"Boats, Dolphins and Log Booms" A Management Tool for Water Related Facilities

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Lower GIS implementation costs are giving smaller corporations, previously not able to cost justify a GIS, the opportunity to replace conventional management tools with a Geographic Information System. This case study demonstrates the value and economy of scale of a GIS implementation by dealing with the start-up process and applications of the recently implemented system at the North Fraser Harbour Commission (NFHC). NFHC is a Federal corporation, administered by a Board of Commissioners, having jurisdiction over all water related activities on the North Arm of the Fraser River in the Greater Vancouver Regional District. NFHC extracts the majority of its revenue from lease payments for water lot areas. Therefore NFHC's biggest concern is the accurate mapping of water lots along the river, and associated information. NFHC previously managed these lots with orthophotos, updated every ten years, plus a paper record file. It was cost beneficial to replace these management tools with the more accurate and dynamic GIS digital product.

Beyond the mapping of the river and its elements the Fraser River Estuary Management Program, a Federal/Provincial agency concerned with the environmental balance between the river's natural habitat and the accommodation of a growing population, was interested in a minimum 200 metre river buffer zone for thematic analysis. Data gathering for this buffer zone required cooperation between different agencies and levels of government, utilizing a variety of systems.

The project itself also required vigorous organization between three teams respectively involved in the surveying, photogrammetry, and data conversion- project management. The project's deliverable was an interactive GIS used for land management and applicable to environmental and hydrological problem solving.

BACKGROUND

The North Fraser Harbour Commission (NFHC) is required to organize a broad base of information and supply it, on demand, to requesting agencies. NFHC is responsible for all water related activities of the 1400 hectare corridor abutting the north arm of the Fraser River, covering 15 map sheets at a scale of 1:2500; from the mouth of the river to New Westminister. NFHC recognized the applicability of computer technology as a management tool and have installed a networked system of computer stations. Hence, every employee has a station on their desk. Initially, use of the system was limited to word processing and simple database files, but NFHC felt the system was not being used to its full potential and hired a consultant to make system recommendations. The consultant worked from May 1988 to September 1989, and found that geographic relation was the data's common denominator.

After demonstration of a similar system on NFHC's CAD workstation development of a GIS was approved. This allowed NFHC and the consultant to develop a phased implementation plan:

Phase I : Design of Data Specifications
Phase II : Trial Conversion
Phase III: Develop Initial Applications
Phase IV : Initial Photogrametry
Phase V : Total Feature Conversion

At this stage Underhill Geographic Systems (UGSL) was hired on a fixed price contract to implement the system for the NFHC. This report deals with the implementation strategy and procedures used.

INTRODUCTION

The North Fraser Harbour Commission GIS implementation is an example of a small scale corporation implementing a GIS. After a management system analysis the GIS was deemed cost effective not only because it would increase the utility and availability of data, but because it would facilitate the replacement of manual mapping techniques. For example, the scribed orthophotos used in the past by the NFHC for land management were replaced by a digital mapping product. Although the initial cost of digital mapping was slightly higher, the long term maintenance costs are lower and data currency is easier to preserve. The technological advancement demonstrated here is that a GIS is more applicable as a management tool than traditional tools, creating an unprecedented long-term cost effectiveness. Thus the quantitative elements of the GIS: increased data currency; better organization of the data; and increased analytical capabilities, are extra benefits from the system rather than mere cost-justification.

This type of cost justification is a major advance in the application of GIS technology. Present day technology allows any small business or corporation currently using geographically based information to implement a GIS. The increased number of small scale GIS implementations will create other issues related to the ensuing decentralization of data. By describing the procedures NFHC have completed to implement their GIS, this paper details the considerations of both the new GIS users and the associated agencies that will require, use and aid in data supply and implementation of smaller scale GISs.

NORTH FRASER HARBOUR COMMISSION'S INITIAL VISION OF A GIS

NFHC wanted a number of practical considerations and concepts to be researched. These included researching the possibility of:

1. *Inputting a 200 metre buffer of land banking the river, both for the use of theFraser River Estuary Management Program (FREMP) and for the management of NFHC owned properties.*
2. *Selling any of NFHC's digital data to private or institutional users.*
3. *Inputting land based lots using coordinate geometry.*
4. *Using a raster scan of orthophoto data as a backdrop for the GIS.*
5. *Inputting three dimensional views of buildings.*
6. *Deriving a Digital Terrain Model (DTM) from the data.*
7. *Maintaining existing cartographic standards to be consistent with the original scribed orthophotography, to minimize the effects of change to a digital product.*

Underhill Geographic Systems Limited (UGSL) then formulated general considerations for the NFHC's GIS. These considerations required that:

1. *The digital database be flexible, and as system independent as possible.*
2. *Current data be utilized.*
3. *The implementation utilize the shortest possible development time frame.*
4. *The system be forward compatible.*
5. *NFHC have minimum staff disruptions.*
6. *NFHC have comprehensive staff training.*
7. *Communication be open at all levels of management.*

These initial requirements were maintained where possible. Unfortunately, in the short run, the information did not have paying demand. The data did however provide a good bargaining tool for UGSL to negotiate, on behalf of the NFHC, for coordinate geometry input data from the adjoining municipalities.

As a backdrop for the GIS, raster scans of the orthophoto information were deemed uneconomical. Instead, specific data was digitally collected and edited in the vector environment.

Although possible, a three dimensional building simulation was found to be superfluous for the NFHC's current applications, and so was added to the future requirement list.

During this process NFHC and UGSL were able to improve on the phased implementation strategy outlined in the management study. The resulting sequence and expansion of the phases is delineated in Figure 1.

PHASE I: FEATURE DESCRIPTIONS

Phase I was a completely iterative process in which feature descriptions were developed based on a series of meetings involving all NFHC staff and UGSL. These meetings not only helped to develop practical feature descriptions, but to involve each staff member. This process made the feature descriptions staff independent and comprehensive. The nomenclature goal of the feature description development was to maintain as many British Columbia Terrain Resource Information Management (TRIM) feature codes as possible, for standardization and future uses. Unfortunately the NFHC's application was so specialized that only about ten percent of the required feature codes were coincident with those of TRIM.

Every foreseeable element of the feature code was broken down and described prior to data input. Although time consuming at start up, this was by far the most cost effective method of dealing with the data, as it facilitated data consistency. The complete database tables also facilitated understanding for system users by detailing such items as element currency and accuracy.

Each database table was then accompanied by a data dictionary. The purpose of this dictionary was to make the terms understandable, to decrease the start-up time for any new system users and to ensure terms are used correctly and consistently.

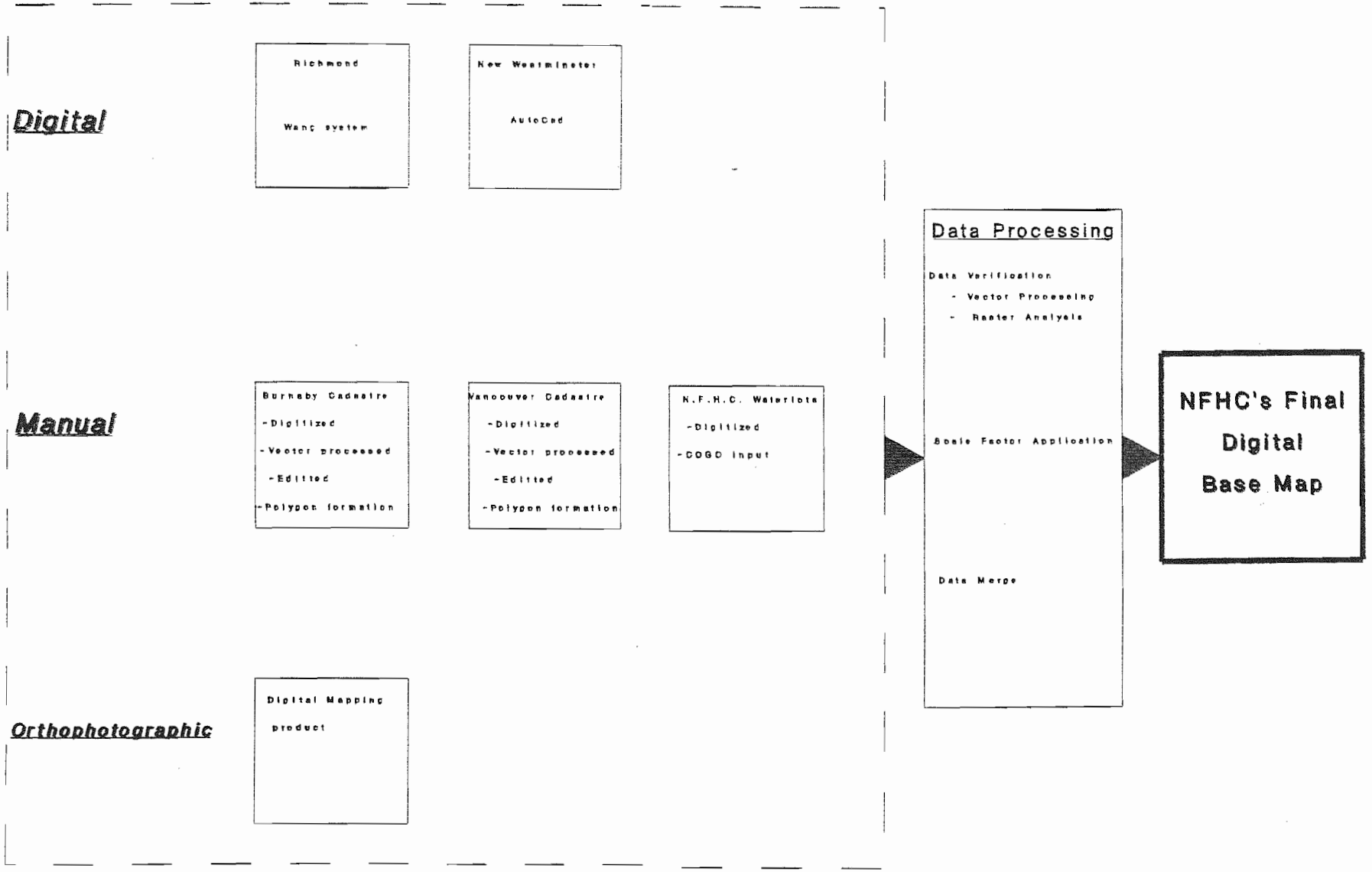
The final deliverable of Phase I was a report which included the previously stated information as well as minutes of the UGSL/NFHC and UGSL/municipality meetings. The designed feature codes and descriptions were specialized to NFHC's application while maintaining lateral and forward compatiblity. At the end of Phase I there was a reassessment of the project by NFHC staff and approval to enter into the next phase of the project (Phase II: Trial Conversion).

DATA EXCHANGE ARRANGEMENTS

UGSL met with the Corporation of the Township of Richmond, the City of Vancouver, the Corporation of the City of New Westminister, and the Corporation of the District of Burnaby. Each municipality agreed to exchange data with the NFHC, and to be kept on the data update schedule. The general result of these agreements was that NFHC received, in digital format, a coordinate geometry input cadastre for two of the four municipalities (Figure 2). In return, each municipality received a digital file, hard copy, and feature description of all water related data under the North Fraser Harbour Commission's jurisdiction. These data exchange agreements will continue to facilitate cross agency updates monthly.

The utilization of data exchange rather than digitization resulted in a substantial cost reduction. This reduction offers one of the first methods of decreasing the cost of building the database, currently the greatest cost associated with a GIS implementation. In the future the increased occurrence of data exchange will require municipalities and other agencies to develop procedures for data transfer and to formulate data processing costs. Reasonable data processing costs will decrease the data uploading costs of future implementations while assisting to offset the development or conversion cost of the original database.

DATA ORGANIZATION CHART



PHASE IV: INITIAL PHOTOGRAMMETRY

Running concurrently with the first phase, the photographic control was set in this phase. This process also formed the major portion of the pre-total feature conversion ground truthing. During the ground truthing each of the control monuments set eleven years previously were verified. The verification revealed that forty-nine percent of the control monuments had been destroyed. These monuments had to be reset before setting the photographic centers. The photography was taken at the lowest tide of the year to allow the identification of shore features normally below water.

PHASE II: TRIAL CONVERSION

In the second phase the feature descriptions designed in the first phase were put to practical test. Sheet seven of the fifteen was chosen for input, because it was the densest, most dynamic and representative of the map sheets, and because the data would be useful immediately. Prior to the input of this sheet three implementation team members completed an upstream general field verification to procure a general feel for management concerns and the possible areas of inaccuracy.

The accuracy tolerances, so closely designed in the first phase, dictated the input methods used for the second phase. The water lots and all water based cadastre, which are the major concern of NFHC, were to be input using coordinate geometry. This was possible for the harbour headlines, channel center line and channel lines as each of these points were derived in Universal Trans-Mercator (UTM) coordinates from the NFHC control survey. In contrast, review of the water lot surveys revealed their inconsistency. While some of the more recently surveyed water lots were tied to the NFHC control survey, the majority dated pre-1978 and therefore were at best tied to the theoretical line of the harbour headline. This seriously degraded the initial accuracy predictions and forced the implementation team to change some of the feature code characteristics. "Users of the information must know just what the quality is in order that they may use it properly" (Lodwick & Feuchtwanger, 1987). To facilitate this goal, the inputting team fully documented each input, stating its survey tie and documenting any associated problems with the survey file. To make the data accuracy graphically identifiable each input water lot was assigned a different line weight, line type and level depending on the assessed accuracy of the data. At the request of the NFHC a cost for increasing the level of cadastral water lot accuracy was derived. NFHC decided to update the accuracy of the lots over time, rather than sustain a large one time cost. Therefore graphically identifying the water lot accuracies allowed NFHC to quickly identify inaccurate water lots and indirectly gave the NFHC accuracy goals.

As previously discussed the land based cadastre was attained through data exchange agreements with the municipalities. This data exchange was the first time, for each municipality, that data had been transformed in and out of their system digitally. The trial conversion area required that data be converted from

Richmond's Wang system. This conversion was completed without incident and the data was used in the final deliverable to the NFHC, after a scale factor had been applied. Analysts for Vancouver's system were convinced the data was untranslatable. Therefore UGSL used a different technique to enter the data. All of Vancouver's data was digitized from their 1:1000 map base. After input the line work was vector processed and edited so that a network data set could be derived from it and polygons could be subsequently formed.

The third major type of data that still needed to be input was the vectorized digital mapping product (from aerial photography). This conversion process was subcontracted to the producer of the orthophotos. The subcontractor derived a product that identified twenty-five unique elements from buildings to vegetation. These were translated into the Terrasoft system as well, and provided a backdrop to the cadastre that made the total information package more intuitive.

The final product of the trial conversion was then reviewed and used by the NFHC staff for a one month term. This gave the staff an opportunity to assess the previously set standards set up in Phase I using a graphical data set.

The Phase II final product also provided a basis from which to make a more educated prediction of the quantity of graphic data that would be contained in the final product. Due to this assessment the decision was made to split the graphical data set at a logical location. The goal had always been to have a continuous data set, but the graphical data set was limited to thirty- two thousand elements in the utilized version of Terrasoft. Digital Resource Systems (Terrasoft developers) assured the implementation team that this data limitation would be overcome by the time of the final NFHC implementation. Therefore, for forward compatibility, the database division was designed to allow a simple future transition from a divided to a continuous graphical database.

PHASE V: TOTAL FEATURE CONVERSION

The total feature conversion provided few surprises for the implementation team, proving that the trial area was truly representative of the majority of the data. For simple logistical reasons the AutoCAD digital data from New Westminister had to be edited before it was translated, to decrease the size of the nine megabyte file. The Burnaby data provided no obstacles.

The only problem was the sparsity of the data near the mouth of the river. The data quality of the majority of the water lots in this less dense area was very poor. The insufficient data meant an increase in the required data interpretation and a decrease in data accuracy. As an interim procedure, before the water lot resurveys, each member of the implementation team was advised of site specific anomalies. Each anomaly was discussed with the Underhill & Underhill staff surveyors that completed the control survey. These measures increased the level of the required data interpretation.

The good news of Phase V was that all goals of the initial vision of the GIS were attained. The implementation team was pleased that all the data fit, after application of a scale factor, as the data originated from six sources. The feature codes and their descriptions did not require any changes or additions. The implementation team attributed the success of the implementation to the proper choice of a trial conversion site, as well as to the constant interaction between UGSL's implementationteam and NFHC. The full support and commitment of NFHC staff was essential for the success of the project.

Before final approval of this phase each member of the NFHC staff was trained to use installed versions of the database. NFHC staff then used the data in their day to day operations for a month, allowing them to assess the designed specifications through application. This testing procedure was successful in getting the staff to use the system and ensuring that the data was in the most usable format.

PHASE III: THEMATIC ANALYSIS

As previously described thematic analysis was viewed by the NFHC as a 'bonus' rather than a system justification. Previously the NFHC had little opportunity or reason to do any type of analysis on the river systems. As there was so little information on the type of thematic analysis that would be useful to the NFHC it was very difficult to design a comprehensive, long term plan for the implementation of such thematic analysis. Therefore the implementation strategy chosen was one in which a limited number of themes would initially be implemented. The initial themes were chosen for their immediate applicability to NFHC procedures. The themes chosen were:

1. **Leases**: *designed to contain information and status of the lease holder as well as information regarding the lease itself.*
2. **Legal Parcels**: *designed as the basis for completing economic and environmental analysis of upland fee simple lots.*
3. **Shoreline Inventory**: *designed as a linear theme to indicate shoreline sensitivities.*
4. **Fraser River Estuary Management Program**: *designed to contain the three environmental designations relating to distances from the current high water mark.*
5. **Lease Rate Zones**: *designed to classify water lease areas of similar property value to be used to determine costs and changes.*

The implementation team is currently assessing the advantages and disadvantages that have been associated with the thematic analysis. If the assessment is favorable more themes will be developed. It is anticipated that the future themes will be more environmental in nature. For example, future anticipated themes include dynamic models of sedimentation, flow velocities, salt wedge intrusions and tidal variations (Stepchuk, 1989).

ONGOING PROCESSES

A constant system concern will be the accuracy of the data that forms the base of the system and maintenance of this data. Therefore updating water lot surveys, receiving and delivering updates, ground truthing, and system reevaluation will all be ongoing processes. It is the overall desire of the NFHC project team to increase the data accuracy over time. Thus a solid maintenance program has been designed and implemented.

CONCLUSION

This description of the NFHC implementation has served as a platform to describe new GIS issues. The first major issue relates to the graphical representation of data accuracies. With the great variety of data sources used for this implementation UGSL classified the data sources into five categories. At the time of input each category was assigned a different line weight and type relating to the data accuracy. This procedure has proven valuable in the long term providing easy data accuracy access and indirectly providing NFHC with accuracy goals. UGSL's subsequent in house automation of this procedure has broadened its application so that it can be used to indicate the reliability of surveys following a least squares adjustment. It is anticipated that many more applications will be found.
The implementation team has also been very pleased with the implementation procedure. Phased implementation facilitated approvals and consultation between the NFHC and UGSL. As well, the implementation of a trial area allowed the implementation team to make required changes before the total feature conversion. This process minimized the problems associated with the total feature conversion.

The NFHC's implementation has also indicated the new issues that are arising as more small agencies enter the GIS field. Traditionally the most expensive procedures involved in implementing a GIS are data uploading and hardware costs. In this case, both these costs have decreased, hardware because of decreasing costs of technology and data uploading because of the increasing possibility of data exchange.

The increasing reliance on data exchange to decrease GIS implementation costs will require a number of agency design changes. Data exchange procedures must be formulated to facilitate the technical and institutional aspects involved in data transfers. Input procedures and source data must be recorded so that data accuracy and quality can be assessed at a later date, when required for a future application. The dollar value of the data will have to be determined. If data uploading is shared between a number of agencies it will be possible to reduce database costs by economies of scale.

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