Google Earth Visualizations: Preview and Delivery of Hydrographic and Other Marine Datasets (unpublished)

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Abstract

Existing hydrographic data analysis and visualization tools are very powerful, but lack easy access to web data management tools. Virtual globe software provides a gateway to a host of important data products in formats usable by specialized tools such as CARIS, Fledermaus, and ArcGIS. With virtual globe interfaces, users see complimentary and consistent geographic representations of available data in an easy-to-navigate format. This paper presents a preview of visualizations that build upon virtual globe software. These examples are viewed in Google Earth, but could also be implemented in a number of alternative programs (e.g. NASA World Wind, Dapple, OSSIM Planet).

Three datasets are assembled here as Google Earth visualizations to illustrate each of the four primary types of data (point, line, area, and time data). The USCG Marine Information for Safety and Law Enforcement (MISLE) database of ship incidents illustrates point data. A small sample of the USCG National Automatic Identification System logs (N-AIS) demonstrates rendering line and time-varying data. Area data is exmplified in the MBARI multibeam bathymetry of the Santa Barbara Basin. S57 chart objects are combined to demonstrate point, line and area data.

The visualizations for our initial work were created with hand coding and small scripts. However, tools such as Fledermaus and RockWare have added Google Earth export functionality that makes authoring Google Earth resources easy to construct. For large datasets that require additional processing and analyses, Google Earth pop-up windows can include a range of download formats and list appropriate software to use. This virtual globe-based approach can make geospatial datasets more widely accessible via the World Wide Web.

1 Introduction

Navigating hydrographic datasets can be time consuming and confusing when they come in a wide variety of formats requiring a suite of software tools to access. Virtual globe software provides a unified and simple way to view a wide variety of data in a preview mode. It is possible from these previews to link to the original datasets such that a user can quickly download the data and begin more complex analyses. Producing globe-referenced visualizations was much more challenging (e.g. [14]) before the wide deployment of virtual globe software with massive online databases of imagery. Now these tools are ubiquitous. Here, Google Earth demonstrates how several hydrographic data products can be previewed. This paper should be taken as an initial exploration of possibilities. The tools and data streams are evolving at a break-neck pace where a matter of a few months results in significant improvements in technologies.

2 What are the Google Earth KML and KMZ formats?

Data is brought into Google Earth in a format known as KML (formerly known as Keyhole Markup Language; [8]). KML is an XML Language [17] that specifies groups of objects. There are many object types, but the most basic types are placemarks/points, lines, images, and areas. Objects may have a range of attributes such as icon styles or a time range to show the object. Figure 1 is an example of a Google Earth KML file that places a thumb tack at the site of the U.S. Hydro 2007 conference. Generally, there is no need to directly edit the KML, but the option is always available. KML files can point to other data sources across the internet. These might be images or other KML files specified by Uniform Resource Locator (URL). However, it is often more convenient to wrap up all the required data objects into one file called a KMZ. KMZ files are compressed collections of files that contain a main KML file to view along with any additional KML or image files that are needed to display the collection.

3 Methods for creating KML/KMZ files

KML and KMZ files can be created by hand with a text editor or from within Google Earth by using its menus and tool bars. Selecting the properties ("Get Info") of any object on the display or in the "Places" window allows the user to alter the object. The "Save As" option allows the user to save to either a KML file or save a collection of objects as a combined KMZ. Writing KML by hand provides the most flexibility but is time consuming and error prone. There are a number of tools available that can produce/export KML. Software that provide this capability are GDAL[19], Arc2Earth [1] for ESRI ArcGIS (including Arc/Info; [5]), Global Mapper [11], and Fledermaus [9]. More tools are being released all the time. The following paragraphs show examples of creating KML files using GDAL and Fledermaus.

GDAL (the Geospatial Data Abstraction Library [19]) provides a low level method to convert a wide range of input data formats into KML. As a command line tool, the ogr2ogr program in GDAL converts vector datasets into KML without much control of the results. GDAL is used by many GIS applications with graphical user interfaces to allow for more control of the export process. It is possible to create small

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.1">
<Document>
  <Folder>
    <Placemark>
      <name>U.S. Hydro 2007</name>
      <Point>
        <coordinates>-76.289163,36.843432,0</coordinates>
      </Point>
    </Placemark>
  </Folder>
</Document>
</kml>
```

Figure 1: KML file to place a thumb tack at the conference site.

programs in scripting languages to rapidly convert simple formats into KML. The noaadata package [13] is an example of such a scripting package that provides some minimal KML export capability.

Using Fledermaus 6.4 to export KML files, the first step is to open a scene or sd file of the target area. Create a mapsheet then export the map as a geoTiff image in geographic coordinates. The scene or sd file will then be ready for a final conversion in IVS3D Imageviewer. Imageviewer can set the white background areas transparent (otherwise the overlay image in Google Earth will block the background imagery even in areas with no data in the image). Next, export the file to Google Earth. A folder with a KML and image files will be created and available for viewing in Google Earth.

4 MISLE/Marine Casualty and Pollution Database

A subset of the U.S. Coast Guard Marine Information, Safety and Law Enforcement (MISLE) system is published by NiST as the Marine Casualty and Pollution Database [15]. The Marine Casualty portion of the July 2006 version of the database is displayed using placemarkers (Fig. 2). This first visualization prototype provides an overview of the incidents and shows that the most frequent events in the Marine Casualty database are allisions (marked with red icons). Zooming into a region such as the U.S. East Coast (Fig. 3) allows the user to distinguish individual casualty events.

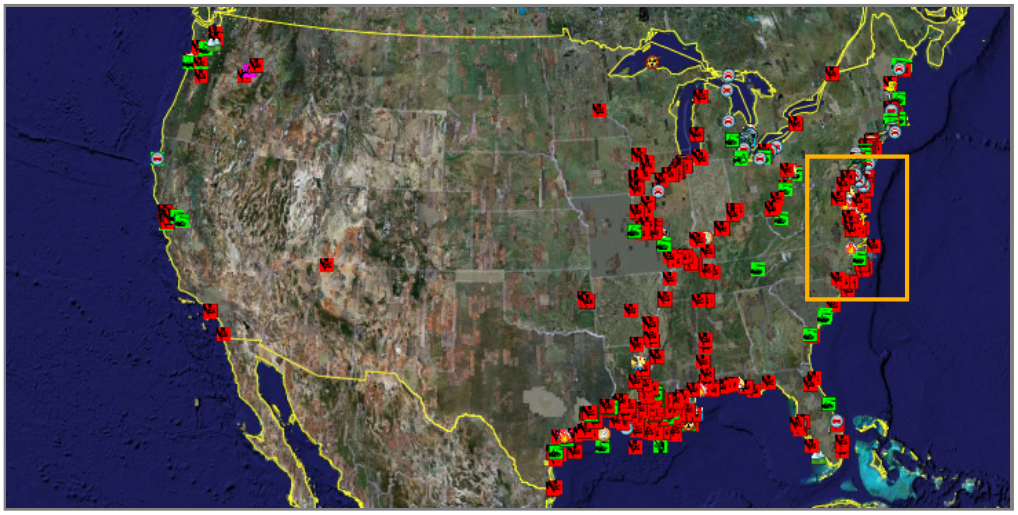

Figure 2: An overview of incidents in the continental U.S. from publicly available Marine Casualty and Pollution Database [15] that is a subset of the USCG MISLE [7] database. Red icons indicate allisions. Green icons are material failure events. Fire icons represent fires and/or explosions. The car icons represent emergency response events. The orange box shows the focus of Figure 3.

Figure 3: Expanded view of the rectangle in Figure 2, the central eastern seaboard from North Carolina to New York. The orange box shows the focus of Figure 4.

The zoomed scale of Figure 3 allows the user to select events and get the detailed MISLE event summary (Fig. 4). For example, with the incident shown in Figure 4, the placemarker could be modified to make the activity_id link directly into the U.S. Coast Guard web page for that activity:

http://cgmix.uscg.mil/IIR/Search/IIRDetails.aspx?ActID=2277795

Additionally, the visualization could benefit from better icons that more directly matched the event being represented.

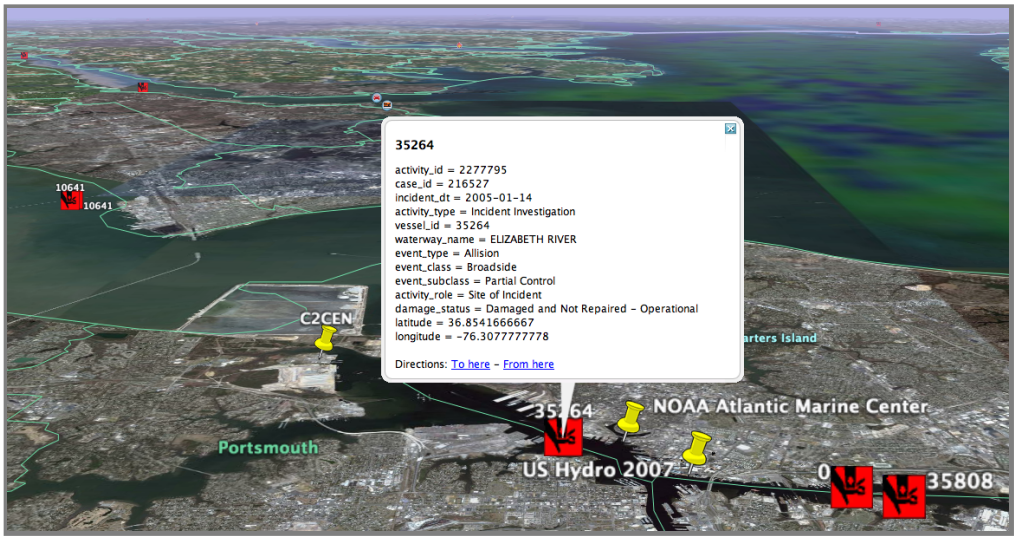

Figure 4: The Hampton Roads/Elizabeth River region. The user is able to click on the icons for an event to get detailed information such as the vessel MISLE identification number or the investigation case number.

5 National Automatic Identification System

The National Automatic Identification System (N-AIS; [16]) is a network of marine AIS receivers around the U.S. that records ship-position broadcasts from vessels that are required to carry AIS by the Safety of Life at Sea (SOLAS) regulations. The N-AIS, related systems line such as AIS Live [6], and AIS receivers provide operations with valuable awareness of ship traffic and cargo. Figure 5 shows AIS tracks in Chesapeake and Delaware Bays. Lines are defined for a time period between each position report received for a particular ship. The user is then able to move the time slider (Fig. 5) to pick a range of times or hit the play button to see ship movements.

If the user needs to see more details on ships, then placemarks can be located at the most recent position reported. Table 1 shows the information sent within one position report. Figure 6 shows a pop-up with a subset of the available data created by noaadata[13]. The pop-up can be easily modified to link to information from other AIS message packets (e.g., the Ship Cargo and Destination message) or to ship registry databases. Software such as noaadata, can produce KML files with the most recent position from received AIS message traffic. This kind of display is also available on Electronic Chart Display and Information System (ECDIS) displays on the ship bridge or Vessel Traffic Service (VTS) stations, but the operator cannot integrate these reports with arbitrary additional data layers.

6 Multibeam bathymetry

Figure 7 is an example of georeferenced areas shown in Google Earth. The bathymetry of the Santa Barbara Basin [4] was converted to an image overlay and added as a layer to Google Earth. By clicking pop-ups, the user is able to obtain additional information relating to the site. The top pop-up in Figure 8 shows an oblique view rendered in Fledermaus with the ship track and coring from a repeat cruise to study the area. Links to download the data, a cruise web page, and published papers provide quick access to detailed information.

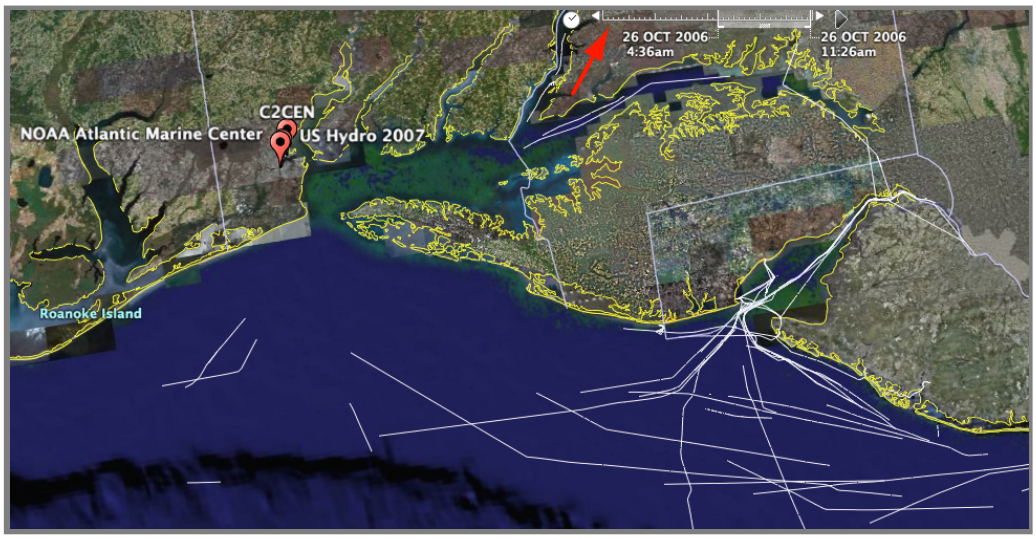

Figure 5: The marine National Automatic Identification System (N-AIS; [16]) provides position (white lines) and status information about vessel traffic in U.S. waters. N-AIS is still in development with coverage continually expanding as receivers are added to the network. The red arrow points to the time slider at the top of the figure that used to select a range of times. To the right of the time slider is a play button used to animate time data.

The lower pop-up illustrates how Google Earth can be used to compliment published papers. Figure 8 from Schwehr et al. [12] allow the user to easily correlate how figures in a paper are spatially located.

Parameter	Number of bits	Description
MessageID	6	AIS message number. Must be 1
RepeatIndicator	2	Indicated how many times a message has been repeated
UserID	30	Unique ship identification number (MMSI)
NavigationStatus	4	What is the vessel doing
ROT	8	Rate of turning. Positive right; negative left.
SOG	10	Speed over ground
PositionAccuracy	1	Accuracy of positioning fixes
longitude	28	Location of the vessel East West location
latitude	27	Location of the vessel North South location
COG	12	Course over ground
TrueHeading	9	True heading (relative to true North)
TimeStamp	6	UTC second when the report was generated
RegionalReserved	4	Reserved for definition by a regional authority.
Spare	1	Not used. Should be set to zero.
RAIM	1	Receiver autonomous integrity monitoring flag
state_syncstate	2	Communications State - Sycronization state
state_slottimeout	3	Communications State - Frames remaining until a new slot is selected
state_slotoffset	14	Additional Communications State information
Total bits	168	Appears to take 1 slot

Table 1: AIS message number 1: Scheduled position report. AIS messages provide critical ship status information.

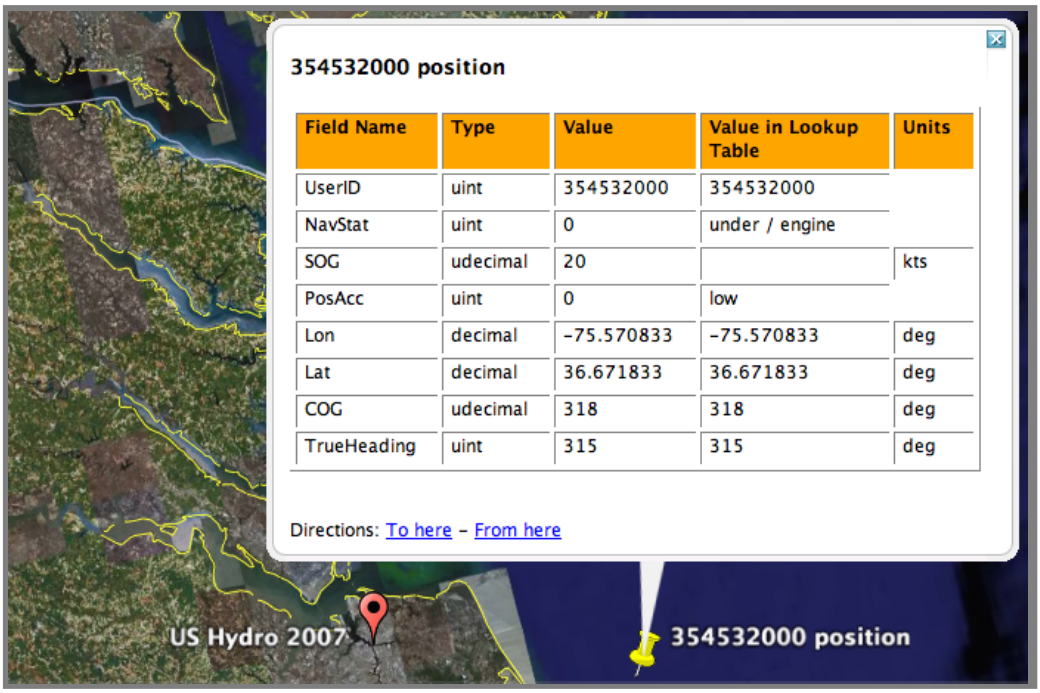

Figure 6: Individual AIS position reports can be plotted in Google Earth with icons. The user can then select these icons for more detailed information. Shown here is a subset of an AIS position report for a vessel. Ships are identified by their "UserID".

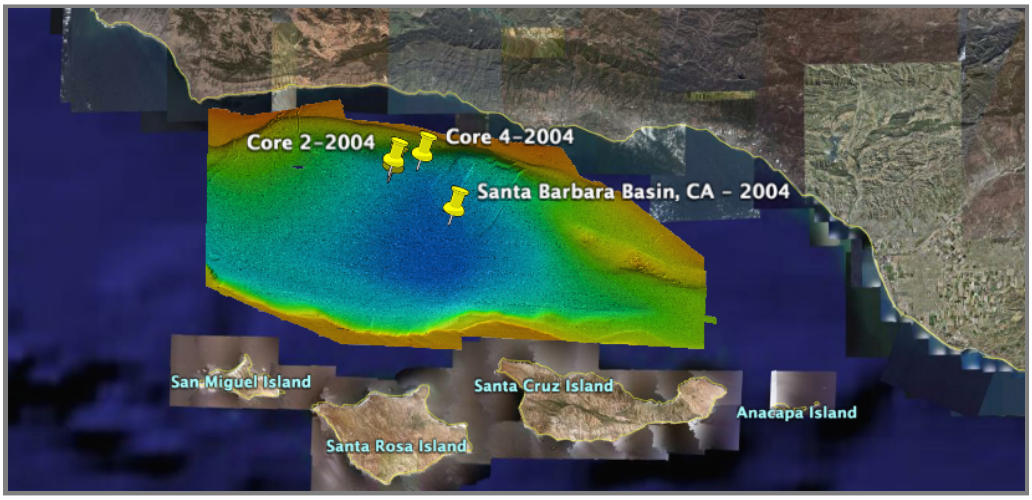

Figure 7: The MBARI multibeam survey of the Santa Barbara Basin [4] is shown here with thumb tacks that can display additional information.

7 S57 Chart Display

The National Oceanic & Atmoshperic Administration (NOAA) publishes electronic versions of charts on the web in both raster and vector (S57) formats[10]. NOAA has an innovative program where users can download these charts from a NOAA web server and/or from certified vendors for use in electronic charting applications. New software and products have recently been released that make use of these publicly available data to bring ENC data into virtual globe visualizations (Fig. 9).

The simplest of these tools is GDAL[19]. Starting with release 1.4.0, GDAL's vector geospatial library

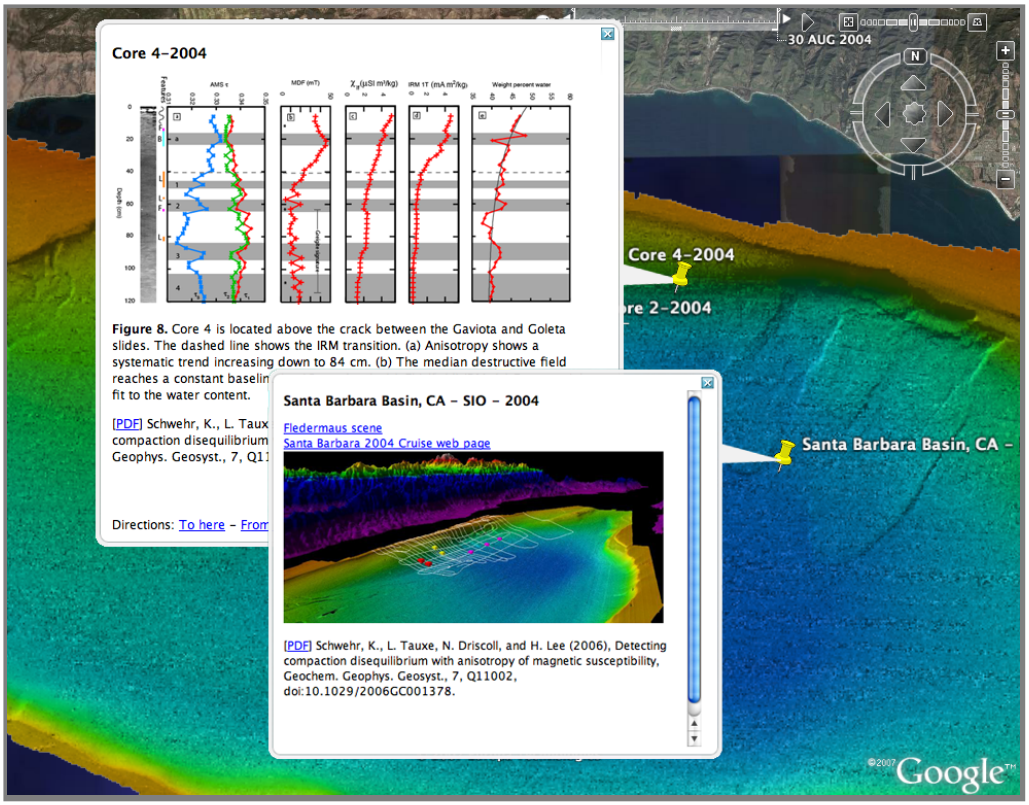

Figure 8: Thumb tacks can show pop-ups with additional information and links to downloading data products. Note: Image has been modified to show two pop-ups at once which is not possible in GoogleEarth.

is able to both read S57-formatted files and write KML files. The results are shown in Figure 10. All vector data types are rendered as red lines and all point data objects (except for soundings) are shown as thumb tacks that, when clicked, show pop-ups providing S57 record data. This capability leads to the potential of having automatically generated S57 previews and download options in Google Earth and Google Maps available directly from the NOAA servers.

Another ENC product, EarthNC, has released their EarthNC nautical chart CD in 2007[3]. The EarthNC CD comes with a complete set of NOAA S57-based charts plus inland-waterway maps that use familiar chart symbols as icons to show items such as navigation buoys (e.g. cans and nuns).

8 Conclusions

Virtual globes interfaces provide a new and exciting tool to register datasets to the Earth. They provide an easy way to georeference data with a simple interface. This allows users to preview and download data in a manner that, only a few years ago, was available only to those with deep pockets and enormous computers.

Tools such as Google Earth have their limits. Google Earth is constrained by an inability to load very large datasets and to show data below the earth and ocean surfaces. The program quickly runs out of memory when loading more than small sets of time referenced ship tracks. Where the limits of these very general tools are reached, the user can transition to task specific tools to continue their analyses. Such tools include (but not limited to): GeoZui4D [18], ESRI's ArcGIS tools (e.g., Arc/Info; [5]), IVS Fledermaus [9], and CARIS [2].

This paper only scratches the surface of what is possible with Google Earth and other virtual globe tools. Combined with web mapping, these new GIS technologies are only beginning to show their potential. I encourage the reader try creating his or her own virtual globe visualizations with a variety of tools.

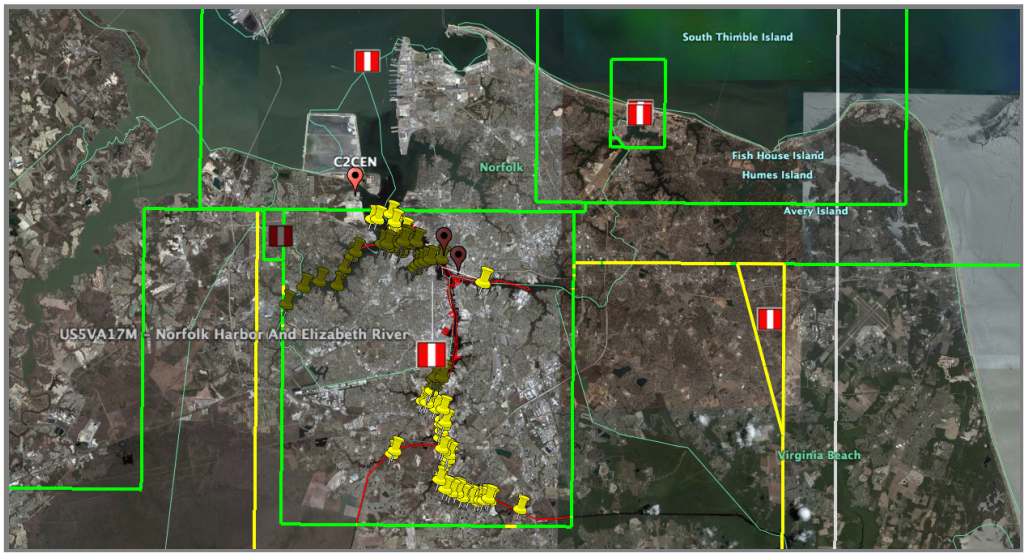

Figure 9: This image (from EarthNC;[3]) shows a chart catalog with bounding boxes and US5VA15M S57 data converted to KML by the ogr2ogr program in GDAL[19]. This lets the user quickly scan an area and identify key features and charts. See Figure 10 for a detailed view.

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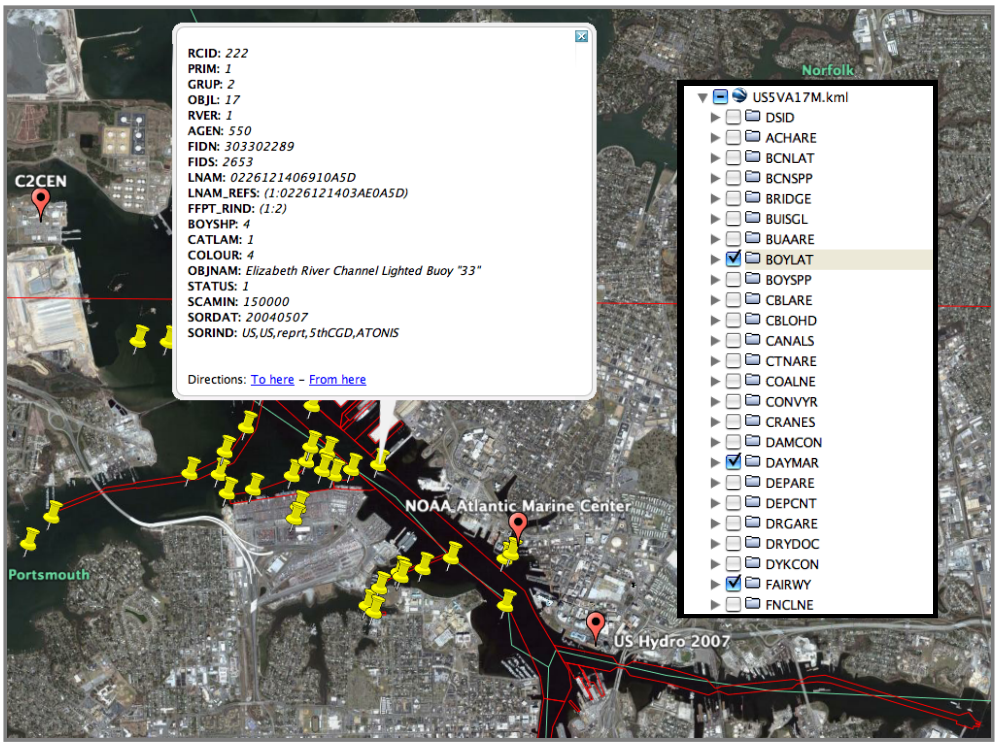

Figure 10: This is an S57 display of the Elizabeth River created with GDAL[19] from US5VA17M Electronic Navigation Chart (ENC) data from NOAA[10]. Using the places control in Google Earth (see inset) allows the user to control which S57 chart features are displayed. Buoys and other point objects are shown with thumb tacks that can be selected to pop up additional information.

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