Dictionary, S-32, 5th Edition, 2457).
TSEZNE (Traffic Separation Zone)	<A>	A traffic separation zone is a zone separating the lanes in which ships are proceeding in opposite or nearly opposite directions; or separating traffic lanes designated for particular classes of ships proceeding in the same direction (IMO Ships Routing, 6th Edition).
TSSLPT (Traffic Separation Scheme Lane Part)	<A>	A traffic lane is an area within defined limits in which one-way traffic flow is established (IMO Ships Routing, 6th Edition). A traffic separation scheme lane part is an area of a traffic lane in which the direction of flow of traffic is uniform.
TWRTPT (Two-way route part)	<A>	A two-way route is a route within defined limits inside which two-way traffic is established, aimed at providing safe passage of ships through waters where navigation is difficult or dangerous (IHO Dictionary, S-32, 5th Edition, 5712). A two-way route part is an area of a two-way route within which traffic flow is generally along one bearing (and possibly its reciprocal).

OBSTRN (Obstruction)	[P|L|A]	In marine navigation, anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel. The term is usually used to refer to an isolated danger to navigation... (IHO Dictionary, S-32, 5th Edition, 3503).
RADSTA (RADAR Station)	<P>	A station with a transmitter emitting pulses of ultra-high frequency radio waves which are reflected by solid objects and are detected upon their return to the sending station (International Maritime Dictionary, 2nd Ed.).
CGUSTA (Coastguard Station)	<P>	Watch keeping stations at which a watch is kept either continuously, or at certain times only (IHO Chart Specifications, M-4).
PILBOP (Pilot Boarding Place)	[P|A]	The meeting place to which the pilot comes out. (IHO Chart Specifications, M-4).
ACHARE (Anchorage Area)	[P|A]	An area in which vessels anchor or may anchor (IHO Dictionary, S-32, 5th Edition, 130).
ACHBRT (Anchor Berth)	[P|A]	A designated area of water where a single vessel, sea plane, (etc...) may anchor.
RSCSTA (Rescue station)	<P>	A place where lifesaving equipment is held (IHO Chart Specifications, M-4).
NAVLNE (Navigation Line)	<L>	A navigation line is a straight line extending towards an area of navigational interest and generally generated by two navigational aids or one navigational aid and a bearing.
RCRTCL (Recommended Route Centerline)	<L>	The recommended route centerline indicates the centerline of a recommended route. A recommended route is a route of undefined width, for the convenience of ships in transit, which is often marked by centerline buoys (IHO Dictionary, S-32, 5th Edition, 4448).
RCTLPT (Recommended Traffic Lane Part)	[P|A]	An optional part of an IMO-adopted routing measure.... Several Hydrographic Offices, in consultation with their Ministries of Transport, have added recommended directions in areas such as the outer approaches to major ports in order to show the best routes for crossing traffic or to minimize head-on encounters. (...) (IHO Chart Specifications, M-4).

Tab 3. Useful S-57 navigation-oriented objects (compiled from [3])

The following figure (Figure 2) illustrates few of these layers accessed with GIS software QGIS after integration.

4. S-57 Integration Scripts

Regarding the integration in a relational database, together with 10.5281/zenodo.1167595 dataset, two options can be considered. First, import all the content of a given S-57 nautical chart in the database. In that case one database schema, labelled with the name of the maps, is preferred for each chart. This allows managing access rights for instance and more importantly avoids a mix of objects from different levels within the same object table. Indeed, objects have the same name in each chart. However, let us note some objects might not be part of some charts. Then each object should be assigned to a table based on the name of the object class to which it belongs. A typical S-57 transfer provide between 30 and 100 layers according to the map scale and details. The script given in annex A provides a mean to integrate a chart in a postgres/postgis database. It relies on ogr2ogr (available with postgres/postgis).

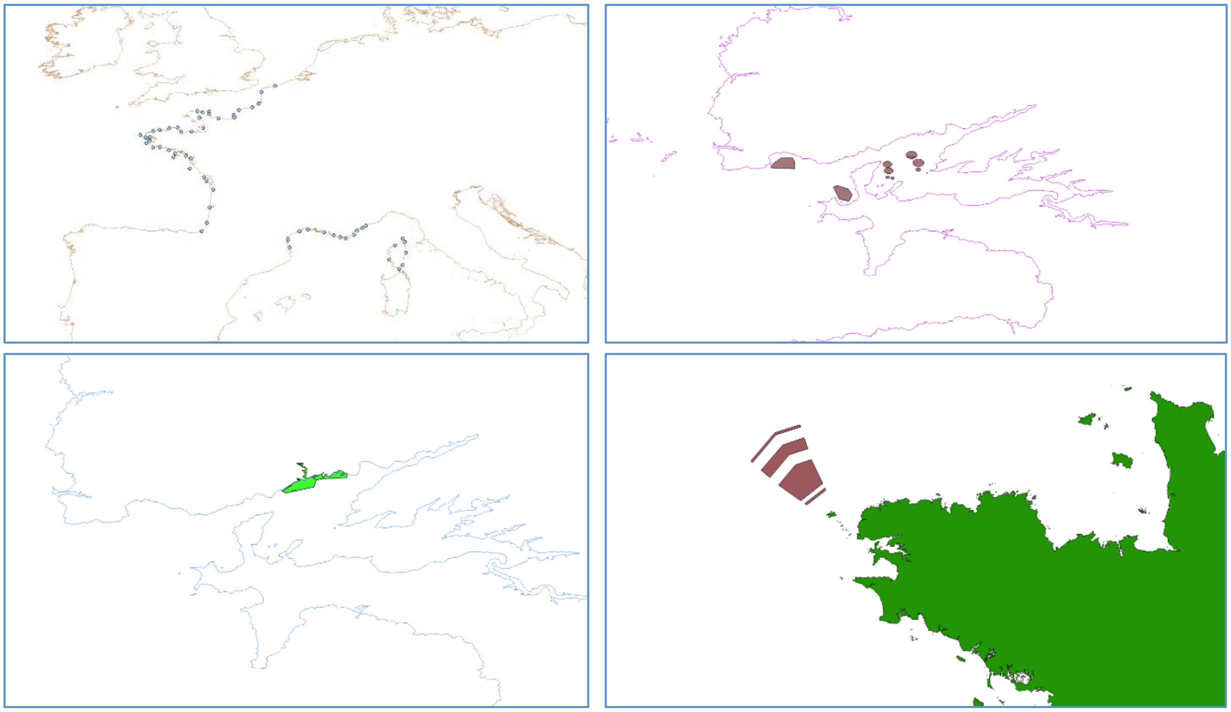

Fig. 2. Examples of S-57 objects (top-left: anchorage areas, top-right: Brest port, bottom-left: monitoring stations (semaphore), bottom-right: Ushant traffic separation scheme)

The second option interests users who want only a specific set of objects of a given chart (for instance, the one mentioned in Tab. 3). In that case, a full integration in the database is not required. One of the best approaches is therefore to transform your nautical chart into a set of ESRI shapefiles. Once obtained each shapefile can be loaded using “PostGIS 2.0 Shapefile and DBF Loader” or integrated using shp2pgsql as illustrated by Script 1. The script given in annex B provides a mean to split S-57 charts in a set of shapefiles.

```
SET DB_NAME=doi105281zenodo1167595
psql -d %DB_NAME% -U postgres -c "CREATE SCHEMA IF NOT EXISTS
geographic_s57;"

shp2pgsql -I -s 4326 "%~dp0\ RESARE.shp" geographic_s57.resare | psql
-U postgres -d %DB_NAME%
```

Script 1. Integration of a shapefile in 10.5281/zenodo.1167595 database

5. Acknowledgements

This work is supported by project datAcron, which has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 687591.

6. Références

[1] C. Ray, R. Dréo, E. Camossi, A.-L. Jousselme. Heterogeneous Integrated Dataset for Maritime Intelligence, Surveillance, and Reconnaissance (Version 0.1) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.1167595

[2] IHO, Transfer standard for digital hydrographic data edition 3.0, Special publication No. 57. International Hydrographic Bureau, Monaco, 2000

[3] IHO, S-57 APPENDIX B.1. Annex A - Use of the Object Catalogue for ENC EDITION 4.0.0, 2014, https://www.iho.int/iho_pubs/standard/S-57Ed3.1/S-57_AppB.1_AnnA_UOC_e4.0.0_Jun14_EN.pdf

7. Annex A – S57 files to postgis

```
#!/bin/bash
#
#NAME
#      scs2pgsql
#      Import S57 data contained within "files.000" to postgis
#
#SYNOPSIS
#      scs2pgsql SOURCE
#
#DESCRIPTION
#      This script import cartographic data encoded in the 'S57' format to
postgis.
#      This script uses the FWTools ogr2ogr function
#      The ogr2ogr can only convert base file (.000)

#initialize connection variable
dbname=doi105281zenodo1167595
host=localhost
port="5432"
user=yourname
password=yourpassword

#check for a correct number of argument
nb_arguments=$#
case $nb_arguments in
            0)     echo "Error : missing argument. You must specify an input"
; exit 1 ;;
            1)     input_directory=$1 ;;
            *)     echo "Error : too many arguments. You must specify an input
only" ; exit 1 ;;
                   esac

#check if the input directory exists
if [[ !(-d $input_directory) ]] ; then
      echo "!!!!!!!!!! $input_directory : wrong directory"
      exit 2
fi
#ensure slash at the end
[[ $input_directory != */ ]] && input_directory="$input_directory"/
```

```
#check if the output directory exists ; if not, create it. The
output_directory will be error_log
output_directory="scs2pgsql_log/"
if [[ !(-d  $output_directory) ]] ; then
      mkdir $output_directory 2>/dev/null || echo "cannot create
$output_directory directory" | exit 3
fi

#create error.log
current_date=$(date --rfc-3339=seconds | sed -e  's: :-:' -e 's:+.*::')
#reformat the output of date
output_file="${output_directory}scs2pgsql_${current_date}.log"
touch $output_file

########## START IMPORT ##########

echo -e "`date` - $input_directory : looking for files to be imported
(CCxNNNNy.000) \n" >>${output_file}

#looking for S57 data to be imported  (.000)
list_S57files=$(find $input_directory -name *\.000)

#checking if data have been found
if [[ -z $list_S57files ]] ; then
      echo -e " `date` : !!!!!!!!!! No data found \n" >>${output_file}
      exit 4
fi
echo -e "Files that will be loaded into Postgis : \n">>${output_file}
echo "$list_S57files" >>${output_file}
echo -e
"\n##################################################\n">>${output_file}

for S57file in $list_S57files; do
      #Name the schema to be created (one schema per map)
      current_schema=$(echo $S57file | sed -e "s:.*/::" -e "s:\.000::")
      #set current_schema to lower case
      current_schema=$(echo $current_schema | awk '{print tolower($0)}')

      #create the schema '$current_schema'
      echo -e "`date +"%T"` : Creating schema $current_schema in $dbname"
>>$output_file
      PGCREATE="psql -h $host -U $user -d $dbname -At -c \"
                  CREATE SCHEMA $current_schema AUTHORIZATION $user
                  \""
      export PGPASSWORD=$password
      eval "$PGCREATE" &>>$output_file
      echo "loading data into $current_schema" >>$output_file
      echo "loading data into $current_schema"
      #convert s57 data into sql and load into postgis
      ogr2ogr -skipfailures  -f "PostgreSQL" PG:"host=$host user=$user
dbname=$dbname password=$password schemas=$current_schema" $S57file
&>>$output_file
      echo -e "\n------------------\n">>$output_file
done

echo "End of scritp" >>$output_file
echo "End of script : consult $output_file to check for errors"
```

8. Annex B– S57 files to shapefiles

```
#!/bin/bash
#
#NAME
#     scs2shp
#     Convert S57 files (.000) to .shp files
#
#SYNOPSIS
#     scs2shp SOURCE DESTINATION
#
#DESCRIPTION
#     This script intends to convert cartographic data encoded in the 'S57'
format to a pool of '.shp' files.
#     There will be as many '.shp' files as there is themes in the 'S57' file
(.000)
#     This script uses the FWTools ogr2ogr function
#     The ogr2ogr can only convert base file (.000)


#check for a correct number of argument
nb_arguments=$#
case $nb_arguments in
      0|1)  echo "Error : missing argument. You must specify an input and an
ouptut directory" ; exit 1 ;;
        2)  input_directory=$1 ; output_directory=$2 ;;
        *)  echo "Error : too many arguments. You must specify an input and
an output directory" ; exit 1 ;;
esac

#check if the input directory exists
if [[ !(-d $input_directory) ]] ; then
      echo "!!!!!!!!!! $input_directory : wrong directory"
      exit 2
fi
#ensure slash at the end
[[ $input_directory != */ ]] && input_directory="$input_directory"/

#check if the output directory exists ; if not, create it
if [[ !(-d  $output_directory) ]] ; then
      mkdir $output_directory 2>/dev/null || echo "cannot create
$output_directory directory" | exit 3
fi
#ensure slash at the end
[[ $output_directory != */ ]] && output_directory="$output_directory"/


#create error.log
[[ -f ${output_directory}error.log ]] && echo > ${output_directory}error.log
|| touch ${output_directory}error.log

######## START CONVERSION ########

echo -e "`date`: $input_directory  : looking for files to be converted
(CCxNNNNy.000) \n" >>${output_directory}error.log
```

```
#looking for S57 data to be converted (.000)
list_S57files=$(find $input_directory -name *\.000)

#checking if data have been found
if [[ -z $list_S57files ]] ; then
      echo -e  "`date` : !!!!!!!!!!! No data found \n"
>>${output_directory}error.log
      exit 4
fi
echo "$list_S57files" >> ${output_directory}error.log

#convert all S57 files (.000) found in the input_directory
for S57file in $list_S57files
do
            #Name the local output directory, 1 depth under the
output_directory
            local_output_directory=$(echo $S57file | sed -e "s:.*/::" -e
"s:\.000$:\_shp:")
            local_output_directory=$output_directory$local_output_directory
            echo -e
"\n############################################################################\
n" >>${output_directory}error.log
            echo -e "`date` : Converting $S57file into
$local_output_directory \n" >>${output_directory}error.log
            ogr2ogr -skipfailure $local_output_directory $S57file
2>>${output_directory}error.log
done
```