Implementation of a Hydrographic Product Database Solution for Land Information New Zealand Hydrographic Services: Challenges and Efficiency Gains

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Key words: CARIS, HPD, ENC, Electronic Navigational Charts, LINZ

SUMMARY

The New Zealand Government is obligated to produce Electronic Navigational Charts (ENCs) to meet international carriage requirements. To achieve this, Land Information New Zealand (LINZ) Hydrographic Services has implemented a CARIS Hydrographic Production Database (HPD) solution. As well as enabling the creation of ENCs, this system allows the creation of paper charts from the same single source vector database.

This one-source, multiple-product model provides a full software suite for the creation of products in-house. This will lead to efficiency gains and will replace the legacy raster-based system.

The implementation of the new system was a major task for a small hydrographic office. Careful testing and planning was required prior to going live with the production environment. As bugs and other issues arise, vendor support is critical in ensuring that timeframes are not compromised.

Implementation is ongoing, and there are a number of future challenges. Raster-based paper charts will be phased out on a chart-by-chart basis and Notices to Mariners will then be integrated into this new paper chart production process. There will also be ongoing requirements to modify paper chart and ENC schemas. As well as these technical challenges, the introduction of these new processes and carrying out additional work in-house will require additional human resources and training.

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1. BACKGROUND

1.1 Electronic Navigation Charts (ENCs)

Land Information New Zealand (LINZ) is the National Hydrographic Office in New Zealand (NZ). It is this government agency's responsibility for the publication of official NZ charts.

Digital charts are available in various formats from both official and private parties. While official charts can be used for navigation, charts produced by private parties do not meet carriage requirements.

The digital chart in raster format is one way to display electronic navigation chart information on-screen for mariners. However, the presentation and the type of information which can be displayed via raster are relatively restrictive when compared to that of vector-based navigation charts. Electronic Navigational Charts (ENCs) are vector-based navigational charts which follow an international standard (IHO 2000). It is the National Hydrographic Office's responsibility to publish and maintain these.

ENCs are used on ships with Electronic Chart Display and Information Systems (ECDIS). These systems combine ENCs with other data, such as from Global Positioning Systems (GPS), Automatic Identification System (AIS), radar and the ship's speed log. Users can then tailor their chart display, interrogate certain objects for more information and set safety and alarm depths to aid safe navigation.

ENCs are becoming mandatory on various classes of shipping internationally, beginning with high-speed craft, and, from 2012, international trading vessels that carry large numbers of passengers (IHO 2010).

1.2 Hydrographic Data Infrastructure (HDI) Project

In 2006, due to the impending mandatory requirements for carriage of ENCs, LINZ began a project to identify the current and future requirements of the hydrographic infrastructure.

Existing infrastructure used to support the capture, access, management, maintenance and distribution of hydrographic information was identified as being inadequate to meet future requirements.

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The aim of the project was to ensure that LINZ continues to meet its commitments as a national hydrographic authority, delivering products more efficiently and meeting increasing expectations through the use of modern technology. Also, to deliver the capability for LINZ to respond to increases in the volume of survey data being produced by multi-beam echo sounder systems (MBES).

The International Maritime Organization (IMO) is regulating the mandatory use of ECDIS on Safety of Life at Sea (SOLAS) class vessels. The IMO has specifically requested that member governments encourage their National Hydrographic Offices to produce ENCs as soon as possible. In July 2008, mandatory carriage requirements for ECDIS came into place for all new high speed craft. From 2012, it will also become mandatory for international trading vessels that carry large numbers of passengers. Once the carriage requirements for ECDIS become mandatory it will require the supply and updating of authoritative electronic charts in S-57 format by LINZ (IHO 2010).

The timing of this project has positioned LINZ to take advantage of the second-generation software tools coming onto the market. These provide a more integrated and rounded toolset than the earlier generation of data management tools available to the hydrographic community.

Current trends are moving from 'product-centric' to 'source-centric' processes; i.e. first validate and authorise the underlying source data; then various products flow from the authorised data. The data is validated once and used many times.

1.2.1   Existing Product Infrastructure

LINZ hydrographic infrastructure from 1996:
— Chart programme management (1996)
— Survey programme management (1996)
— Nautical publications, e.g. NZ Nautical Almanac (1999)
— Notices to Mariners templates and files for the production of the official New Zealand Notices to Mariners booklet (2005)
— Tide station and tide data for the production of official tide predictions for New Zealand (2005)
— Raster Maintenance System (RMS) for the maintenance of the official New Zealand chart folio (2006)
— Creation and update of New Zealand's official raster chart product NZ Mariner (2006)

1.2.2   Request For Proposals & Evaluation of Tenders

In 2006 a review of the LINZ requirements of a hydrographic infrastructure was begun. This review looked at:
— Scope, rationale and approach

— Constraints (relevant standards, specifications, government guidelines, internal procedures)
— Functional requirements (data capture, data quality control / quality assurance, maintenance and retrieval of metadata, data management, data access and publication)
— Non-functional requirements (look and feel, usability, performance, operational, maintenance and support, security, cultural and political, legal)
— Data conversion requirements (projections, datums, existing metadata, GeoTIFF creation and storage)

Based on the above user requirements, a Request For Proposals was issued for software providers to tender a proposed solution.

In December 2006, CARIS was awarded the contract to provide LINZ with a core database system – CARIS Hydrographic Production Database (HPD). As part of the contract CARIS was to provide LINZ with a solution for the management of: the list of lights, an online chart catalogue, a GIS / database approach to ENC and chart production and a system to manage Notices to Mariners.

This paper will focus on the infrastructure and responsibilities for producing paper charts and ENCs and the selection of CARIS HPD solution for the creation and management of these.

2. LINZ IMPLEMENTATION OF CARIS HPD

2.1 Timeline of Events (Actual)

Oct 2006 – Request for Proposals issued
Dec 2006 – CARIS awarded contract to provide LINZ with the HDI system
Aug 2007 – HPD System Admin training
          – HPD Source Editor training
Oct 2007 – HPD ENC Editor training
Nov 2007 – HPD Paper Chart training
          – User Acceptance Testing
Feb 2008 – CARIS assistance in database setup and preparation
Mar 2008 – Conditional acceptance of HPD v2.6
Apr 2008 – Priority areas for the first release of ENCs identified
          – Further CARIS assistance resolving HPD implementation issues, review of proposed setup
May 2008 – Production processes for implementation tested in development environment for the first release of ENCs with two run-throughs
Jun 2008 – Production environment in a go-live state
          – Database schema setup begins with appropriate users, usages, and custom attributes added
          – Data loading into the production environment begins for the first priority area

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Aug 2008   – Conditional acceptance of HPD v2.7
Nov 2008   – Release of first official ENCs from HPD
May 2009   – HPD Paper Chart Editor refresher training
Jun 2009   – Final acceptance of HPD
Oct 2009   – Release of first official paper chart from HPD

2.2 CARIS HPD Overview

CARIS HPD provides LINZ with an integrated application suite and database approach to source data and product management.

The HPD data model is hosted on an Oracle Spatial database which allows:
— Storage of complex spatial and attribute data in a seamless database
— Simultaneous data access and processing by multiple users
— Ability to track changes between source data and multiple products

The model supports real-world objects defined by a combination of descriptive and spatial characteristics based on the IHO S-57 data structure (IHO 2000).

The HPD application suite includes the following:
— HPD Server - Creates and maintains the data model in the Oracle database.
— HPD Source Editor - Creates and maintains the source data.
— HPD S-57 ENC Editor - Creates Electronic Navigational Charts (ENC) including updates, reissues and new editions to S-57 3.1 specifications (IHO 2000).
— HPD Paper Chart Editor - Creates paper charts to IHO INT1 and INT2 specifications (IHO 2007a, 2007b).

LINZ has purchased licensing for HPD Server, Source Editor, S-57 ENC Editor, and Paper Chart Editor.

The HPD Editor applications allow the display in various projections of a number of raster and vector formats, plus the selection and import of data from external files in a number of vector formats.

A key feature of HPD is the ability to store features only once, and create multiple representations for different products. This is achieved by storing data on different layers in the HPD database called 'usages'. A 'usage' is a layer within the database that is used to store hydrographic objects that are appropriate for a particular purpose. In most cases, this refers to an appropriate range of scales over which the objects can be viewed and used in products. This allows the creation and update of multiple kinds of products from a single source, with generalized representations of source objects based on scale ranges.

Source data can be loaded from an external file in vector format. This is stored in the database and from this data both paper chart and ENC products can be created. There is no need to

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digitize or load source data twice. Although there are some product specific features that are added as part of product creation, the underlying source features are essentially the same, differing only in the way they are symbolized. In the past, different software packages were used to create different products and with no direct connection between the source data, the product data needed to be managed separately.

The HPD data model makes the update of source data and products more efficient. For example, the update of source data in the database for Notices to Mariners can immediately be applied to ENC and paper chart products by a function 'compare product to source'. The user can apply the changes to the source directly and automatically update the product.

HPD Paper Chart editor uses the S-57 based vector data stored in the database, customized symbol libraries and paper chart templates to create a paper chart product based on the vector data. This differs from the existing CARIS Raster Maintenance System (RMS) in which paper charts are stored as high resolution colour-separated TIFF images on a file server.

2.3 Existing S-57 Datasets

To begin ENC and paper chart production from HPD, S-57 (IHO 2000) data has to be either created interactively via the HPD application, or loaded directly from external datasets into the database. Royal New Zealand Navy (RNZN) ENCs were initially used to populate the LINZ database. In order for LINZ to use this data for official purposes, each ENC was first validated and any rework completed. Since then, external providers have been contracted to provide new S-57 datasets as required (e.g. for new charts and new editions).

Both existing and new S-57 datasets have therefore been used to populate the database. A staged approach has been adopted, areas are selected for official ENC release depending on priority. This means that instead of populating the database with all available datasets, data is loaded on an area by area basis, as per the planned release of official ENCs.

2.4 Training

A key part of the implementation of HPD at LINZ was staff training. All Hydrographic Services staff undertook training in one or more of the CARIS applications. In order for LINZ to undertake User Acceptance Testing, staff needed to be proficient in the use of the applications prior to testing.

Training in all modules was based on-site in a dedicated training room with a training provider from CARIS. One week of training was organized for each application, staggered over several months to prevent too much disruption to staff and their business as usual work.

Training was provided for the following:
— Install and set up of HPD Server and Oracle
— HPD Source Editor

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— HPD ENC Editor
— HPR Paper Chart Editor

As part of the contract to provide CARIS HPD to LINZ, CARIS also provided four separate weeks of on-site assistance which LINZ could use when it would be of greatest benefit. These CARIS 'weeks' were spaced out over the implementation phase, usually at critical stages of the project.

The last CARIS 'week' was dedicated to further Paper Chart Editor training. This was due to the amount of time (over a year) between the initial Paper Chart Editor training and LINZ beginning to use to use the application for production. The week was deemed necessary as a refresher and to resolve remaining issues using Paper Chart Editor in the production environment.

Prior to implementation of HPD, LINZ staff members gained valuable experience with S-57 and ENC encoding through the LINZ / RNZN ENC validation project which proved important in enabling LINZ to begin official ENC production through HPD. The addition to the Hydrographic Services of a new staff member with prior experience working with ENCs and S-57 data also helped considerably.

2.5 User Acceptance Testing

During November 2007, LINZ began formal user acceptance testing of the HPD system. Test plans were created based on the user requirements in the Request For Proposal and tender documents. This involved extensive testing of items in a number of areas including:

— Import of vector and raster data in a number of formats
— Export of data in a number of formats (e.g. vector, raster, ASCII)
— Selection of areas for chart processing
— GIS toolsets
— Production of paper charts
— Production of raster charts
— Production of vector electronic charts (ENCs)
— Presentation of maritime boundaries, coastlines and chart limits
— Workflow management

A number of items were identified during testing which meant formal acceptance could not be made at that stage. The outstanding items were graded on severity and CARIS informed that acceptance was conditional on the resolution of these.

A new release of the software was made which fixed the remaining issues, and together with feedback from CARIS, the system was re-tested in August 2008. A few issues still remained and a conditional acceptance was again made.

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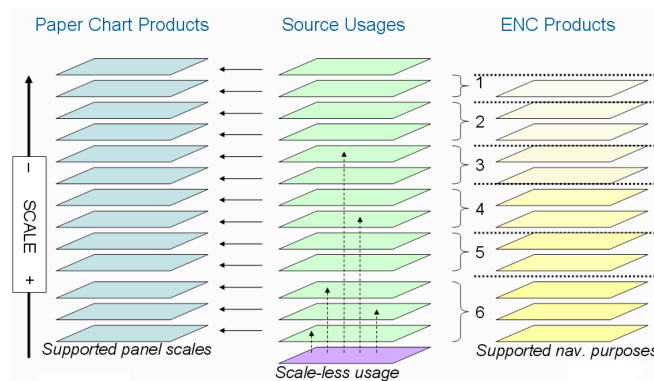Sydney, Australia, 11-16 April 2010

CARIS delivered a further update of the software together with custom scripts enabling LINZ to produce a List of Lights from HPD. This formed the final set of deliverables from CARIS and following successful, formal acceptance was made in June 2009. The system had been successfully delivered as per the user requirements.
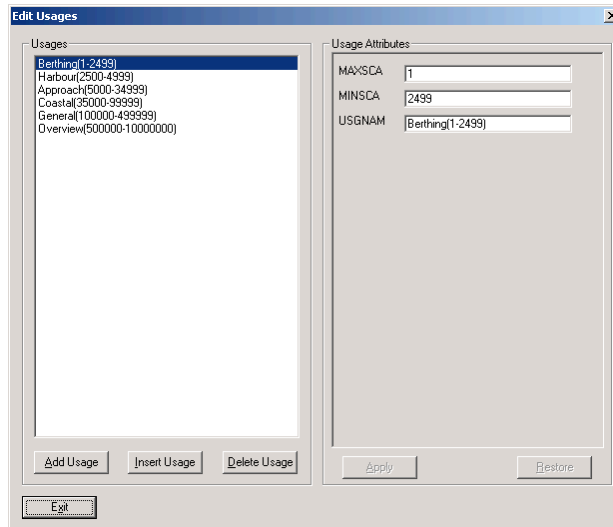
2.6 Database Setup

After the basic install of HPD Server and client applications, there were other setup and customisation requirements. User logins were required for each user needing access to the database and an administration user setup and appropriate roles assigned to all users. There was also a requirement to have LINZ custom attributes added to the S-57 dictionary. These would be used for internal purposes only to help manage data. The custom attributes added were: *llknum*, an attribute against which the light list 'Volume K' number can be recorded; and *sornfo*, which provides an indication of which dataset was used to populate features. Later, additional attributes were added to record an extended set of attribution against survey information.

A fundamental issue to resolve when setting up an HPD database schema, is what HPD usages to define within the database. This issue is related to the purpose of the database and intended product types and scales it will be used to create. CARIS carried out a study of our paper chart series and our intended ENC Navigational Purposes scale ranges (CARIS 2008).
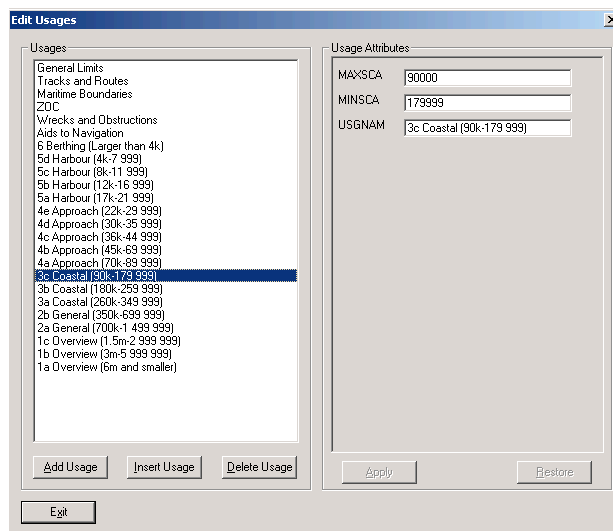
The HPD usages chosen need to support the production of both ENCs and Paper Chart products. The following graphic shows how different HPD usages support the production of both ENCs and Paper Charts from the data on usages based at different scale ranges. It also shows how a 'scale-less' usage can be used to store point features from which smaller scale representations could be derived, a key feature of the HPD system.

The default usages are based on the IHO recommended S-57 ENC Navigation Purposes (IHO 2004, 2007a), with a default set of maximum and minimum scale values:

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The study by CARIS showed that there are over 40 different scales represented on LINZ charts. So in order to support the production of the paper chart series, data must be loaded into the database on different HPD usages so that no overlapping chart panel data is loaded onto the same usage. This meant that there had to be significantly more usages than the six required for ENC production to support the production of the NZ paper chart folio. The number of HPD usages therefore required was determined by the number of charts in the NZ folio.

A number of 'scale-less' usages were also created, including: Aids to Navigation, Wrecks and Obstructions. The 'best scale' versions of point objects for these features are stored on these usages. While not truly scale-less, the HPD system allows representations at different scales to be created from these features. Assigning representations from these usages makes update

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and management of this data easier. For example, instead of updating the same navigation aid a number of times on different scale-based HPD usages, the update can be made once only.

2.7 Production Processes, Documentation, Planning

The development environment was used to create and refine the processes that would eventually be used in the production environment. A requirement prior to beginning work in production was an adequate set of procedures and process documentation. Two pilot stages were used to test, refine and update process documentation. The areas chosen for the pilots would be the first two areas of ENC release: Wellington and Auckland. The pilot stages also validated the way we had set up the database: the HPD usages, and how we would use the custom attributes.

The focus during the initial implementation of HPD was the production of ENCs. It was not until some time later that Paper Chart production from HPD began. Paper Chart process development and documentation therefore occurred much later, but this was also carried out in a development environment for two paper charts: Picton and Onehunga. At this stage, the Paper Chart symbol libraries were further refined to make them more suitable for our national charting preferences.
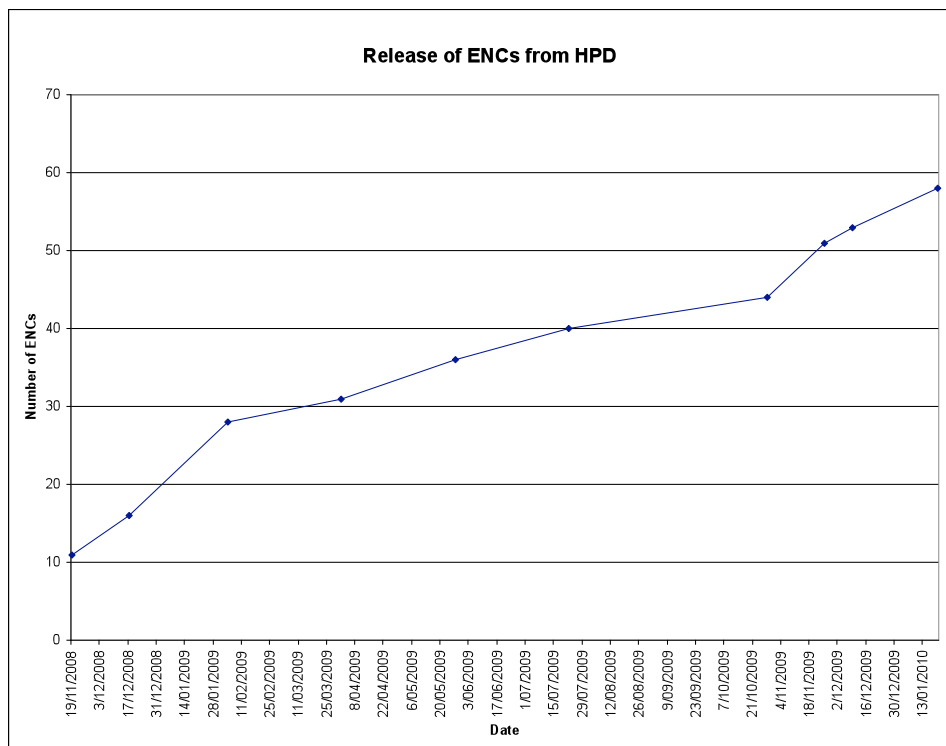
Workflows and documentation were developed for the following areas:

— Preprocessing: This involves preparing the source data prior to loading into HPD. Source S-57 data was used from ENC products. During this stage data is edited and optimized outside of the database as external files. Data cleaning is performed where redundant information is removed, overlapping area issues resolved, redundant vertices deleted, merging of areas and lines, deletion of collection objects and product specific objects removed which are later added by ENC Editor. Text notes which are used to provide additional information to the mariner via the ENC are created at this point then validation checks are run over the dataset to ensure its integrity. The data is then exported as a HOB file prior to loading into the database.

— Data Loading: Scripts are prepared which load the data from the HOB file onto the correct scale-based usage, and scale-less usage if applicable. This process also includes a thorough independent check of the load.

— Optimization: This process is used to remove duplicate 'worst scale versions' of data loaded onto the Aids to Navigation, Wrecks and Obstructions scale-less usages. Features on the scale-based usages are then replaced with representations created from the larger scale representations stored on the scale-less usages.

— Remediation: Any errors picked up during previous checks or Notice to Mariners corrections are fixed. Collection objects are created. Validation checks are again run.

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— ENC Creation and Update: Product-specific features are created in HPD. The S-57 dataset is exported and an ENC exchange set is created. Additional independent checks are made, datasets are run through third-party validation software (ENC Analyzer) and a test load is made into third-party charting software (Endeavour Navigator). The process also covers the update of ENCs for minor corrections and Notices to Mariners changes.

— Paper Chart Creation and Update: This involves the paper chart creation process from HPD, including the addition of the many product-specific features required for paper charts. A comprehensive independent quality control process is carried out using a detailed examination of plotted test sheets. Updates to source data for Notices to Mariners and minor corrections are integrated with the process to update source data for ENCs, this ensures Paper Charts and ENCs contain matching content. Raster charts versions of paper charts are exported from HPD and imported into the legacy Raster Maintenance System (RMS).

3. RELEASE OF ENCS AND PAPER CHARTS FROM HPD

The first ENC to be published from HPD was in November 2008. Since then, ENCs have been released by areas with priority given to areas of significant port activity. There are now (as of 21st January 2010) 52 ENCs published, with an aim of completing adequate coverage of ENCs by the end of 2010.

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Since Paper Chart production is in its early stages, planning for the release of new charts from HPD has only just begun. The prioritization of the release of paper charts from HPD is based on: scale (larger scale charts first), time since last edition, time since last reprint, number of corrections, stock levels and sales. The first chart was released from HPD in November 2009 and is the only chart in our portfolio created from HPD (as of 21st January 2010). It is planned that a further five charts will be completed before the end of June 2010.

Originally it was envisaged that the legacy RMS would be used in tandem with the HPD chart production process. With the paper charts being released in a staged approach, the number of charts maintained in our RMS (180 charts) will reduce over time, eventually being phased out completely. However, CARIS have recently created a new application for HPD which would allow the storage of paper charts within HPD in raster format. The new application has yet to be assessed by LINZ, but if adopted would allow us to manage the raster charts within HPD until they are replaced with paper charts created from vector data within the database.

4. CHALLENGES

Many challenges were faced during the initial implementation of the HPD system and further hurdles remain.

4.1 Human Resources

HPD Paper chart production in particular has only just begun. Until now the staff focus has been on ENC production, and it has also taken considerable time to refine the processes and symbol libraries for paper chart production. Work on paper charts also requires much more staff time than ENC production. This is due to the number of additional product-specific metadata and features that are captured when paper charts are created in HPD including: projection information, graticules, chart title and notes, and the addition of topographic detail. While HPD provides some automation for paper chart production, many aspects are necessary manually intensive due to the nature of paper charts, such as text placement and masking.

The hydrographic team is only small, which has made it difficult to progress production from HPD as quickly as desired. However, there are advantages to having a small team. It makes us more adaptable: we are able to update software quickly, change our processes, specifications and documentation easily when required, and up-skill in new areas relatively quickly.

4.2 HPD Upgrades & Communication

HPD is relatively new software which is undergoing constant development. Because of this, new releases and hotfixes are quite frequent. If the upgrade resolves a major issue, or adds functionality of considerable benefit to the user, there is pressure to apply the upgrade quickly to our system.

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Any upgrades to software at LINZ must go through a rigorous change approval process and undergo testing prior to release on the production environment. EDS* carry out the work on LINZ servers on our behalf. In the past, this lengthy line of communication (CARIS – LINZ Hydrographic Services – LINZ Information Technology – EDS) has caused delays in applying changes. However, LINZ IT and EDS now have a lot of experience with the software and system and have a better understanding of our requirements. Likewise, LINZ Hydrographic Services now better understands the process of change control.

* EDS is an external IT service provider contracted by LINZ.

4.3 Support from CARIS

Late delivery of significant HPD updates has delayed the project. Releases were delivered up to a month later than originally indicated. Due to tight time frames, this caused delays in the acceptance of the software and problems for LINZ rescheduling testing and implementing the updates.

With any new release there is the risk that some bugs are not picked up during testing but later found in the production environment. To handle these, LINZ can raise requests through an online Help Desk system provided by CARIS. This enables LINZ and CARIS to correspond and track outstanding issues. The time zone difference between New Zealand and the CARIS headquarters in Canada mean that responses sometimes cannot be received on the same day for critical problems. Insufficient information or time taken to work through and resolve issues can also cause further delays. Production schedules may be delayed until a fix is available.

4.4 HPD Usages

The LINZ decisions during HPD implementation regarding the definition of HPD usages were based on the requirement to produce our existing paper chart series as ENCs based on the IHO-recommended navigational purpose scale ranges. ENC products created from HPD being based on source data loaded into our database compiled by contractors from existing paper charts. However, it has been found that the scale ranges recommended by the IHO (IHO 2004, 2007a) do not necessarily reflect the type of navigation intended for New Zealand charts.

Using the recommended scale ranges by the IHO, within one navigation purpose we have too many overlapping charts. Since we can only produce one ENC from a given navigation purpose, for a particular area, we are currently maintaining source data which is only required for paper chart production. Further work is intended to review our navigation-purpose scale ranges and therefore our HPD usages and to review our paper chart series to determine if we have too many charts at a given scale range. This is quite a difficult task since chart scales in New Zealand were based around local area schema. Whereas, with a database approach and

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the release of ENCs, a coherent national charting schema is required. Changing the HPD usages would also present a number of challenges in terms of adjusting the HPD system to suit the new schema.

4.5 Source S-57 datasets

S-57 data loaded into the database is sourced from ENC products. With the data loaded into a seamless database, differences in the consistency of encoding between datasets are much more apparent. These are due to the slightly different encoding practices between contractors regarding the interpretive parts of the S-57 standard. LINZ has a contract specification for ENCs which provides guidance for contractors regarding the more interpretive parts of S-57 encoding. Refining this specification has helped with the consistency of encoding by different contractors and reduced the amount of work necessary in preparing the data before loading.

The seamless database has also highlighted the issue of edge matching between abutting S-57 datasets. Contracted S-57 deliverables are based on paper chart equivalents. In paper chart products, the issue of edge matching is not readily apparent, but when abutting S-57 datasets are displayed together these differences between the charts are readily noticeable.

Horizontal consistency issues are also present in the database. This is where features are represented differently (or not at all) between abutting datasets. Likewise, vertical consistency issues exist. This is where inconsistencies are present between the content and encoding between datasets of different scales covering the same area. At this stage these issues are not being remedied, as they are considered a lower priority. However, this will need resolving at some stage to improve the quality of the data in the database.

5. FUTURE

Once a complete folio of ENCs is released by LINZ, the focus on the work carried out with HPD will change: from the loading of data in a staged approach corresponding with a release schedule, to the management of the source data within the database. Data management activities include incorporation of new source data, updates for Notices to Mariners, updates for new charts or new editions, and further work to improve consistency of the data.

Paper charts will continue to be published from HPD albeit at a reduced rate compared to ENCs due to the additional work involved. However, as more charts are published from HPD, the ability to create new charts or editions will be much easier, providing LINZ with efficiency gains.

The legacy RMS system will also be gradually phased out as more paper charts are published from HPD. However, if LINZ decides to purchase the new Raster Chart module for HPD, the legacy system could be retired sooner and remaining raster charts managed in HPD until they are replaced with vector chart equivalents from the system.

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6. CONCLUSION

A lot of knowledge has been gained by staff during the implementation of the HPD and the production of ENCs and paper charts from the system. It has also challenged our traditional view of hydrographic products, with the focus now changing from a product-centric viewpoint to a source-centric one.

Implementation of HPD at LINZ has presented numerous challenges to a small hydrographic office. Among these were the system setup, processes and staff training. Some significant hurdles remain, including building capacity within the team both in terms of staff numbers and training to help us transition from our legacy systems, and increase our productivity.

Already the system has provided considerable benefits to LINZ and the maritime community. A large number of ENCs have already been released and the intention is to complete adequate coverage by the end of 2010. LINZ also anticipates efficiency gains through the use of HPD for paper chart production.

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BIOGRAPHICAL NOTES

Kristian is a member of staff at LINZ Hydrographic Services – New Zealand's Hydrographic Office. In his current role as Nautical Cartographer, Kristian is responsible for the day to day operation of the new CARIS HPD System. He also assists with Notices to Mariners, paper chart and ENC production. His background is in GIS.

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