CHS & HPD
The New Hydrographic Production Environment

By
Lynn Patterson
CHS – Integrated Science Data Management

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Abstract

The Canadian Hydrographic Service (CHS) began investigating alternative production environments in recent years in order to continue to produce quality products and to produce them in greater numbers with fewer resources. We needed to find another way of doing our business in order to continually provide the mariner and our expanded client base with up to date products.

5 years ago we began to investigate the potential of the Hydrographic Production Database, which offered many potential benefits such as the ability to produce more products with fewer resources and with less duplication of work.

CHS has been migrating their production environments towards this next generation of hydrographic software for the production of Electronic Navigational Charts (ENCs) and Paper products for the last 1-2 years. In the near future, CHS will look at migrating other CHS products and potentially the creation of new product lines as well in this environment.

This presentation will detail to the viewer, the CHS production environment before HPD, since HPD, and the future.

Before HPD

The Canadian Hydrographic Service (CHS) maintains a large portfolio of marine based products, ranging from Tides tables to navigational products such as paper and electronic charts.

Before the introduction of our current production environment, Hydrographic Production Database (HPD), the production of our navigational chart products was accomplished using the CARIS suite of products. These tools were used to complete every task, from the preparation of the data returned from survey to the actual creation of our paper and electronic charts.

CHS currently produces 982 paper charts and 673 ENCs, covering all major shipping routes as well all the major navigable water in Canada (Figure 1). On introduction of the first ENCs, CHS decided to use existing paper charts as the starting point, hence CHS ENCs cells are based upon paper charts. Where an ENC cell could be, the main body of the paper chart, an insert or any compartment of a paper chart.

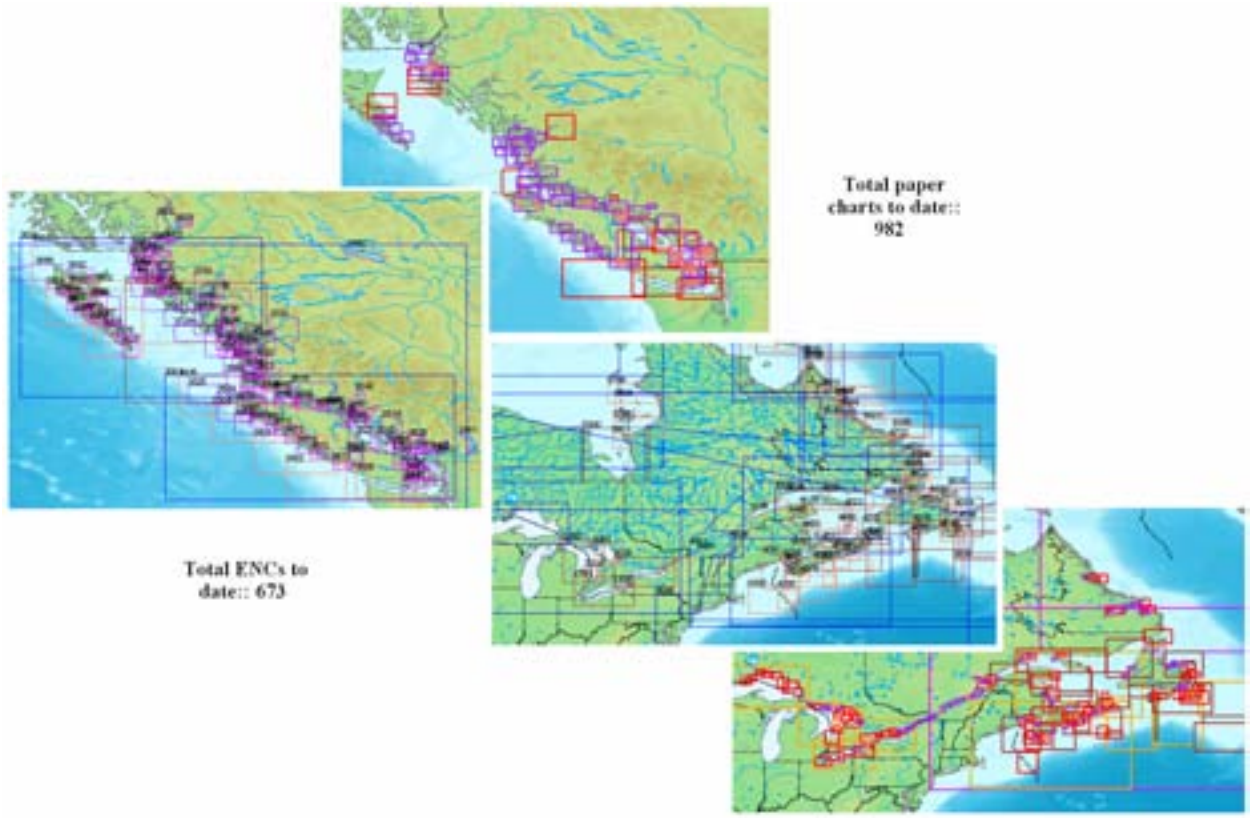

Figure 1: CHS Products

Pre HPD Work Flow

When CHS wanted to add a new ENC to our portfolio of products, the following steps were followed:

- Regional paper chart section would update the latest version of the paper chart file with any outstanding source documents.
- The final version of that file was then given to the ENC section for the population of the S-57 object information.

Due to the length of the process, new NTMs are incorporated before the release of the ENC.

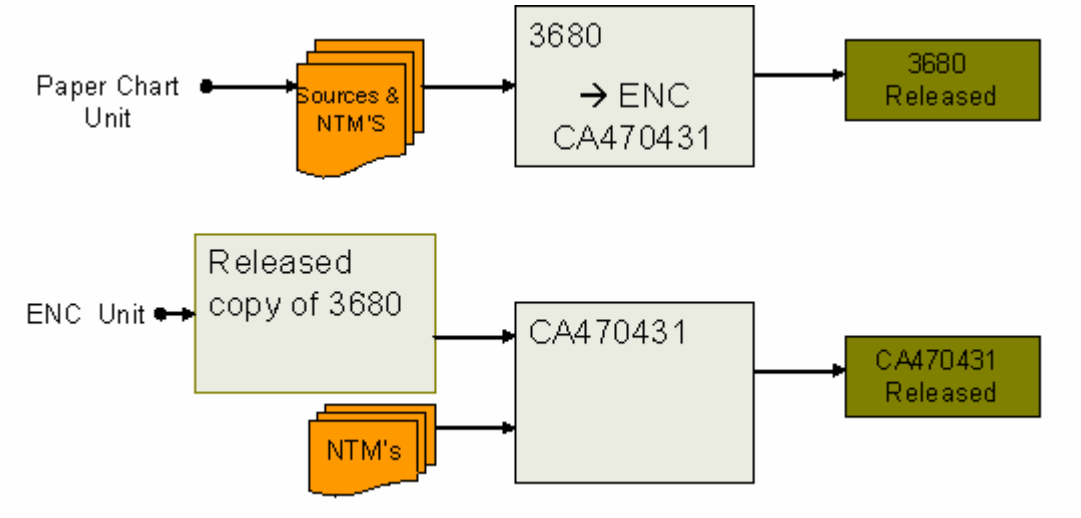

Figure 2: Workflow New Edition

For regular maintenance of ENC and paper products, the process differs from region to region. Some regions maintained separate production streams with separate sets of files used to generate the different products (Figure 3).

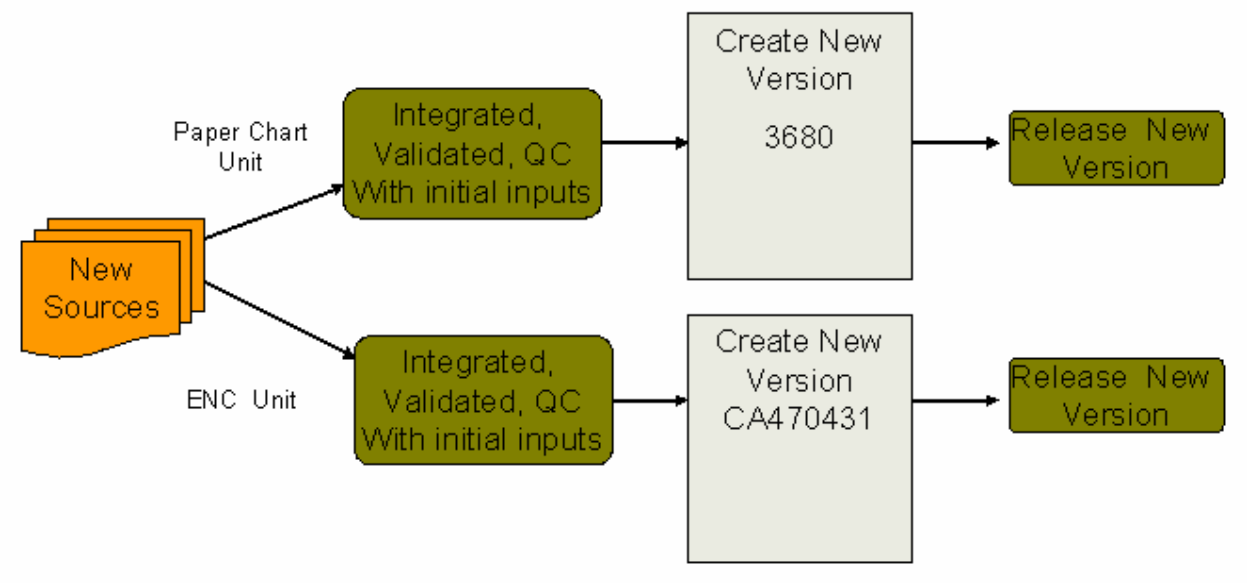

Figure 3: workflow Maintenance

While other regions managed to use a common set of files to produce both the ENC and paper products, simply passing the same set of files from section to section as the work required.

The main issue with the common file system is the link that connects the spatial information to the object information is very fragile. There are several commands that are used in normal paper chart maintenance, but if these commands were used in cases where one file supports both products, they would destroy the linkage between the spatial information and the objects. This would necessitate the recreation of all the object information.

CHS creates an annual production plan for the year's work and each product in that plan is assigned to different staff members for completion. Individual products are compiled independently from each other. For each chart on the production plan, all sources are gathered, integrated together, validated and compiled into a new edition of a chart.

If the newly compiled chart contains an area of overlap with one or more other charts, the data in the overlap is then cut and copied to every other chart that resides in that area when they appear in the production plan. At that time the overlap data can be integrated with the rest of the sources for the other chart(s) along with any new sources that may have arrived in the overlap area since the overlap data was compiled initially.

When it comes time for another new edition, the process starts over again.

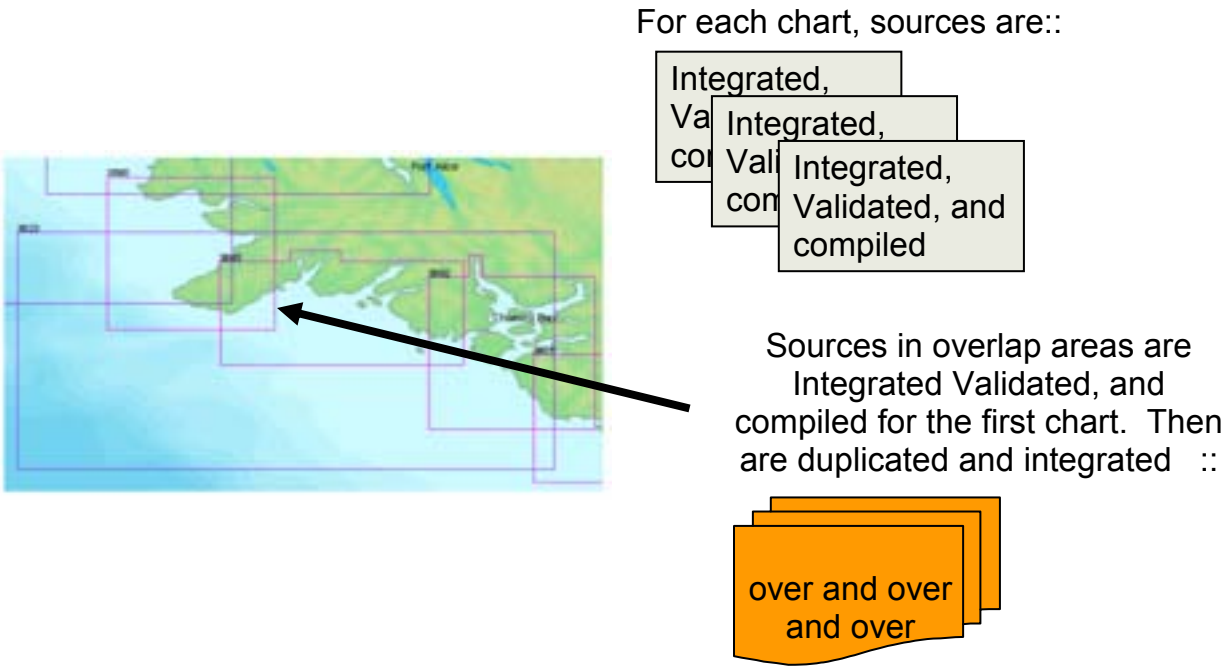

Figure 4: Workflow Overlap Areas

What Needed To Be Addressed

CHS is constantly being asked to provide updated products faster and to provide more new products than ever before. Yet, in the last 15 years CHS' workforce has reduced in numbers from approximately 600 people to 300, but during that same time frame CHS went from producing 978 Paper Charts to producing 982 Paper Charts plus 673 ENC products. We can no longer afford to have our resources duplicating work for different products or product types. We must implement a single national production process.

Specifically we wanted to address the following items:

- Handle a new source only once.
- Increase accountability, recorded with the data.
- Multiple people working in the same area at the same time.
- We want to be able to work on the Paper chart and the ENC at the same time.
- We need to manage the data better. Files are copied to the working folders of different users depending on who is working on the file at any given time, this leads to confusion as to who has the most up to date version.
- We need a simpler process that will allow us to produce more products more efficiently.

° New HPD Environment

In our new environment, a single database stores all the data used to produce ENC and Paper products. It stores all the polygon data, all the line data, all the point data and product level bathymetry. (Excluding the massive stores of raw bathymetry).

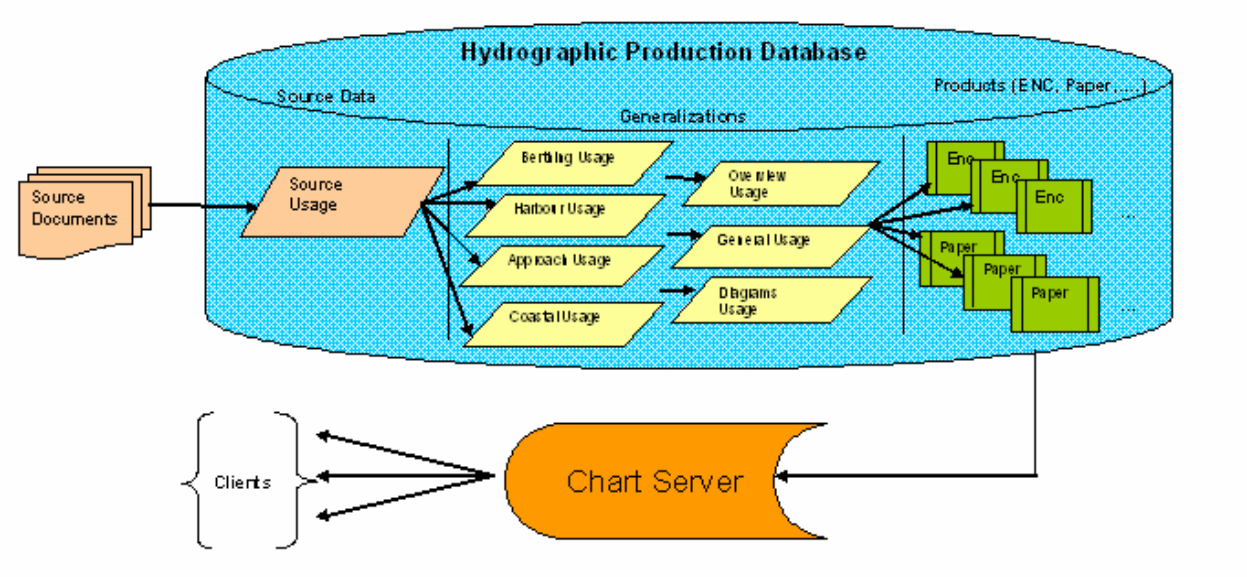

Figure 5: CHS' HPD Environment

Our database is divided into 3 sections:

- The Source Data - where we integrate all our sources into a single validated layer, from which all other data is generated.
- The Generalizations - where we generalize the spatial portion of every source object for each of the various scale bands where products currently exist. (CHS uses the same scale bands as defined by CHS ENC products)
- The Products section - where the data is stored for the various defined products.

Our finished products are exported from the database into the proper file formats and then delivered to out clients via our Chart Server system.

Model

This model allows for increased efficiency. Each feature is created, generalized, verified and incorporated into one or more products. The feature is thus stored once in a common format and used many times.
This model works because the same object that is created in the source usage, that has been generalized to one or more scaled usages and that has been used in one or more products, is the same object.

Each object is defined with a single set of feature attributes and with one to many spatial representations of the geometry (Figure 6). The geometry can be anything from something as simple as a point or as complicated as a complex polygon. Every product records which generalized version of the object's geometry is used in the product.

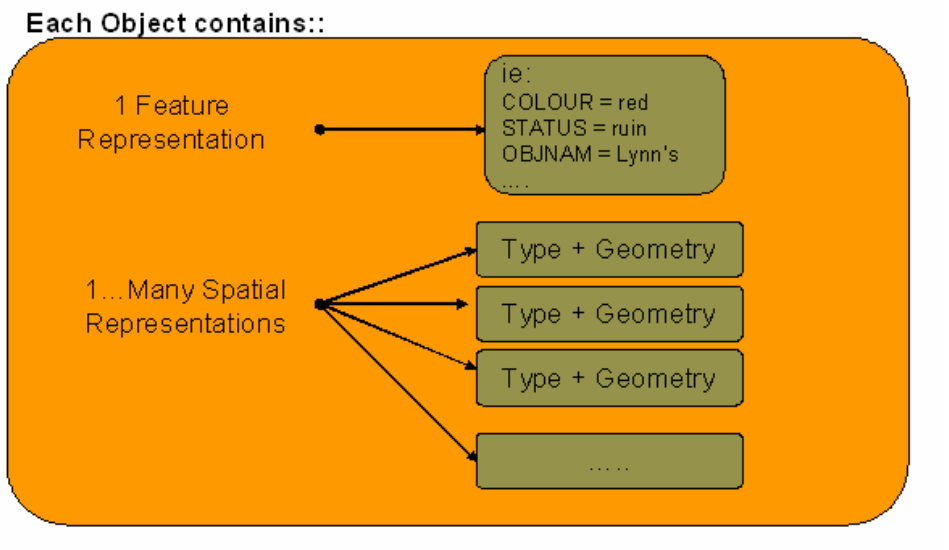

Figure 6: HPD Object Model

Figure 7 is a simplified example of a feature that has been integrated in the source and then generalized for the different scaled product usages.

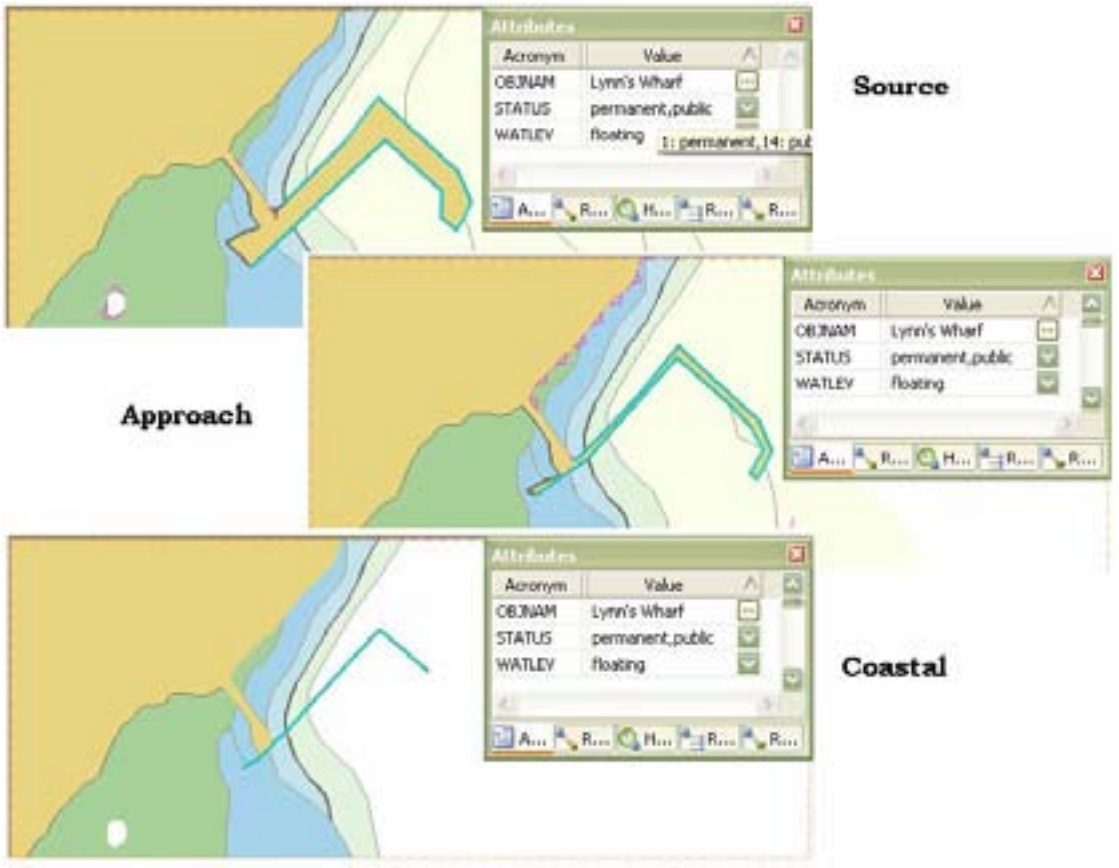

Figure 7: HPD Example

Model Benefits

This model offers several benefits:

- There is no longer a risk of different users updating the same information differently in different products. A single user updates the object once and all products apply the same change.
- Any geometry change to an object's spatial information can be applied to the next generalized version easily.
- Because you are dealing with a single object, all representations are completely linked from source to generalizations to products. This allows the system to be able to automatically apply simple changes without having to redo the work in every product, the HPD system provides you with other functionality to facilitate the generalization of more complex geometries.

HPD Benefits

This new environment is seamless. We are no longer limited by the boundaries of our chart products. This will allow for future product generation that is not confined to the limits of existing products.

Because the HPD is a database and databases use row level locking we can now have multiple people working in the same area on different sources at the same time. They just can't edit the same feature at the same time.

Our products will have consistent attribution for the same features that appear in products of differing scales.

Features are stored once, and used in multiple products.

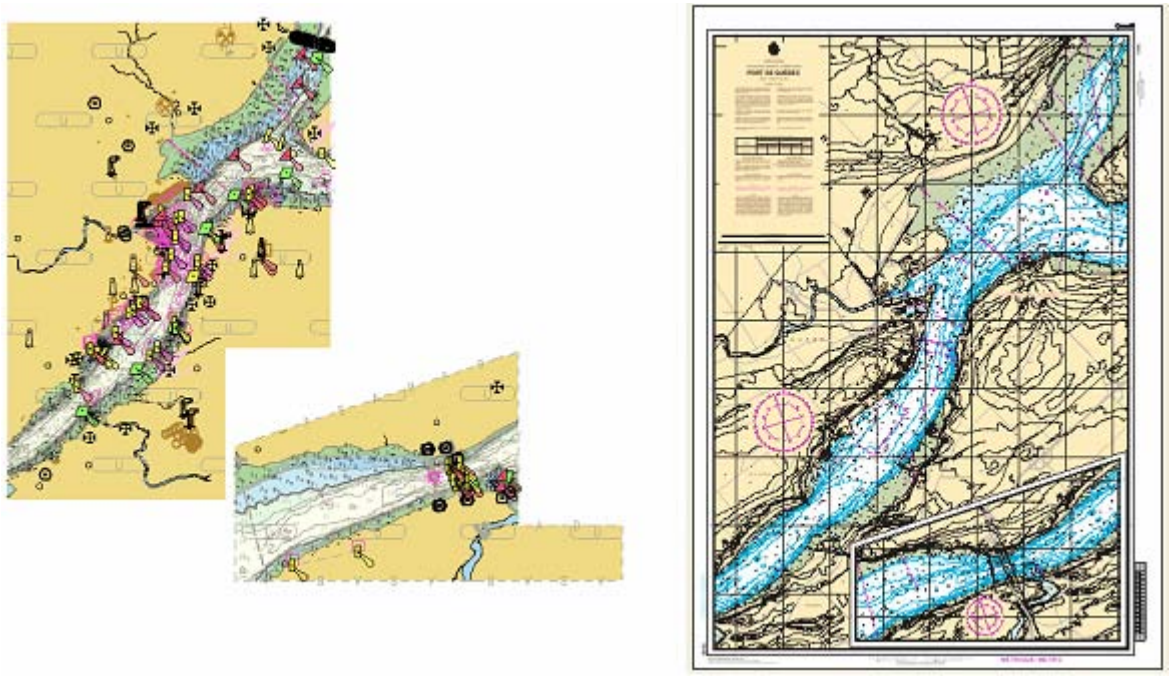

Figure 8: Multiple Products from Same Data (2 ENCs & 1 Paper Chart)

The HPD environment makes use of a dictionary that completely describes the set of objects and attributes used in our production. It further makes use of product profiles that specify which objects use which attributes to define a product type. This data model is flexible enough to support many different nautical product types such as ENC, AML, Paper Charts, and as many others as we would require.

This environment provides us with built in functionality to record the history of changes to every object, product or project created in the system. If necessary we can view historical versions of any specific object or of a set of objects at a specific point in time.

Data certification is built into this environment as well. We can now record who certified or rejected what objects and when. This data certification is further broken down so that you can have multiple sign-offs in the system.

The history in combination with the built in certification tools now gives us the capability of knowing exactly who did what and when for every task, from object creation, to modifications, to certification.

Due to the data model, we now know which products use which objects and can easily check to see which products may be affected by changes to the source. Those changes, once integrated at the source level, can easily be applied to the products once the changes have passed data certification.

HPD Work Flow

With the HPD environment, there is a single workflow for both maintenance and product generation. (as detailed in Figure 9).

- Integrate new sources as they arrive.
- Complete the validation and quality control.
- Generalize the spatial information to the required scaled usages.
- Bring forward the changes in the source to the Paper product, generating a new version as necessary.
- Bring forward the changes in the source to the ENC product, generating a new version as necessary.

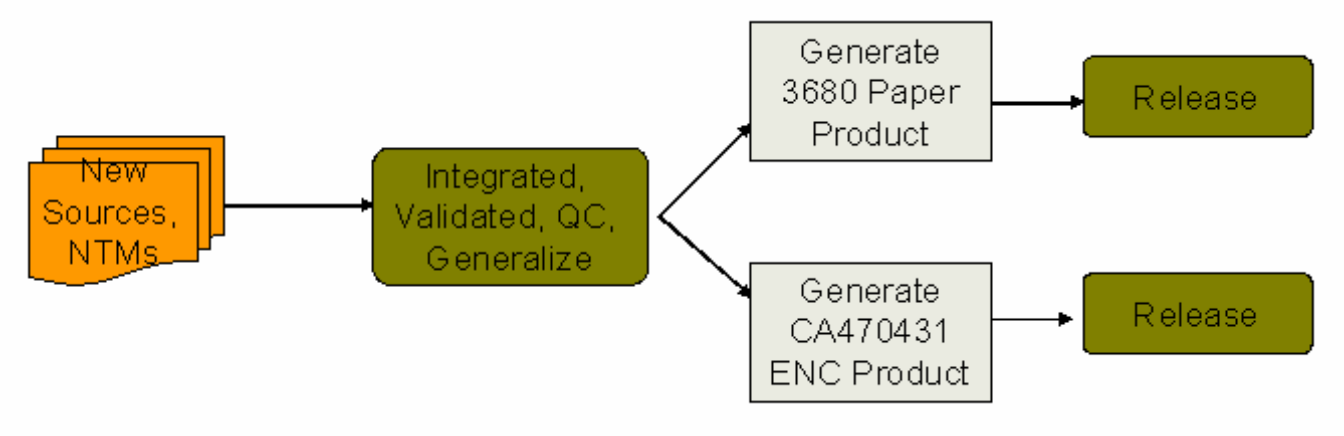

Figure 9: HPD Workflow

Tools

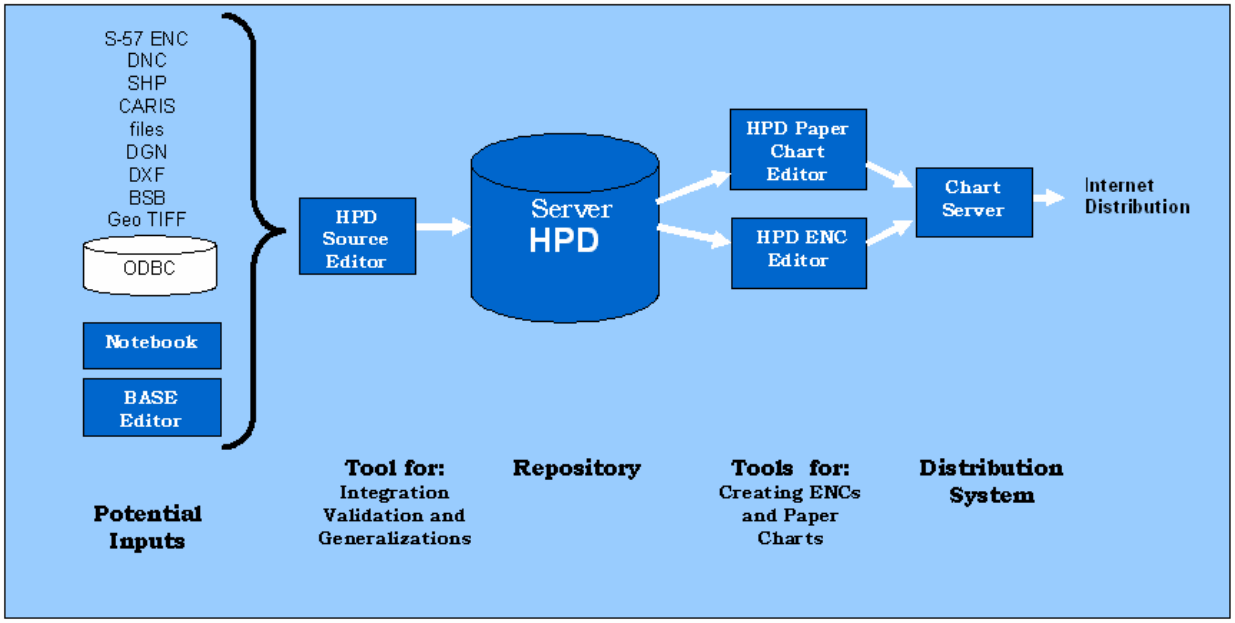

Figure 10: Tools

CHS uses the tools as described in Figure 10 to transform hydrographic data into hydrographic products. The tools described here are only those that interact directly with our HPD environment.

We use data from a variety of sources such as: CARIS GIS files, DGN, DXF, or even data directly from other databases through ODBC (Oracle DataBase Connections) connections; output from other programs such as CARIS Notebook, and BASE Editor; and existing product files such as ENCs and DNCs. All of these inputs can be integrated into our HPD database, validated, verified, and generalized as necessary using the HPD Source Editor tool.

After the data has been certified it is then ready for use in our products. Currently we use the HPD ENC Editor to produce ENCs and the HPD Paper Chart Editor to product paper products.

Once the products have been completed we submit those to our Chart Server for distribution to our clients.

Not included in the above diagram is the connection to our meta database called CHSDIR. This database contains all the meta information about the sources used in our products as well as the product specifications for all of CHS' charting products. CHS has fully integrated and

automated the connections between our meta database and our production HPD databases. Users who record the creation of source records or product specification records in the meta database can trigger the passing of data to our production HPD environments. This automation generates the required projects for source documents and products as well as product definitions in the HPD environment and eliminates the need to renter data into both databases.

CHS Organization

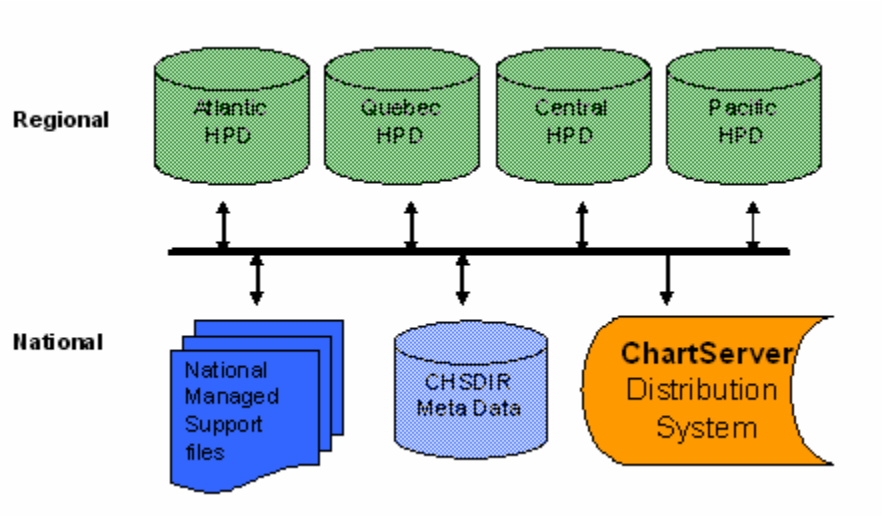

Figure 11: CHS Data Organization

CHS has 5 offices across Canada. Ottawa is the head office (HQ) for CHS. The section "National Application Support" provides a national support function to all the other regional offices. Any common support files for the HPD environment are modified and maintained from there, and all nationally agreed to customizations are implemented and released from this office in conjunction with new versions of the HPD software. The national meta database "CHSDIR" is maintained at the HQ office as well, however regional personnel input their own data into this system.

CHS currently has 4 regional production offices, located in Dartmouth Nova Scotia, Mont Joli Quebec, Burlington Ontario, and Sidney British Columbia. It is from these offices all ENC and Paper Chart production is completed.

Each regional office has a production HPD environment in which they store and create regional data and products.

When a region has completed a new version of an ENC product, automated procedures transfers the generated product files to HQ for distribution via the Chart Server to our clients. Finished Paper products are transferred to our "Print On Demand" section for normal paper chart distribution from our own chart sales office.

Implementation

Implementation Steps

1. In 2003 HQ became aware of the new product being developed at CARIS called HPD – Hydrographic Production Database. After initial investigation, it seemed that this piece of software could resolve some of the production issues that CHS had been facing. We started looking at and testing some of the preliminary versions to determine if the software could fit into a CHS production environment.

2. Late in 2003/ early in 2004 we visited each regional office to introduce this new software to them, and detailed the potential benefits that this system could offer CHS. After each presentation a demo was provided to a smaller group of ENC and Paper chart producers.

3. We use these demos to gain extensive feedback on the software, what users liked, what they didn't like, and what they wanted to see in the software. All of this information was then relayed to CARIS for consideration and incorporation into future versions of the software.

4. During the initial introduction to the regions, we discovered great interest by all regions in participating in a pilot project. This pilot was to further assess how the software would perform in a production type environment. We divided our large pilot into 4 smaller more manageable pieces and each region completed the work for one of these smaller pilots which allowed us to completely test the software in every aspect of CHS production in a much shorter time frame.
    a. One region created an ENC.
    b. One region created a Paper product.
    c. One region integrated various sources.
    d. And one region generated an ENC update.

5. Once all the pilots had been completed we had a much better idea of what the software would require to work in a true production environment as well as how CHS could customize the software to better reflect our environment. CHS made the following customizations to the standard CARIS HPD installation::
    a. ENCs are produced using the S-57 standard, along with the ENC product specification dictates the allowable objects and attributes in an ENC. CHS uses a subset of that standard for our product specification. The HPD environment allows us to create a dictionary and product profiles that match CHS' ENC product specification.
    b. The Paper Chart Presentation library files were updated to reflect CHS' Paper Chart presentation rules.
    c. CHS created a Border control file that reflected the borders in use on Canadian charts.
    d. Due to procedural issues, CHS decided to add some user defined objects and attributes to implement some of our procedures. As an example we added the

attribute “proscl” to sounding objects, in order to record the scale that bathymetry was created for in areas where we have overlapping paper chart cells at different scales. By populating this attribute we can easily select the sounding objects for the appropriate Paper Chart cell.

e. We also implemented control files for each of the product profiles and minimum scale display rules for ENCs

6. The next step was to develop a single set of national production procedures for use with these new tools. A first draft was created by HQ using all the regions ISO production procedures. That was then circulated to all the regions for comment. We then brought ENC and Paper Chart representatives from each region to HQ for a meeting to finalize these procedures. Since that time this set of procedures has been converted into a set of official ISO procedures that all regions use for the production of ENCs and Paper charts.

7. Production with the HPD environment started in 2005, with each region starting in a small area in their region.
   a. Central decided to start with all new production in Lake Ontario, integrating all new sources in the HPD as they arrived.
   b. Atlantic concentrated their efforts on the Bedford Basin and Halifax Harbour area.
   c. Quebec devoted production of 1/3 of the St. Lawrence River to the HPD environment.
   d. Pacific started working in the HPD environment in the Prince Rupert area.

   The idea was to start small and move production over to the HPD environment one area at a time, moving both ENC and Paper production at the same time for those areas.

In June of 2006, the first paper chart completely generated in the HPD environment was publicly released at the CHC (Canadian Hydrographic Conference) conference of 2006

CHC 2006 - the official release of the first Paper Chart from the HPD

Canada, Chile and Mexico Join to Announce Publication of First Chart from HPD

Fredericton, NB, Canada — June 26, 2006 — Canada, Chile and Mexico joined together during the 2006 Canadian Hydrographic Conference (CHC 2006) held in Halifax, Nova Scotia on June 8, 2006 to announce the release by each of these three countries of their first paper chart produced using CARIS Hydrographic Production Database (HPD).

The CHC 2006 HPD Paper Chart announcement presided by (from left): LCDR Rafael Ponce, Mexican Navy Hydrographic Office; LCDR Juan Gomez, Chilean Navy Hydrographic and Oceanographic Service, Dr. Salem Morcy, CARIS President & CEO; Dr. Soni Narapanan, Dominion Hydrographer, Canadian Hydrographic Service; CPT Fernando Angli Rodriguez, Director of Hydrography, Mexican Navy; and LT Boris Arguedilla, Chilean Navy Hydrographic and Oceanographic Service.

This announcement commemorates the successful transformation of these hydrographic organizations to a fully integrated hydrographic data management and production environment.

HPD provides a higher degree of consistency between product types (e.g. ENC and Paper Chart) because all products are derived from a common source. It also removes duplication of work and lowers maintenance costs relative to previously separate production lines. Updates can be done once on the source data and included into the appropriate products. Status of updates can be tracked from source to product and the history of changes recorded allowing better management of liabilities. New products which share some or all of the common data can be introduced (e.g. Additional Military Layers (AML)). Work can be planned and managed in a common multi-user environment allowing the agency to overcome the limitations of a file-based or segregated approach.

This announcement is significant and indicates the success of this revolutionary concept which will help modernize the hydrographic offices' operations.

Figure 12: Press Release

Two years later CHS is in full production mode. (see Table 1 for production stats as of March 2008) Currently we have 21 released ENC with 12 updates, and 50 more listed as "under construction" in the system. We also have 12 released Paper Charts and 10 more being worked on.

Table 1: Current Production Stats

Region	*# ENCs Released*	*# ENC Updates*	*# Paper Released*	*#Sources Registered*	*# ENCs Under Construction*	*# Paper Under Construction*
Atlantic	**4**	**2**		**2**	**10**	**2**
Quebec	**11**	**10**	**10**	**205**	**34**	**1**
Central	**5**		**1**	**102**	**3**	**6**
Pacific	**1**	**1**	**1**	**70**	**3**	**1**

Currently each region has expanded production in the HPD environment.

- Central has begun loading all new digital sources into their HPD environment.
- Quebec has moved production for a second 1/3 of the Lawrence River to their HPD environment.
- Pacific has now devoted a unit entirely only to HPD production.
- Atlantic has begun loading all new sources into their HPD environment.

Performance Measurements

For the first chart area compiled in the HPD environment (ch1316 - Port of Quebec), Quebec recorded a 48% reduction in the time required to produce a new edition paper chart, and a 66% reduction in the time to produce the corresponding ENCs.

Comparing the time required to complete maintenance is more difficult. If one simply looks at the time required to completely integrate a new source in an ENC and the corresponding Paper product, it appears to take as much time as it did in the past. But when maintenance has been completed in the HPD, you've completed the maintenance for every product that overlaps the area at all scales, not just for a single ENC and Paper product. One must also take into consideration that with a constantly maintained HPD there is no effort required to produce a new edition of a product, the data is maintained as new sources arrive, simply releasing a new edition when sufficient changes to the products warrant a new edition.

As these were the first products released from the HPD environment, these numbers can only be used as an estimate in potential time savings. We have had issues that would adversely affect these numbers, but with use comes experience and it is felt that these numbers overall will only improve with time.

Transition

CHS' transition to this new environment has not been without stumbling blocks. Since production began we have had to deal with adversities in our migration. Such as::

- Having to re-teach hydrographers and cartographers how to work with the new environment.
- Having to completely change how people approach production. They have to move away from a product driven production system to a source driven system.
- Having to deal with hardware issues related to using servers that were 3 years past their end of life cycle.
- Having to wait for new features, enhancements or bug fixes.
- Having to continue to work in 2 environments as only part of our production has been moved to the HPD.

Future

Over the next few years CHS is looking at greatly expanding our production within the HPD environment, with all "new" production of ENCs and Paper products being moved to the HPD within 2 years and with "all" production moved to the HPD within a 4 year timeframe.

We are also looking at the development of full RASTER editing capabilities within the HPD environment, the development of S-100 based nautical publications and products, as well as the production of source data based draft Notice to Mariners.

The future with HPD contains many, many possibilities.

Conclusion

There is large learning curve to setting up and using a new HPD environment and the transition to the new environment is not an easy one.

That being said we are experiencing::

- A great reduction in the amount of duplication of work, and the number of times a new source is handled
- An increase in the accountability of the data, the validation and the products generated from the data.
- A 51% reduction in the amount of time required to do the same work in our traditional production environment.
- A more efficient environment with a set of national ISO production procedures.
- All of our product level data can now be managed in a single database environment.

The transition to the new HPD environment has not been painless or easy, but it has definitely been worth the effort.

Biography

Lynn Patterson graduated from Acadia University with a Bachelor of Computer Science in 1992, and has been with the Canadian Hydrographic Service in Ottawa from 1992 until present. She is currently managing the National Application Support section of CHS, and represents Canada at the Transfer Standard Maintenance and Application Development Working Group, as well at the International HPD Users working group.