

**NATIONAL OCEAN SERVICE
Office of Coast Survey
Marine Chart Division**

CARTOGRAPHIC ORDER 005/01

JANUARY 31, 2001

FILE WITH NAUTICAL CHART MANUAL VOLUME 1, SECTION 2.30

TO: All Cartographers
Marine Chart Division

SUBJECT: Introduction of ENC General Practices and Procedures
to the Nautical Chart Manual

APPLICATION: All Nautical Charts

Effective immediately, the following attachment introduces and adds to the Nautical Chart Manual, Volume 1, Part I, Seventh (1992) Edition, Section 2.30--National Ocean Service/Electronic Navigational Charts Object Specifications - General Practices and Procedures.

The attachment includes Section 2.30's ENC "blue card" containing the title information of the section, pages 2-i to 2-ii containing the section's Preface and pages 2-GP1 to 2-GP2 which contain other introductory information.

The attachment is to be inserted immediately after page 2-86.

Nicholas E. Perugini
Captain, NOAA
Chief, Marine Chart Division

Section 2.30

National Ocean Service/Electronic Navigational Charts
Object Specifications

[General Practices and Procedures]

JANUARY 31, 2001

Section 2.30

Preface

The information provided in the *NOS/ENC Object Specifications* represents the National Ocean Service's interpretation of the object encoding guidelines presented in the *IHO/S-57 Appendix B.1, ENC Product Specification* and the accompanying publication *Annex A - Use of the Object Catalogue for ENC*. All information in the *NOS/ENC Object Specifications* is intended to assist the NOS nautical cartographer not only in the creation of an IHO/S-57 compliant ENC database but also in the application of all previously established but appropriate NOS charting standards and procedures.

The *NOS/ENC Object Specifications* are not intended to replace the *IHO/S-57 Appendix B.1, ENC Product Specification* and the *Annex A - Use of the Object Catalogue for ENC* as the official document from which ENC encoding guidelines are to be obtained, but is only being provided to facilitate the NOS transition from a paper/raster chart production environment to an IHO/S-57 vector ENC production environment.

The *IHO/S-57 Appendix B.1, ENC Product Specification* and the *Annex A - Use of the Object Catalogue for ENC* remain the official and final authorities for the encoding of all NOS ENC information and for the resolution of any discrepancies which may arise between the three aforementioned documents.

Section 2.30

Introduction

The purpose of the General Practices and Procedures Section of the *NOS/ENC Object Specifications* is to provide the following:

1. Guidelines on performing the duties and responsibilities involved in the creation (and maintenance) of an NOS IHO/S-57 compliant ENC database.
2. Guidelines for applying all previously established but appropriate NOS charting standards and procedures required to convert conventional Marine Chart Division nautical chart features into ENC object classes.
3. Interpretations of standard Electronic Navigational Chart **terminology, principles and concepts**.

In addition the following will also be provided:

4. The definition and structural composition of an Electronic Navigational Chart.
5. A general overview of the required ENC data format.
6. A detailed and historical look at the National Ocean Service's entry into the realm of Electronic Navigational Charts (ENCs).
7. A brief description (and respective responsibilities) of the IHO committees and working groups involved in the production of standardized ENCs.
8. A brief description of ECDIS (Electronic Charting and Display System) and its utilization of an ENC.

**NATIONAL OCEAN SERVICE
Office of Coast Survey
Marine Chart Division**

CARTOGRAPHIC ORDER 006/01

JANUARY 31, 2001

FILE WITH NAUTICAL CHART MANUAL VOLUME 1, SECTION 2.30.4.2

TO: All Cartographers
Marine Chart Division

SUBJECT: NOS/ENC Object Specifications-[Section 2.30.4.2](#)-
Which Large Scale Chart Shall Be the Official
Source Document

APPLICATION: All Nautical Charts

Effective immediately, the following attachment adds to the Nautical Chart Manual, Volume 1, Part I, Seventh (1992) Edition, Section Number 2.30 pages 2-GP5 to 2-GP10.

The attachment details the specific procedures for determining which nautical chart shall be the source of an ENC object when there is overlapping and same scale chart coverage.

Pages 2-GP5 to 2-GP10 are to be inserted into General Practices and Procedures Section 2.30 of the NOS/ENC Object Specifications immediately after page 2-GP2.

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2.30 ENC GENERAL PRACTICES AND PROCEDURES

2.30.4 Sources of Cartographic Data

(To be completed at a later date.)

2.30.4.1 Nautical Data Branch

(To be completed at a later date.)

2.30.4.2 Nautical Charts

When a nautical chart is used as the source for the ENC collection and encoding of nautical features, the largest scale nautical chart affecting a geographic region shall be designated as the official source document.

- i. Which of the Largest Scales Shall Be The Official Source Document (i.e., Overlapping Charts/Same Scale).

When selecting the largest scale chart from which to collect and encode objects, the cartographer may be confronted with a situation in which two (2) or more nautical charts have overlapping and same scale coverage.

The cartographer must then decide which one of the two (2) or more overlapping and same scale charts shall be recorded as the official (or primary) source of the information, and which of the remaining charts shall have a portion of their geographic coverage "*blocked out*". "*Blocking out*" a chart refers to the task of:

- identifying and delimiting on a chart, a geographic area containing objects which shall be collected and encoded from another chart.

To determine which of the charts shall be designated as the primary source document, perform the steps provided in the following Figure.

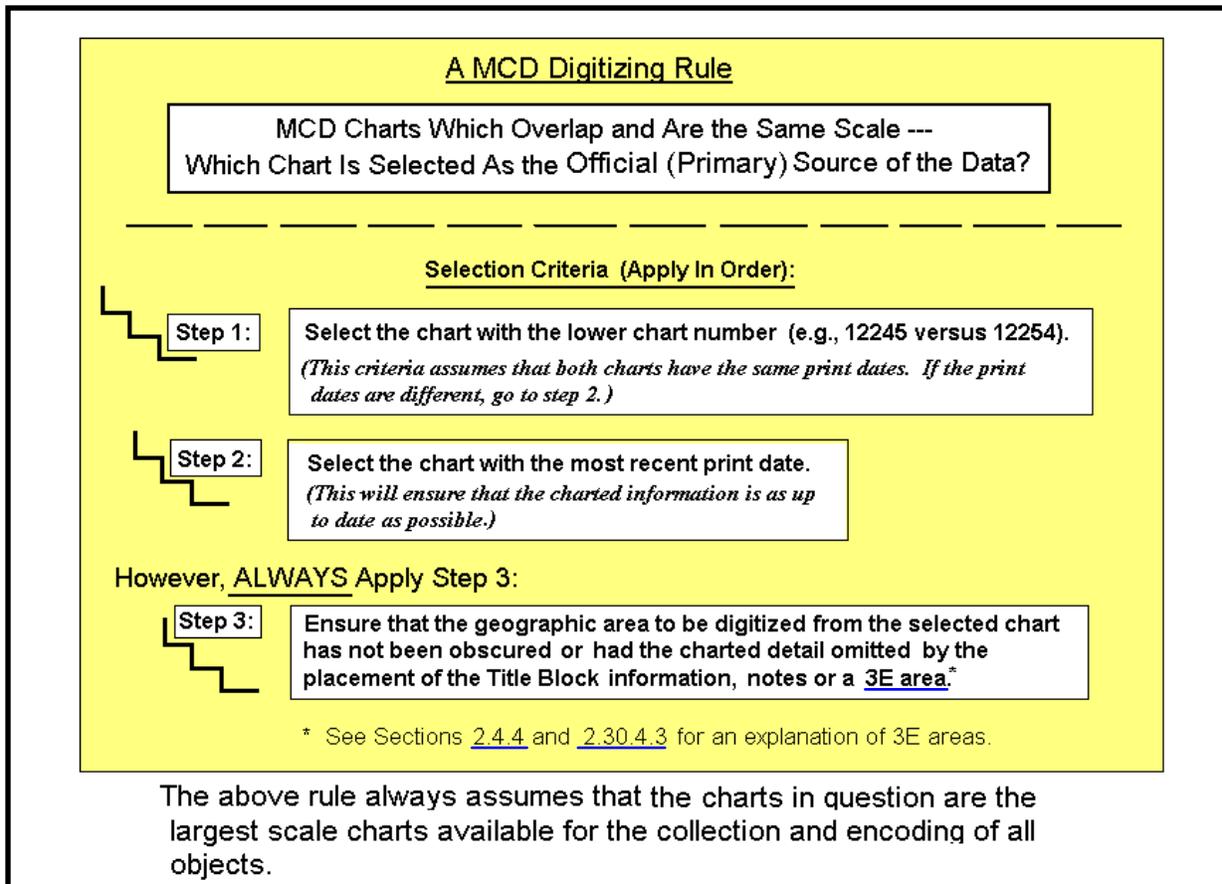


Figure 2-ES001

Note: If during step 3, the geographic area to be digitized from the selected chart **has** been obscured or had charted detail omitted by the placement of the Title Block information, notes or a 3E area, then the omitted detail shall be collected and encoded from an alternate chart(s).

Example: Determining Which Largest Scale Chart Is The Official Source Document and “Blocking Out”

The following example will illustrate:

- the procedures for selecting the proper chart (i.e., the official source document) when two (2) or more charts have overlapping and same scale coverage, and
- the concept of “blocking out”.

To facilitate the explanation, only two (2) charts will be used in the example.

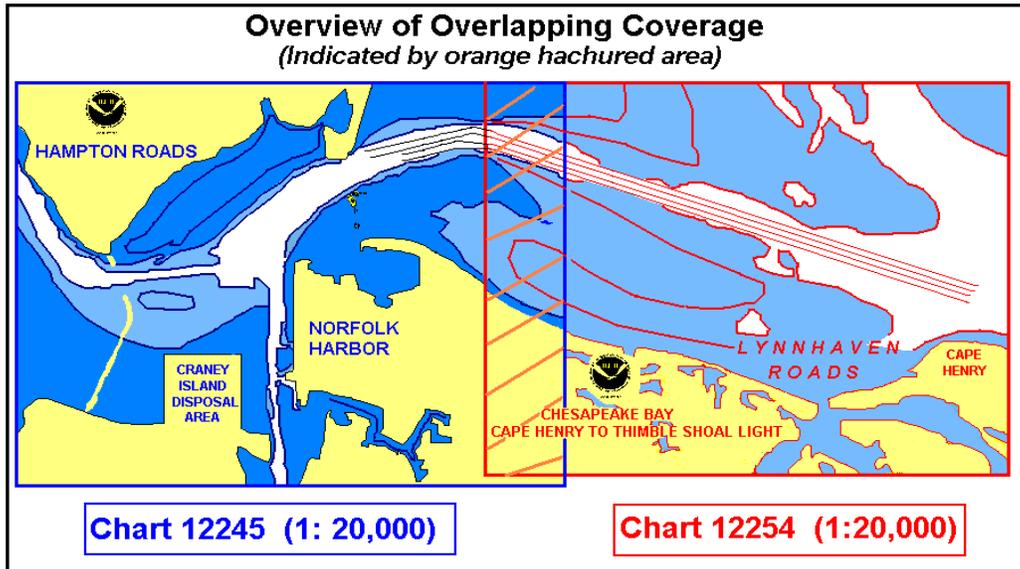


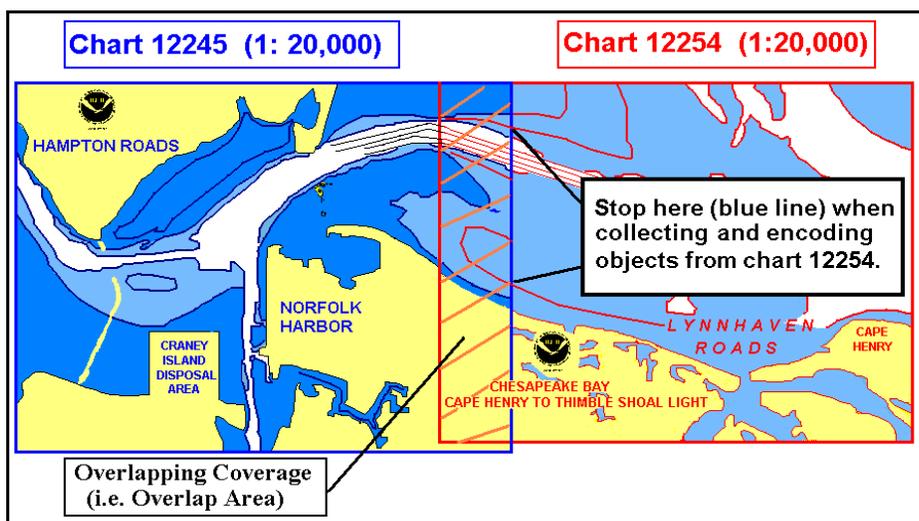
Figure 2-ES002

1. *Figure 2-ES002* presents two (2) MCD charts.... [chart 12245](#) and [chart 12254](#). Assume that these are the only two MCD charts which affect the geographic area of Hampton Roads to Cape Henry. The two (2) charts overlap in the center of the Figure as illustrated by the orange hachured lines.
2. [Chart 12245](#) is outlined with a blue border and has information charted primarily in blue; [chart 12254](#) is outlined with a red border and has its information charted primarily in red.

(continued)

Example (continued): Determining Which Largest Scale Chart Is The Official Source Document and “Blocking Out”

1. By following the steps listed in [Figure 2-ES001](#), and assuming both charts have the same print date, **chart 12245 will be designated as the primary source document.**
2. Having designated chart 12245 as the primary (official) source document means that all ENC objects which are charted in the [overlap area](#) will be collected and encoded from chart 12245 only. The ENC objects charted on the alternate chart (chart 12254) will only be collected and encoded up to the [boundary of the primary chart](#)---chart 12245. See [Figure 2-ES003](#) below.

*Figure 2-ES003*

3. **Exceptions to the Rule:**
 - a. The limits of Regulated Areas, Cable Areas, Pipeline Areas and other area or linear objects (e.g., islands, etc.) which are charted in their entirety on the alternate chart, should be collected and encoded from the alternate chart. This procedure would ensure a more accurate delineation of the object, and would eliminate the performance of the [“edge-matching”](#) (see [comment no. 6](#)) task.
 - b. For the exception affecting the collection and encoding of depth contours, see Section [4.30.13 Situation No. 5](#).

(continued)

Example (continued): Determining Which Largest Scale Chart Is The Official Source Document and “Blocking Out”

4. **“Edge-Matching”:** Edge-matching involves the alignment of the edges or ends of a line whose geometry is partially portrayed on each of two (2) adjoining charts. The purpose of “edge-matching” is to ensure the proper topological structure in a seamless database.
5. If a region of chart 12245's overlapping area was obscured or had charted detail omitted by the placement of Title Block information, notes or a [3E area](#), then the objects which normally would be charted on chart 12245 but are not, will be collected and encoded from chart 12254.
6. [Figure 2-ES004](#) below and comments nos. [9](#) and [10](#) will illustrate the concept of “*blocking out*”.

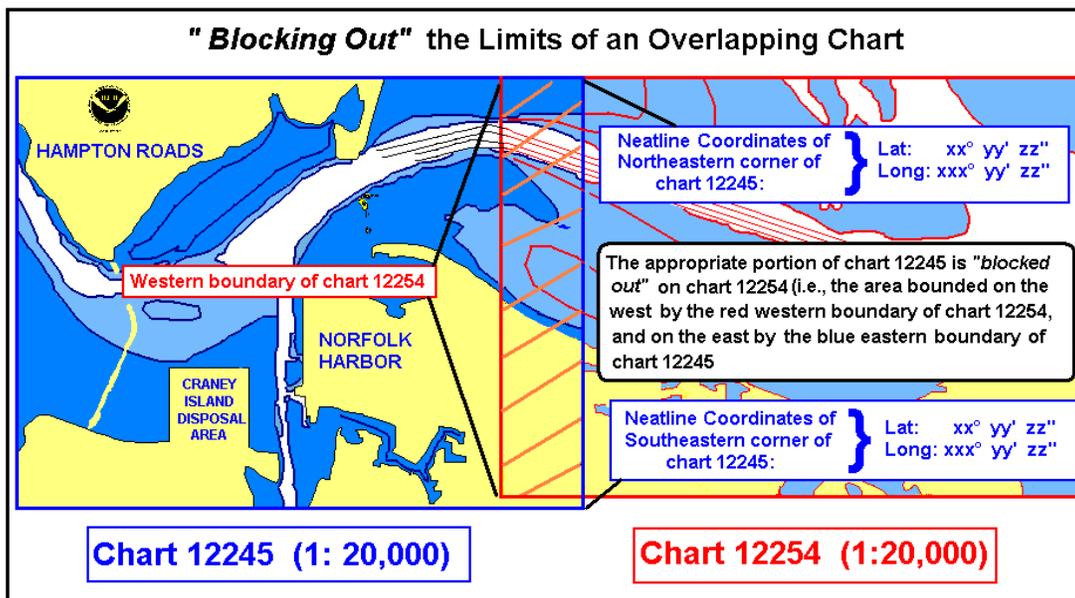


Figure 2-ES004

- 9 Chart 12245 has been designated the primary chart. Therefore, it will be the appropriate neatline coordinates of chart 12245 which shall be delineated (i.e. “*blocked out*”) on chart 12254 (the alternate chart). This “*blocked out*” area of chart 12254 is the geographic area which contains the ENC objects which shall be collected and encoded from chart 12245 (the primary chart).

(continued)

Example (continued): Determining Which Largest Scale Chart Is The Official Source Document and “Blocking Out”

10. ***Post Script.***

All of the previous comments principally involved the overlapping of two (2) nautical charts. However, when more than two (2) nautical charts are involved, (and after the first (official) primary chart has been determined), the selection of a secondary official chart from the remaining alternates must be performed. This selection process is to be continued (i.e. a tertiary official chart, etc.) until all appropriate charts have been properly designated as the respective and official source of each overlapping nautical feature. (See *Figure 2-ES005* below)

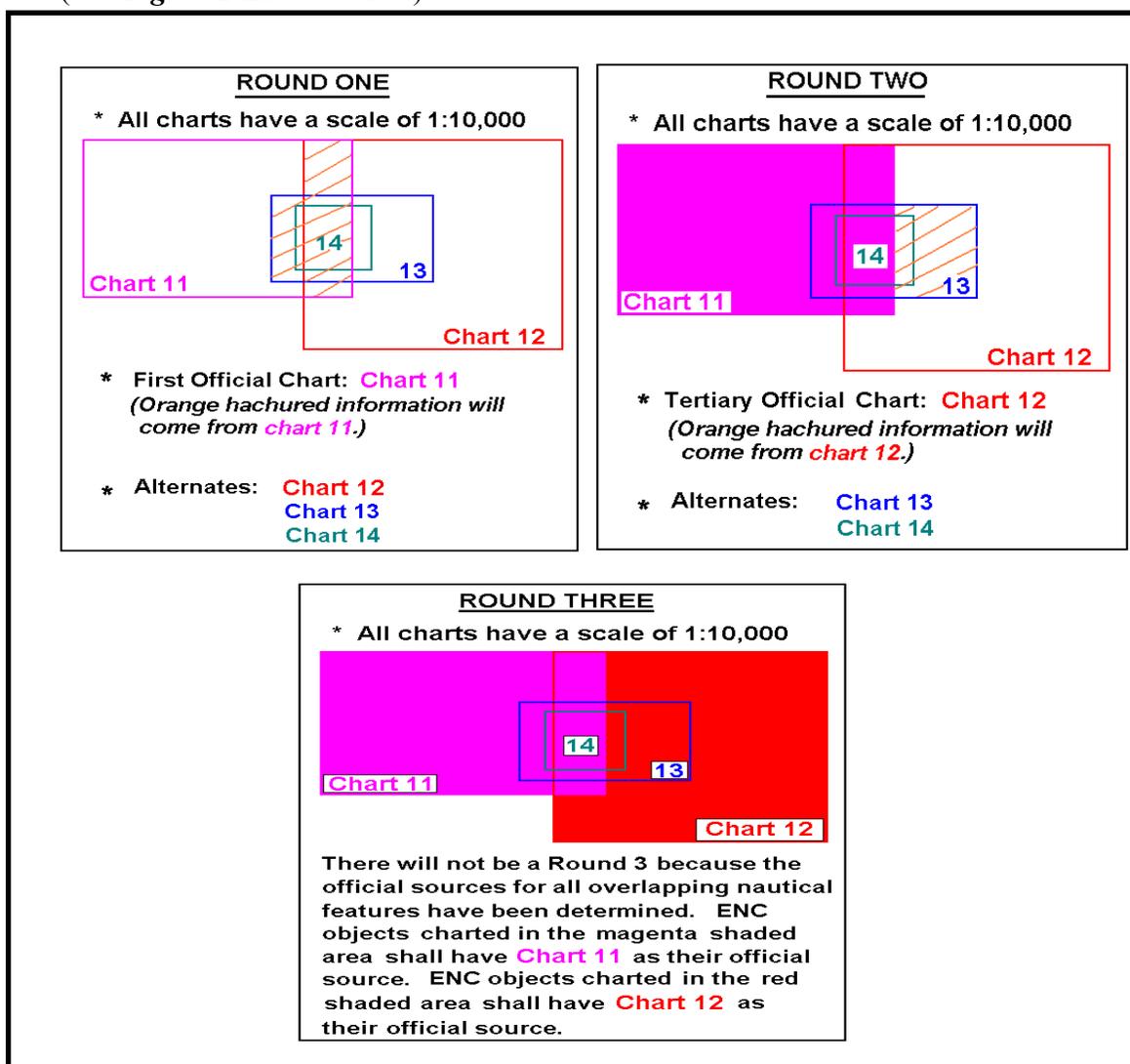


Figure 2-ES005

NATIONAL OCEAN SERVICE
Office of Coast Survey
Marine Chart Division

CARTOGRAPHIC ORDER 007/OI

JANUARY 31, 2001

FILE WITH NAUTICAL CHART MANUAL VOLUME 1, SECTION 2.30.4.3

TO: All Cartographers
Marine Chart Division

SUBJECT: NOS/ENC Object Specifications - Section 2.30.4.3 -
[3E Areas](#)

APPLICATION: All Nautical Charts

Effective immediately, the following attachment adds to the Nautical Chart Manual, Volume 1, Part I, Seventh (1992) Edition, Section 2.30.4.3 pages 2-GP11 to 2-GP12.

The attachment details the specific procedures to be followed when a cartographer is using as a source for encoding ENC objects, a nautical chart which contains a 3E area(s).

Pages 2-GP11 to 2-GP12 are to be inserted into the General Practices and Procedures section of the NOS/ENC Object Specifications immediately after page 2-GP10.

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2.30.4.3 3E Areas

1. Definition

A 3E area is an area on a smaller scale nautical chart in which all aids to navigation and all charted detail falling below the shoreline plane of reference have been removed and replaced with Blue Tint No. 1. The removal of these items in a 3E area has occurred because:

- larger scale charts contained the same detail, and,
- such duplicate coverage could “not be justified by navigational needs”

Therefore, to reduce compilation time and maintenance costs, 3E (economy, efficiency and effectiveness) areas are established. (See also [Section 2.4.4](#) of the [Nautical Chart Manual](#).)

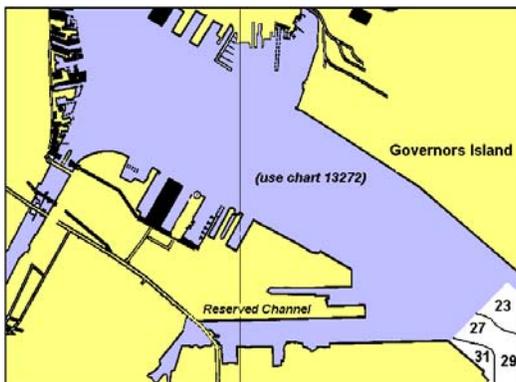


Figure 2-ES006 - Example of a 3E Area

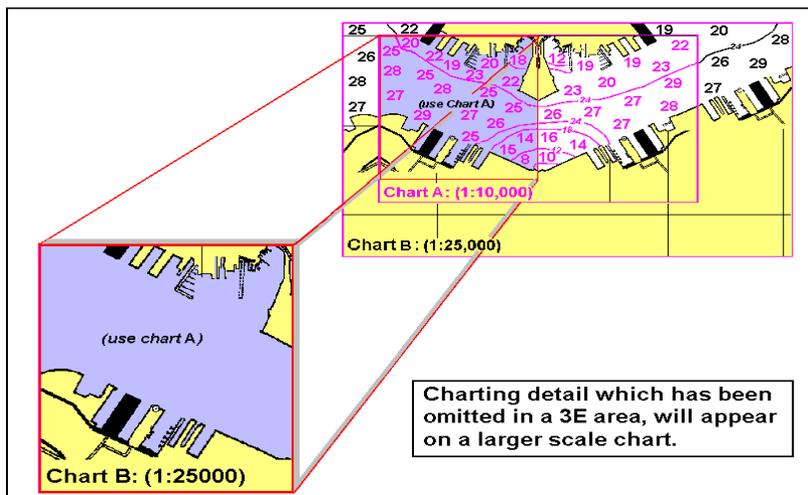


Figure 2-ES007

2. Procedures Prior To Encoding

Certain preliminary procedures should be performed by the cartographer prior to encoding objects from a chart(s) containing a 3E area(s):

A. Determine all larger scale chart coverage.

This first preliminary procedure adheres to the MCD standard of always using as the primary source of data (either for digitizing purposes or charting purposes), the most current and largest scale existing source document.

B. “Block Out” on a copy of the smaller scale chart in question, the neatline coordinates of all larger scale chart coverage. (Refer to [Section 2.30.4.2](#) for a definition of “blocking out”.)

By “blocking out”, on a copy of the smaller scale chart in question, the neatline coordinates of all larger scale charts, the geographic areas containing the objects which are to be collected from a larger scale chart will be identified.

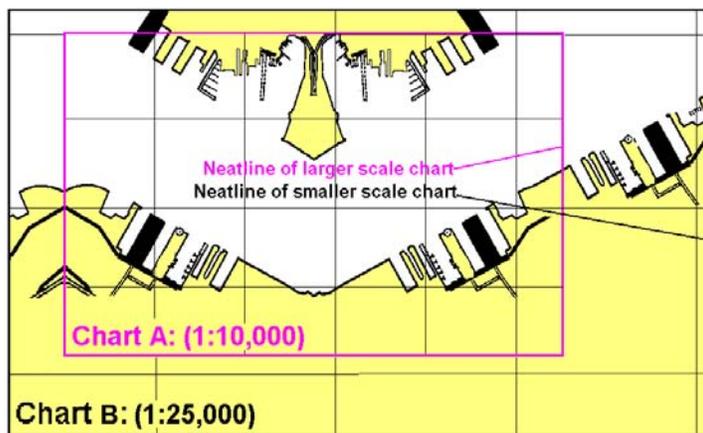


Figure 2-ES008

3. Conclusion

Since objects which have been omitted in a 3E area will appear on a larger scale chart, the task of “blocking out” will also identify the larger scale chart from which these objects shall be collected and encoded.

**NATIONAL OCEAN SERVICE
Office of Coast Survey
Marine Chart Division**

CARTOGRAPHIC ORDER 008/01

JANUARY 31, 2001

FILE WITH NAUTICAL CHART MANUAL VOLUME 1, SECTION 2.30.7

TO: All Cartographers
Marine Chart Division

SUBJECT: NOS/ENC Object Specifications - Section 2.30.7 -
[Topological Structure](#)

APPLICATION: All Nautical Charts

Effective immediately, the following attachment adds to the Nautical Chart Manual, Volume 1, Part I, Seventh (1992) Edition, Section 2.30.7 pages 2-GP19 to 2-GP34.

The attachment provides a definition of topology and its relevance to the collection and encoding of ENC objects.

Pages 2-GP19 to 2-GP34 are to be inserted into the General Practices and Procedures section of the NOS/ENC Object Specifications immediately after page 2-GP12.

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2.30.7 Topological Structure

1. What is topology?

In his 1964 book Experiments in Topology, Stephen Barr stated “topology is curiously hard to define...(it) started as a kind of geometry but it has reached into many other ... fields.”¹

To provide a brief overview of the meaning of topology..... topology involves the spatial relationship (or the connectivity) of geometric objects. Its study provides answers to questions such as:

- what is the object’s **boundary**?
- is the object **connected** (to other objects)?
- does the object consist of several components?
- does the object contain **holes**?
- “is the object **hollow**?”
- is the object **enclosed**, or does it’s limits extend infinitely far?²

Without topology, the spatial component of an object is simply graphical, comprised of a geometric entity (i.e., point, line or area) representing its shape and nothing more.³

2. Why should a cartographer be concerned with topology?

Topology involves the application of specific digitizing procedures to ensure that the information to be stored in the ENC database is in adherence to IHO/S-57 standards and requirements.

¹ Watson, S. (1997, December). A Brief Definition of Topology. (On-Line), Internet:<http://at.yorku.ca/i/a/a/b/14.dir/1.txt>

² Talsi, J. (1999, November). What Is Topology? (On-Line), Internet:<http://www.kolumbus.fi/justal/bits/math/topology.htm>

³ Laser-Scan Limited (1999, May) Training Course-Gothic Database Concepts.

3. What are the ENC digitizing procedures which will ensure correct topological structure?
 - A. Connecting the end points of adjoining lines together where appropriate.

❖ Ensures that there are no gaps between lines.

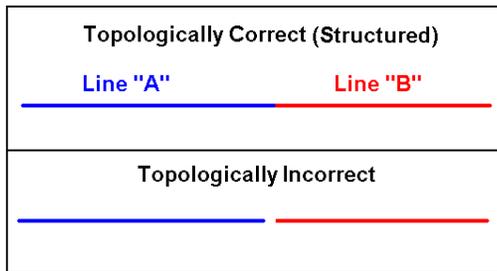


Figure 2-ES009

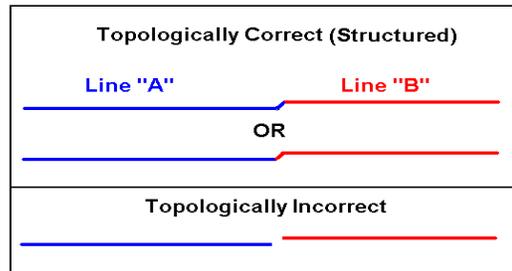


Figure 2-ES010

❖ Ensures that there are no overlapping lines

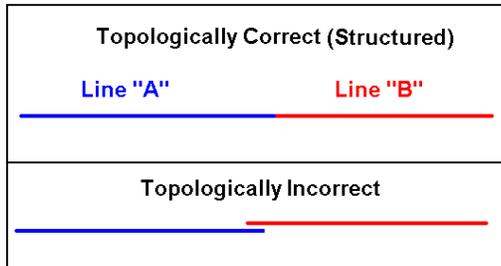


Figure 2-ES011

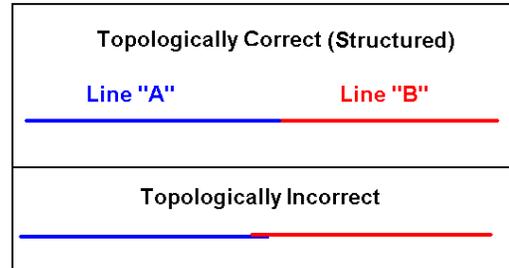


Figure 2-ES012

❖ Ensures that shapes and polygons are totally enclosed area objects

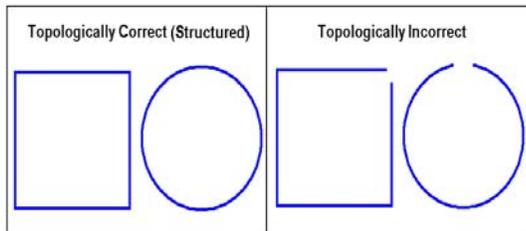


Figure 2-ES013

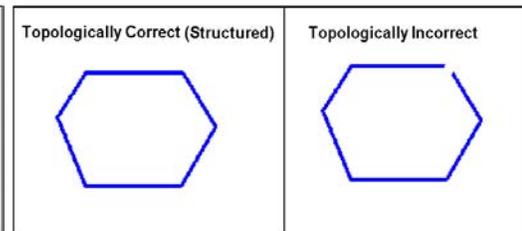


Figure 2-ES014

B. Properly encoding the relationship(s) of associated objects.

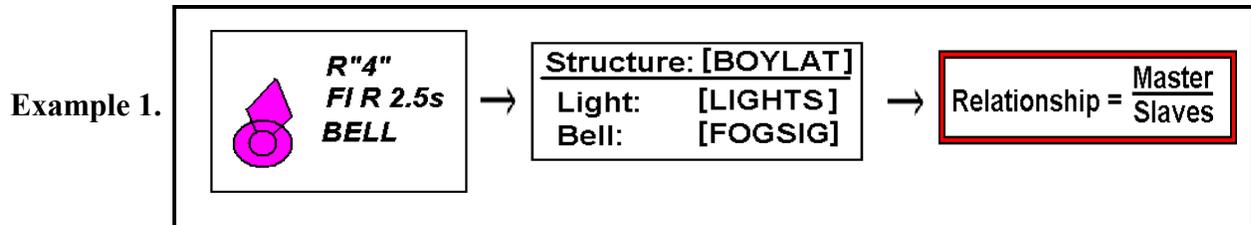


Figure 2-ES015

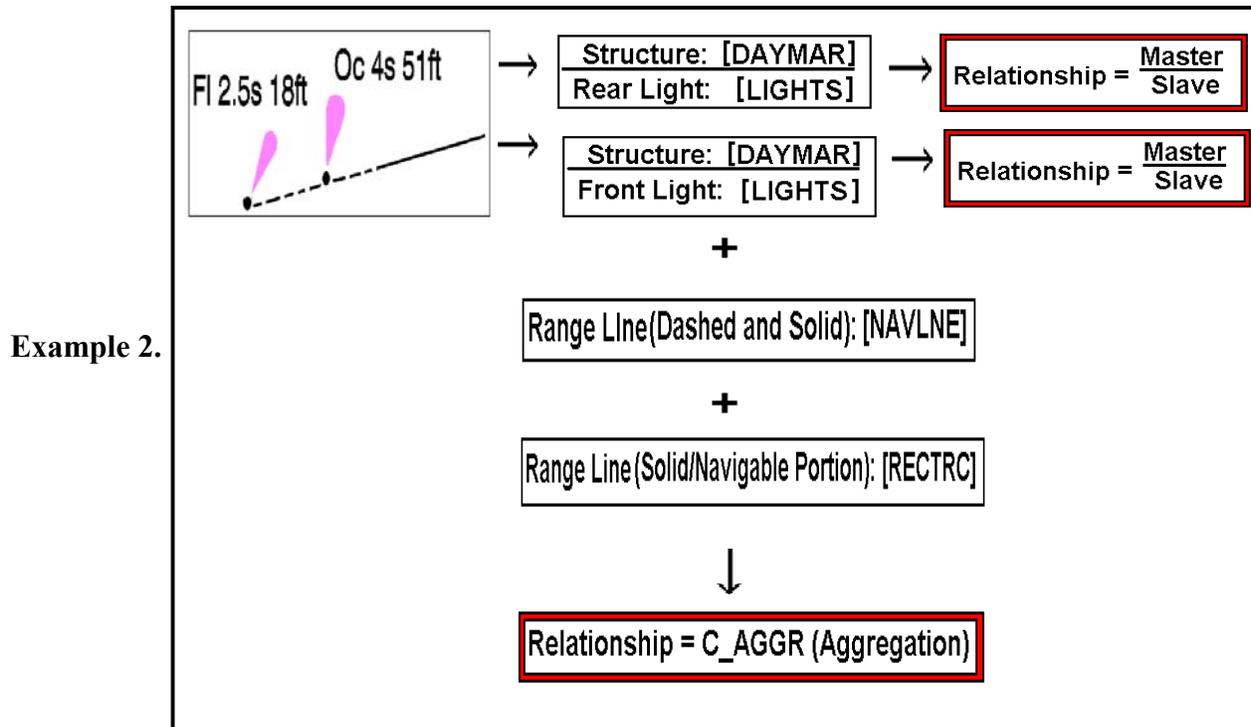


Figure 2-ES016

- C. Forming the proper polygons which are defined by the boundaries of other objects

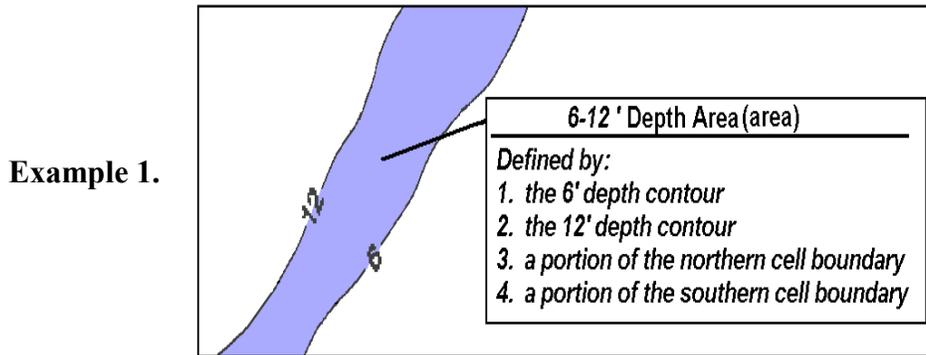


Figure 2-ES017

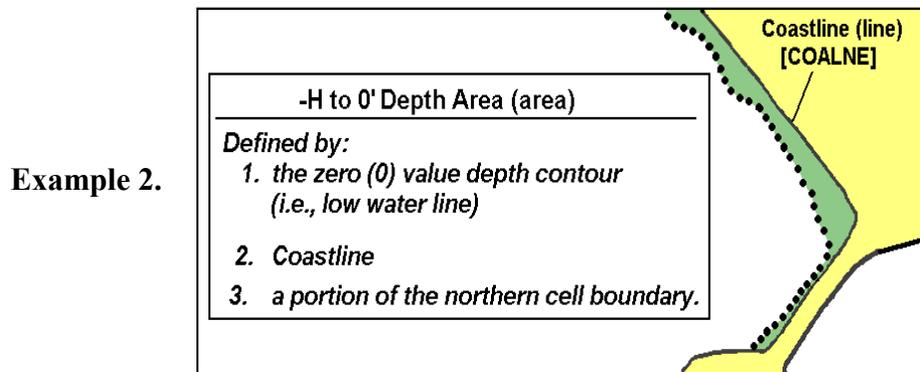


Figure 2-ES018

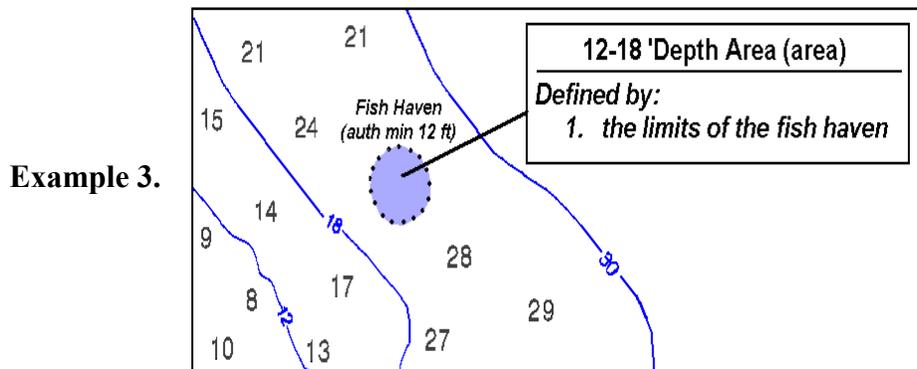


Figure 2-ES019

Example 4.

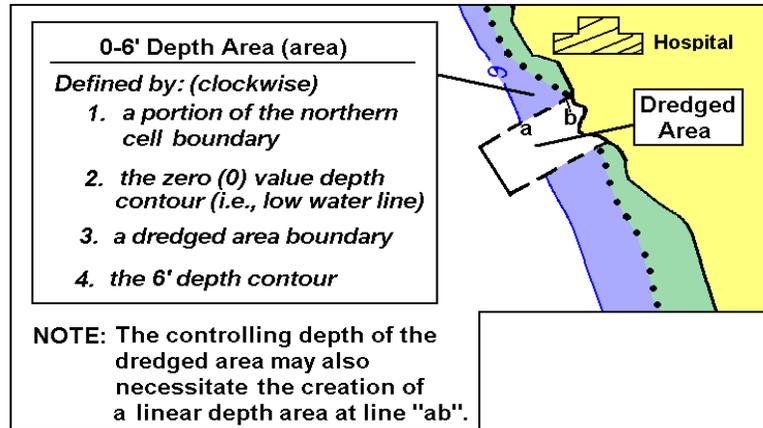


Figure 2-ES020

Example 5.

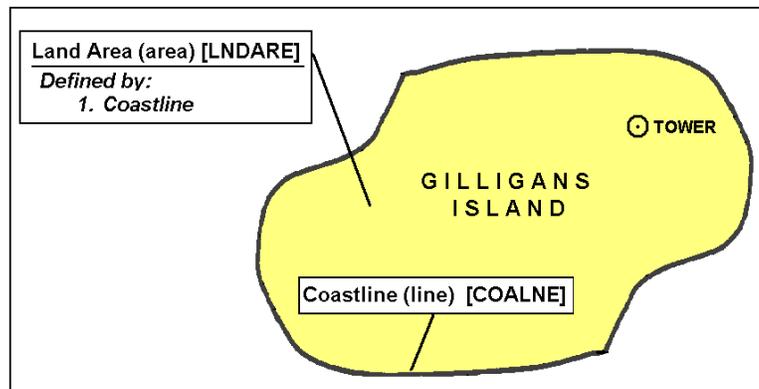


Figure 2-ES021

Example 6.

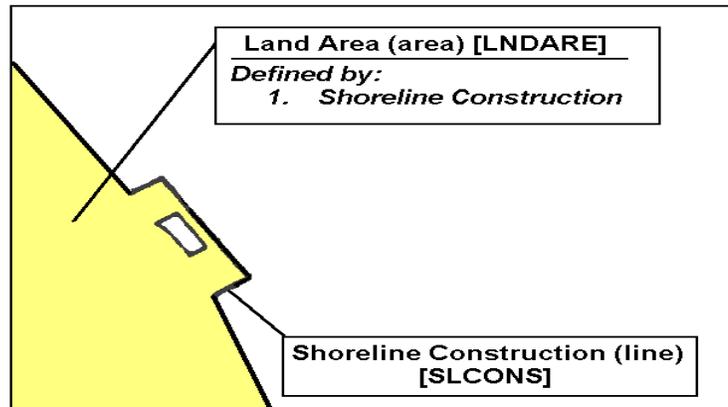


Figure 2-ES022

Example 7.

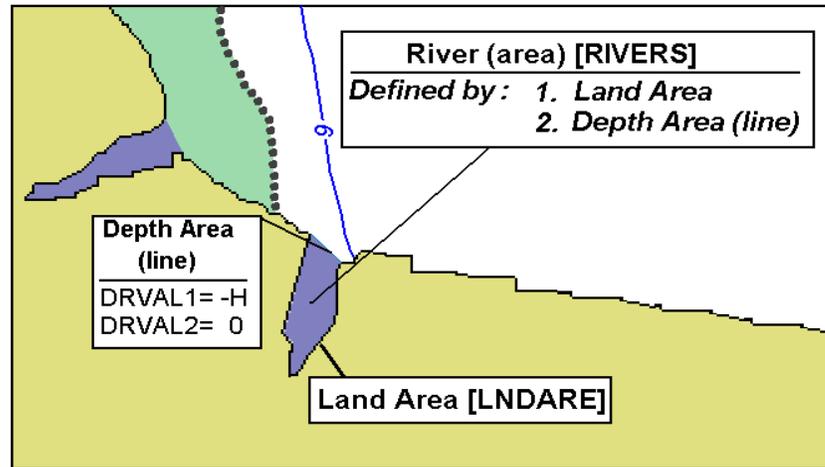


Figure 2-ES023

Example 8.

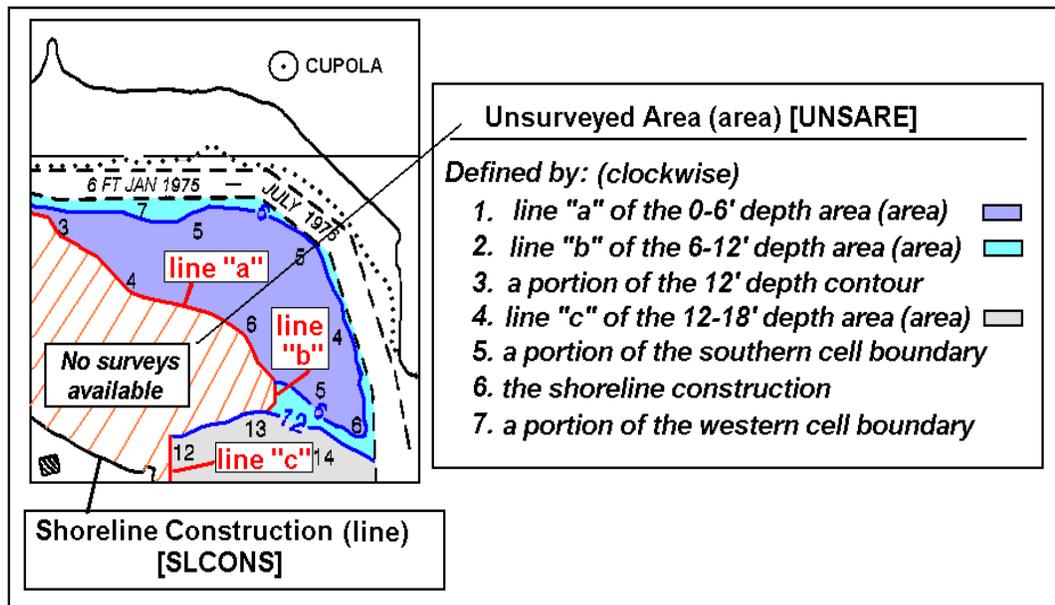


Figure 2-ES024

4. Nodes

A node is the topological element which shall be used to ensure:

- that the end points of adjoining lines have been connected;
- that shapes and polygons have been totally enclosed, and
- that all objects which have a master to slave and/or an aggregation relationship have all been encoded as having the same geographic position.

Also referred to as a geometric primitive, it is a node where the geographic coordinates of objects are stored. (See [Figures 2-ES025](#) and [2-ES026](#) below).

A geometric primitive is a method of data collection and representation and may be a point, line or area. A node is a point geometric primitive.

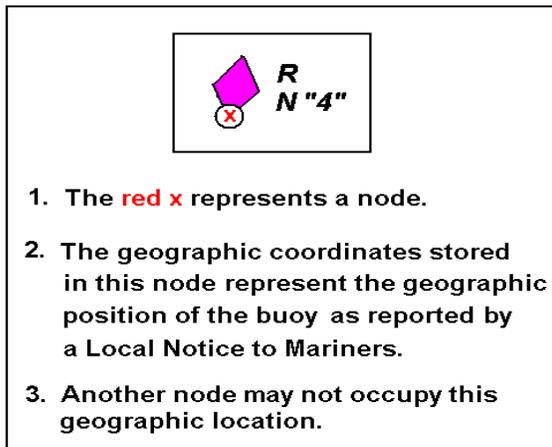


Figure 2-ES025

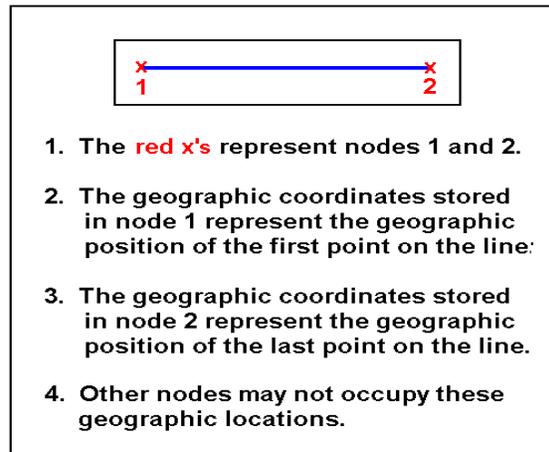


Figure 2-ES026

A. Types of Nodes

There are two (2) types of nodes: *isolated* and *connected*. Isolated nodes ([Figure 2-ES025](#)) are used to store the geographic position of (and represent) discrete point features such as towers, wrecks, buoys and lights. Connected nodes ([Figure 2-ES026](#)) are always located at the ends of linear objects and, therefore, store the geographic position of (and represent) the first or last point on a line. A connected node may also be used to represent a point object when it is located at a juncture of linear objects (e.g., range lights on a range line).

B. Ensuring Lines Have Been Connected

To ensure that two (2) lines have been connected, the geographic position of the beginning (or end) of one line must agree with the geographic position of the end (or beginning) of the adjoining line. This is accomplished through the use of a connected node and by attaching to it, the respective ends of each adjoining line. (See *Figure 2-ES027* below)

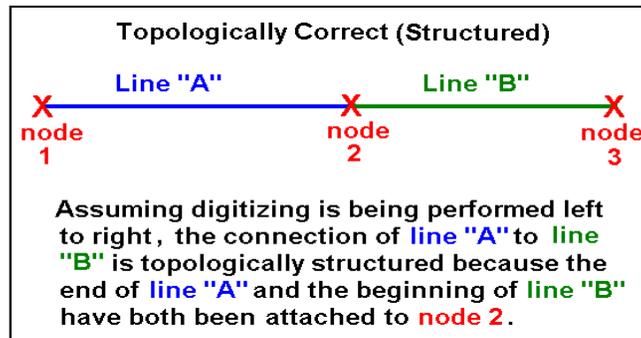


Figure 2-ES027

C. Ensuring Shapes and Polygons Have Been Totally Enclosed

To ensure that shapes and polygons have been totally enclosed, the beginning and ending points of the shape or polygon must have the same geographic position and, therefore, must be represented by, the same connected node. This means that the end of the shape or polygon must be attached to the node which represents the beginning point. (See *Figure 2-ES028* below)

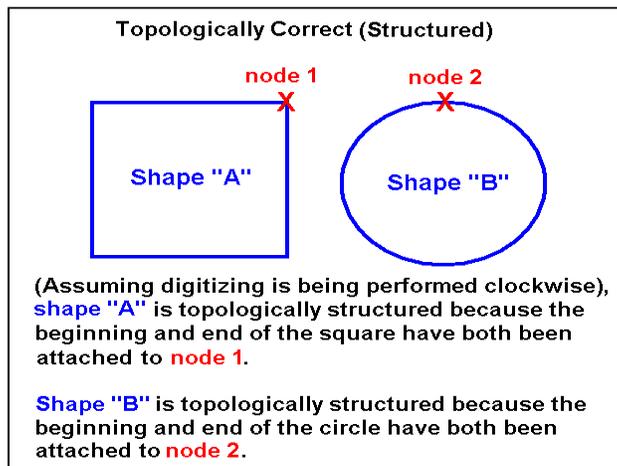


Figure 2-ES028

- D. Ensuring All Objects Which Have a Master to Slave and/or an Aggregation Relationship Have All Been Encoded as Having the Same Geographic Position.

To ensure that all objects which have a master to slave relationship have all been encoded as having the same geographic position, all objects involved must share a common isolated node. For example, when encoding a *lighted horn buoy*..... the light, the horn and the buoy will be encoded as separate objects, however a relationship of *master to slaves* must be established to create the *lighted horn buoy* object. To be topologically structured, the node which stores the geographic position of the buoy (the master object) must also be the node which is shared by the associated light and bell (the slave objects). (See **Figure 2-ES029** below)

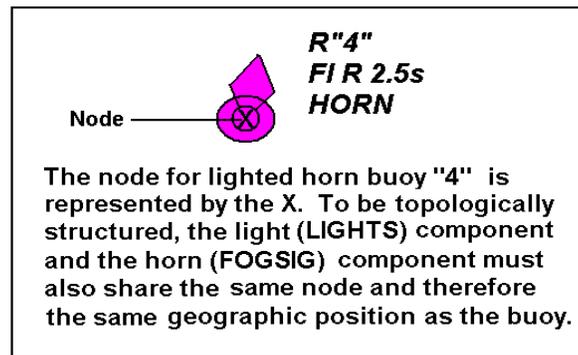


Figure 2-ES029

An aggregation of one (1) or more point objects to one (1) or more linear objects may involve both isolated and connected nodes. For example, range lights on a range line will involve *isolated* nodes for representing the range lights and *connected* nodes for representing the attachment of the lights to the range line.

To ensure the topology of the range lights, the respective structural components must share the *isolated node* of the respective light component. (See Figure 2-ES030 on the following page.)

To ensure the topology of the aggregation, the range light objects shall be represented as components of the range line by using the *isolated* node of each range light to attach itself (as a *connected* node) to the range line. (See Figure 2-ES031 on the following page.)

[NOTE: An aggregation may also involve the grouping of two (2) or more linear objects. For example all of the linear ENC objects which comprise a traffic separation scheme (i.e., traffic separation lines, traffic separation zones, traffic separation scheme roundabouts, etc.)

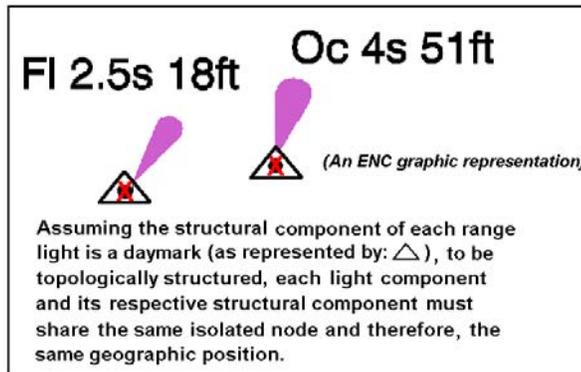


Figure 2-ES030

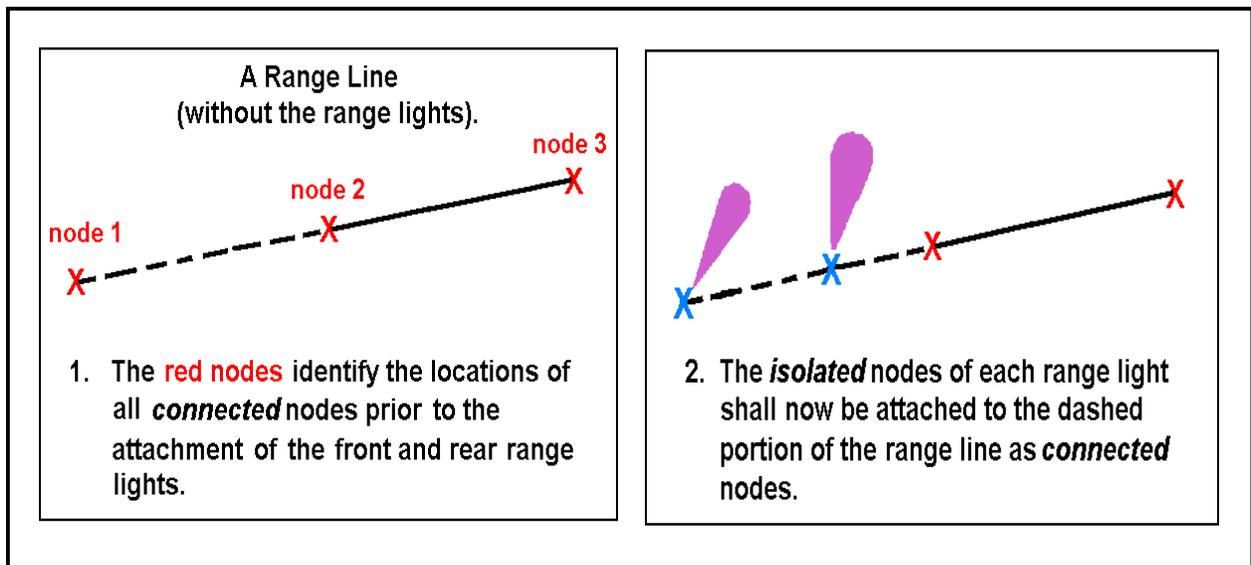


Figure 2-ES031

5. Other Important Topology Terms

A. Vertex (Vertices)

In its most basic form, a vertex is a point on a line . In topological terms vertices represent an ordered set of two or more coordinate pairs [(x,y); (x,y)....] or [(latitude, longitude); (latitude, longitude).....] used to construct a two-dimensional (or three dimensional) element. A vertex may be located:

- at the beginning of a line
- at the end of a line
- on a line between the beginning and ending nodes
- on a line between other vertices
- at the intersection (or juncture) of lines or curves
- at the intersection (or juncture) of two sides of a polygon
- at the turning point of a line

Vertices which are located at the beginning or end of a line are also considered to be [nodes](#).

B. Edges

An edge is the term used to represent the location of a linear object and/or the border of shapes and polygons. Edges are topologically defined by nodes at their beginning and end (referred to as the start and end nodes - see *Figure 2-ES032* below) and a finite number of vertices.

[NOTE: Previously referred to in [Section 2.30.7 Part 4](#), as a *line(s)*. All linear representations (including the borders of shapes and polygons) shall now be referred to as the appropriate topological term: *edge(s)*.]

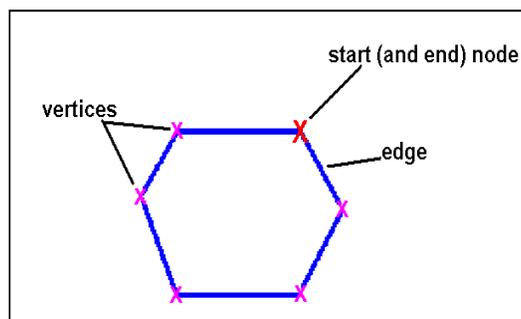


Figure 2-ES032

1. Rules of Topological Edges

- Edges must have start and end [nodes](#).
- Edges may intersect
- Edges that share a common node must refer to each other as “right edge” or “left edge”
- An edge is always broken into two adjacent edges by a node.
- The direction of an edge shall be its orientation from start node to end node.

2. Edges and the Formation of other Polygons

To be topologically structured also includes forming the proper polygons from the boundaries of other existing objects. This procedure involves the sharing of, but **not the duplication of, coincident linear geometry**. (See [Figure 2-ES033](#) on the following page). All properly formed polygons are represented by nodes and edges and are encoded as “closing loops” which begin and ending at a common *connected* node.

C. Chain-Node Topology

Chain-node topology is the level of topology in which all ENC data is to be encoded. It is a method of data structure in which all geometry is described in the (aforementioned) topological terms of [isolated nodes](#), [connected nodes](#), and [edges](#)

1. Rules of Chain-Node Topology

- Edges and nodes are topologically linked.
- Nodes are explicitly coded in the data structure.
- Only one (1) node can occupy a single geographic location.

- Point representations are encoded as [isolated or connected nodes](#).
- Line representations are encoded as a series of [edges](#), *connected* nodes and [vertices](#).
- Area representations are encoded as “closing loops” which begin and end at a common *connected* node and which contain a finite number of vertices.
- Each edge must reference a *connected* node at its beginning and end.
- Vector objects may be shared. (See *Figure 2-ES033* below)
- Duplication of coincident linear geometry is not allowed if there is a “logical topological relationship” between the affected objects (See *Figure 2-ES033* below.)

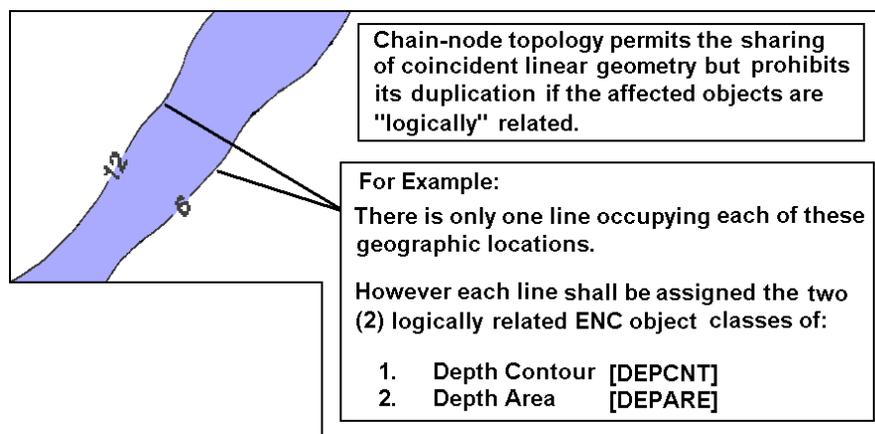


Figure 2-ES033

Other examples of coincident linear objects having a “logical topological relationship” are:

- a. Coastline [COALNE] / Land Area [LNDARE]
- b. A restricted area [RESARE] bordering coastline
- c. A cable area [CBLARE] bordering coastline
- d. A depth area [DEPARE] encroaching into a dredged area [DRGARE]
- e. Land area and non-navigable rivers [RIVERS]

Examples of coincident linear objects not having an “logical topological relationship” are:

- a. A range line [NAVLNE] which is coincident with a depth contour [\[DEPCNT\]](#)
- b. A linear mooring facility [MORFAC] which is coincident with a fence [FENCE]

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Section 2.30.7- Topological Structure

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