COMPILING DIGITAL SMOOTH SHEETS USING STANDARD SOFTWARE

Seamless Digital Hydrographic Data

In line with developments in survey equipment, Japan Hydrographic and Oceanographic Department (JHOD) has constructed a new stream of digital hydrographic data that allows smooth transfer from survey vessel to ENC through newly designed â€˜digital smooth sheetsâ€™. The author reviews the evolution of this GIS-based compilation system.

In 1998 JHOD imposed the compilation of digital smooth sheets (including digital wharf-frontage sounding sheets) on hydrographic surveys. Conventional paper-based (or plastic-sheet-based) smooth sheets compiled manually from analogue hydrographic data have since been replaced by digital smooth sheets compiled on a Geographic Information System (GIS) from digitally obtained hydrographic data. For many years hydrographic data was obtained in analogue form and compiled into smooth sheets using manual processes. Recent development of measurement technology such as GPS and multi-beam echo sounding has not only enabled digital data acquisition but expanded the volume of digital hydrographic data. To establish a systematic digital data-processing scheme, JHOD designed a GIS-based â€˜digital smooth sheet compilation systemâ€™ of which the data structure is compatible with that of the ENC.

Functions Required
The digital-smooth-sheet compilation system mainly aims at direct transfer of digital hydrographic data to Electronic Navigational Charts (ENC) database. System requirements for this purpose are summarised below.

- Import and Editing of Digital Hydrographic Data: multi-beam sounding data is acquired by PCs using the software package â€˜HYPACK MAXâ€™ produced by HYPACK Inc. that provides interactive tools for data cleaning and sounding selection. Processed sounding data is imported to GIS software via ASCII (XYZ) data files and treated as vector point data. Other point-like data, such as characters of the bottom, seamarks et cetera are handled in the same way. Digital coastlining data obtained by GPS can be imported and treated as vector line data. Aerial photographs are also available to obtain coastlines, low-water lines and other land features through â€˜head-up digitisingâ€™: extraction of objects from imported raster photo images on the GIS screen. In order to allow smooth data transfer to the ENC database this vector data accompanies attributes conformable to the data structure of â€˜IHO Transfer Standard for Digital Hydrographic Dataâ€™ (S-57 Edition 3).
- Utilisation of Previous Data: previous data in the large-scale ENC database is utilised after import to the GIS. Paper-based (or plastic-sheet-based) survey products are also utilised after import of rastered images via an image scanner.
- Visual Appearance of Digital Smooth Sheets: each category of digital data forms one vector layer on GIS. The vector layers are displayed using symbols and abbreviations similar to those for conventional smooth sheets and charts. As well as newly surveyed and previous data, additional information layers such as a latitude/longitude grid, scale bar, title and remarks are superimposed on the display and the hardcopy layout. Although such layers are not geo-referenced they are essential for the visual appearance of smooth sheets. Transverse Mercator projection is applied to digital smooth sheets in the same way as to conventional smooth sheets.
- Digitising Conventional Smooth Sheets: in some cases conventional plastic-sheet-based smooth sheets need to be recompiled into digital smooth sheets. Such previous smooth sheets are rastered via an image scanner and converted into vector data through head-up digitising. This vector data is utilised in the same way as 1-3.
- Digital data output for ENC database: the compiled vector data is finally converted into S-57 Edition 3-format files structured by attached attributes.

Other Requirements
For further applications of compiled digital hydrographic data to other products some extensible analytic functions are desirable e.g. geospatial analysis, 3-D display, etc.

Using Standard Software
Creating and editing point/line/polygon vector data are salient procedures for the compilation of digital smooth sheets. From the viewpoint of reduction of cost and development period it is favourable to construct a â€˜digital-smooth-sheet compilation systemâ€™ on a platform of general-purpose analytic GIS software which can visualise the group of geo-referenced digital data through map projection and can be customised to meet surveyorsâ€™ demands. JHOD introduced TNTmips from MicroImages Inc. for this purpose. TNTmips is an analytic GIS software package which supports both vector and raster data and is function-rich in data editing and analysis. It comes at relatively

low cost. The standard features of this software satisfy most of the required functions mentioned above. Data converters to/from S-57 Edition 3 and a series of symbols unique to smooth sheets have been newly developed on the platform.

Structure Based on S-57

In S-57 each element shown on the ENC is called an â€˜objectâ€™ and various attributes attached to the object are called â€˜object attributesâ€™. For the compilation of digital smooth sheets the same data structure is constructed on TNTmips using â€˜tablesâ€™ attached to the vector objects. Each element of the vector data on TNTmips can hold records on the tables. Each record of the table corresponds to an S-57 object and each field of the record corresponds to an S-57 object attribute. TNTmips supports a powerful macro package that enables users to control expression and analyses of geospatial data. A series of macro scripts were developed for expression of each S-57 object that automatically select appropriate symbols and abbreviations corresponding to attribute values of vector data.

Practical Aspects

Unlike the compilation of paper-based smooth sheets, hydrographic surveyors are required to attach appropriate attributes based on S-57 to all surveyed data elements in digital smooth sheets. Therefore they are required to be familiar with the data structure of S-57. For convenience of attaching attributes to various categories of vector data, a quick reference catalogue is provided with them. Not only object names and attribute names, but available data types (point/line/polygon) and remarks for each object are listed on it. Examples of several major attributes are described in the subsections below (S-57 objects and object attributes are referred to by six-letter code):

1. **Soundings and drying heights**
   Soundings are point data. On digital smooth sheets each sounding is defined as a point of 2-D coordinates with a special non-S-57 object â€˜SOUNDGâ€™. Attributes for depth values â€˜DEPTHâ€™, their surveyed date â€˜SORDATâ€™ and their accuracy â€˜SORACCâ€™ can be attached under SOUNDG. Drying heights are treated as soundings with negative depth values.
2. **Quality of the bottom**
   Quality of the bottom is defined as point data with an S-57 object â€˜SBDAREâ€™. S-57 attributes â€˜NATSURâ€™ (nature of surface) and NATQUAâ€™ (nature of surface â€“ qualifying terms) are attached under SBDARE in ID numbers corresponding to the category. When a point has both a sounding depth and quality of the bottom, SBDARE can be doubly attached to the sounding point.
3. **Coastlines**
   Coastlines are defined as line data with S-57 objects â€˜COALNEâ€™ or â€˜SLCONSâ€™. Natural coastlines (COALNE) and artificial coastlines (SLCONS: shoreline construction) are distinguished in S-57. An S-57 attribute â€˜CATCOAâ€™ (Category of coastline) is attached under COALNE in ID numbers corresponding to various categories of natural coastlines. S-57 attributes do not exactly correspond to the symbols designed for conventional smooth sheets: for example, gravel, rocks, boulders and cliffs were expressed by the same symbol. An S-57 attribute â€˜CATSLCâ€™ (Category of shoreline construction) is attached under SLCONS in ID numbers corresponding to various categories of artificial coastlines. Black solid lines uniformly express all artificial coastlines, without distinguishing categories.
4. **Depth contours and low water lines**
   Depth contours are defined as line data with an S-57 object â€˜DEPCNTâ€™. An S-57 attribute â€˜VALDCOâ€™ (Value of depth contour) is attached under DEPCNT. Low water lines are treated as depth contours with DEPCNT.VALDCO=0, while depth contours and low water lines were distinguished in conventional smooth sheets. In addition, S-57 does not distinguish categories of low water lines, while in conventional smooth sheets they were categorised and expressed by browned symbols of coastlines. In order to realise a similar view to the conventional smooth sheets, CATCOA is attached under DEPCNT for categorising of lower water lines, as is an irregular use in S-57. This attribute (DEPCNT.CATCOA) is ignored when transferred to ENC database.

Conclusions

It took less than two years after 1996, when GIS software (TNTmips) was first introduced at JHOD, for submission of hydrographic survey results to entirely shift to digital smooth sheets. Along with the spread of GIS in hydrographic surveys, its application has been expanding to other purposes than the compilation of digital smooth sheets, e.g. survey planning, compilation of other reference maps and so on. Such endeavours on the part of hydrographic surveyors in JHOD have increased their knowledge and skills regarding ENC, GIS and computerised data mapping.