RESOURCE MANAGEMNET APPLICATIONS OF A WEB-BASED GEO-REFERENCED DIGITAL IMAGE MANAGEMENT SYSTEM

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ABSTRACT:

The use of digital imagery is fast increasing for resource management applications. This is mostly due to new and advanced technologies to integrate digital imagery with land related data in a digital mapping environment or in a Geographic Information System (GIS). To support clients of digital imagery, the Crown Registry and Geographic Base (CRGB) of British Columbia Ministry of Forests and Range, Integrated Land Management Bureau (ILMB), Canada has developed Digital Image Services (DIS) program. The purpose of this program is to support and maintain a web-based system to provide a single common repository of raster imagery in the Province of British Columbia. The imagery is accessible to the public and BC government's clients via Internet to support the economic development and better management of the resources in the Province. DIS will address data management issues related to raster data and image warehousing, distribution, and maintenance of a very large volume of geo-referenced raster based imagery. The imagery included are but not limited to scanned aerial photos, digital camera data, orthophotos, satellite imagery, stereo models, and Digital Elevation Model (DEM). DIS has established a corporate, OGC compliant data access facility called the Image Discovery Tool (IDT), allowing BC government and public users to access land related digital image and raster products. DIS design objective is to operate on the Internet using standard browser technology. It is interoperable, utilizes standard computing hardware, is extensible, based on Open GIS Consortium (OGC) standards, is ISO compliant and in compliant with BC Government Land Resource Data Warehouse (LRDW). The scope of this paper is to describe system requirements, development issues, problems encountered and resource management applications.

1. INTRODUCTION

The **Integrated Land Management Bureau (ILMB)** of the Ministry of Forests and Range was established through the merging of resource and data management business areas from seven BC Ministries, Ministry of Environment, Ministry of Agriculture and Lands, Ministry of Energy, Mines and Petroleum Resources, Ministry of Tourism, Culture and the Arts, Ministry of Transportation and Infrastructure, Ministry of Aboriginal Relations and Reconciliation and Ministry of Forests and Range.

ILMB Mandate: Provide British Columbian with access to integrated Crown land and resource data authorization, planning dispositions and resource information services. Many of these services are provided to, or on behalf of provincial natural resource agencies and economy ministries as mentioned before.

ILMB Vision: World-leading natural resource service delivery that exceeds expectations and provides business certainty for our clients.

ILMB Mission: Deliver leading edge, timely, client-friendly and responsive integrated natural resource information and services that support a vibrant BC economy, healthy communities and a sustainable environment. ILMB main shared-services clients include the seven ministries named before.

2. DIGITAL IMAGERY

Digital images as a resource management tool and the land related applications have become an important resource for the Ministry to support integration of natural resources information and land related data. One of the key goals of the Ministry is to integrate resource based information from multiple resource areas. This provides provincial leadership through planning and resource information management which supports economic development within the Province. To support delivery of this goal, an easy access to digital imagery is essential.

The Integrated Land Management Bureau (ILMB) under Ministry of Forests and Range is mandated to fulfil this vision and mission through following four goals:

- Sustainable economic development of land resources;
- Effective delivery of integrated, science based land, resource and geographic information;
- Sound governance of land and resource management; and
- Organizational excellence.

For this purpose, Crown Registry and Geographic Base (CRGB) of ILMB initiated, developed and implemented the Digital Image Services (DIS) program to provide easy and timely web-based access to digital imagery in support of ILMB goals. The mission of DIS program is to establish and maintain a central repository of BC digital geographic imagery utilizing a semi-automated, computer-based system to support the

acquisition, discovery, management, and distribution of geographic digital imagery for the Province of British Columbia, Canada. This service is essential to ILMB, the seven Ministries and many external clients and the public. One of the program goal is to determine the technical and business requirements for management of a very large volume of digital image products such as scanned aerial photos, orthophotos, satellite imagery, Digital Elevation Model (DEM), LIDAR, etc., available as core imagery for the province of British Columbia. The program will support:

- The data management issues related to management, delivery and maintenance of a very large volume of geo-referenced raster based imagery.
- Terrain Resource Information Management (TRIM) digital base mapping and forest inventory program by providing the efficient delivery, maintenance and archiving of digital geographic image data.
- The acquisition, management and data access of aerial photo program in British Columbia.
- The corporate, universal data access facility, commonly known as the " image discovery tool " (IDT) allowing British Columbia government including ILMB and other ministries in Victoria, regional offices and public users to access the digital orthophotos and other raster data/imagery by providing on-line digital indexes and search capability of the available image data.
- Integration of the digital imagery data into the BC government land resource data bases.

3. IMAGE WAREHOUSE

DIS image warehouse has been in operation for almost eight years and during that time has grown in size from 6 to 40 TB of on-line data and the archive imagery from 50TB to 250 TB in size. During this period the system has been in operation, a number of issues have been identified that adversely affect the ongoing operation of DIS warehouse as currently configured.

- Network access to DIS warehouse server is via SPAN/BC network which is the BC Government private network. BC Government users accessing data via Windows Explorer can transfer data at 100 Mbps. External users, accessing the Image web server (IWS) are limited to internet speeds, typically under 10Mbps for most users. External clients are able to directly access the full resolution data for viewing through Web Mapping Service (WMS) but cannot store or manipulate image data.
- Each of DIS warehouse servers are connected to SATA SAN using a single 2 Mbps fiber channel connection (i.e. single-path connection); no fail-over or redundancy is provided with this configuration.

4. IMAGE ARCHIVING

DIS image warehouse comprises both an online and offline (archive) component. Imagery for which there is a high user demand is stored online, while less-used imagery is committed to archive, from which it must be retrieved when needed. SATA SAN storage is provided by Workplace Technology Services (WTS), British Columbia Government.

DIS Annual Online Storage

Year	Servers	Online Storage (TB)
2004	1	6
2005	1	18
2006	2	40
2007	2	40
2008	2	40
2009	2	40
2010	2	40

DIS archive occupies about 250 TB on SDLT tape and is provided by the central backup service. Charges to DIS program for archive storage are on a per-gigabyte, per-month basis. Since archive is considered permanent storage, there is no expiry date, and the storage charges can be expected to accrue indefinitely. As more and more data is consigned to the archive, annual storage charges can also be expected to rise substantially with each succeeding year.

DIS Annual Archive

Year	Size of Archive Storage (TB)
2004	17
2005	57
2006	113
2007	153
2008	200
2009	220
2010	250

As the preceding tables demonstrate, online storage volumes can be managed and stabilized by prioritizing the imagery which is kept online, and archiving the remainder. However, since the archive must be the permanent destination for non-priority imagery, and per-gigabyte archive costs are similar to per-gigabyte online storage costs, archiving low-priority imagery is not necessarily and effective cost/storage management strategy.

Most source imagery is delivered to DIS in uncompressed .tiff format. A recent evaluation of JPEG2000 demonstrates that compression ratio of almost 2:1 are achievable with no loss of data quality. This is true 'lossless' compression – not the 'visually lossless' quality claimed by other wavelet compression schemes at ratios of between 10:1 and 20:1. Use of JPEG2000 as an archival format could reduce future annual archive costs almost by half. Since archive costs accrue indefinitely, a program of converting and re-archiving existing archive imagery into JPEG2000 format could realize even greater savings over the long term. Industry acceptance of the format in orthophoto production and delivery is the key.

5. DIAS PROJECT

Most recently, Digital image Archiving System (DIAS) project has been initiated. The objective of this project is to reduce the cost of digital image archiving by storing our data on removable hard drives and also high density tapes. This project is ongoing and the initial result is very promising.

6. IMAGE DATA TYPES

The current image data stored in image warehouse and also future data sets are from these sources:

- Digital raw imagery scanned from the aerial photography diapositives or predominantly the negatives.
- Digital aerial photograph using full frame photogrammetric digital camera.
- LIDAR data.
- Digital control chips to support aerial triangulation and orthorectification.
- Orthophography which are created from digital raw images that have undergone significant photogrammetric processing to create an ortho "image map ".
- Satellite digital imagery, which are ortho-rectified such as, Landsat, IRS, IKONOS, SPOT, Quick Bird, GeoEye, WorldView, and also raw satellite image data.
- Digital Elevation Models (DEM).
- Stereo models for photogrammetric map productions.

7. THE SYSTEM SOFTWARE

The seven primary software components of DIS program are as:

- Raster Management System/Applications.
- Raster (Image) File Access server.
- Raster Discovery Applications.
- Raster Order Placement and Fulfilment applications, Base Mapping Online Store (BMOS).
- OGC Compliant Web Feature Service (WFS) Server.
- OGC Compliant Web Map Service (WMS) Server.
- Raster (Image) Compression and De-compression Software Tools.

8. RASTER MANAGEMENT SYSTEM

The raster product management component Phase I, Users' Requirements Analysis and Phase II, system Design is completed now. Once the system is implemented it will provide the functionality to manage the raster files (TIFF, GeoTIFF, ECW, MrSID, etc.), the metadata for the online (digital) and offline (negatives, etc.) imagery, metadata about each collection (Air Photos, Satellite Imagery) and other supporting metadata (Flight Lines). The management applications should manage both the metadata and the files as a single asset within the management system. Additionally, this component will publish raster and metadata to the BC land Resource Data Warehouse (LRDW).

9. RASTER FILE ACCESS

The raster file access component of DIS system provides the functionality for clients to access the raster data in DIS system over the Internet. The file access server provides functionality to access the entire original raster, a portion of the raster or a resized portion of the raster. It also supports and/or integrates the security functionality from the Raster Order Placement and Fulfilment component, called BMOS.

10. RASTER DISCOVERY

The raster discovery component provides the facilities to enable for raster products using a spatial and metadata filters. Image metadata has been developed according to ISO/TC211 standards for aerial photos and related products. The result will be displayed as a list and an option to display the photo centres and footprints on the index map. The discovery applications is also include an index map that displays the base map of BC and will also support connections to an OGC Map service to get the layers for display. This functionality is under Image Discovery Tool (IDT) and version 3.2 of the software has been completed to provide search capability for aerial photos, orthophotos, Landsat and SPOT satellite imagery data.

11. RASTER ORDER PLACEMENT

The raster order placement and fulfilment component under Base Mapping Online Store (BMOS) provides shopping cart functionality for the raster discovery applications in order to add products to a user's order. The component will also provide a pricing service for the products and online/offline order fulfilment and workflow. Please see the service provided by BMOS at the following link:

http://www.basemaps.gov.bc.ca/

12. REQUIREMENTS

DIS system and its components have the following common requirements:

- Meets all system requirements as detailed in DIS system requirements document available on the Digital Image Management (DIM) web site.
- Meets all applicable Ministry standards. Ministry standards are available at:

http://www.cio.gov.bc.ca/cio/standards/asdlc/exemptions/

- Performance, functional, and system requirements are proven through adequate system, integration, and regression testing.

13. CONCLUDING REMARKS

The Digital Image Services program will provide a managed environment for storage, maintenance of and access to large volume of raster data on an ongoing basis. The principle data types mostly used include aerial photographs, orthophotos, satellite imagery, digital elevation models, digital control chips and a variety of derived products from these fundamental data sources. In addition to these diverse raster data sets, DIS is in compliance of the corresponding ISO/TC211 standards for image metadata. Many of our users will benefit now from a simplification of business processes by making use of such raster data for resource management., or potentially could in the future.

British Columbia has been a leader internationally in the use of aerial photography starting in 1936. Since the early 1980s this leadership has been maintained in the use of satellite imagery. More recently with the 1:20,000 digital base mapping provided through Terrain Resource Information Management (TRIM) program, British Columbia has emerged in the forefront of digital scanned aerial photography for base map production and

updating. The overall justifications for over seventy years of effort have been the tremendous benefits that such data provides to a large variety of resource and socioeconomic applications. Since BC is so large (95 million hectares) and so varied, and the land is owned predominantly by the Crown, and since the population is so small relative to the land base, digital mapping and digital imagery have played very significant role in mapping the Province's lands and resources.

A number of important reasons exist for pursuing and further developing DIS program at this time. These include the following:

- Duplication of image files and also image storage and server will be significantly reduced and therefore will support to decrease the operational costs of the program.
- The online orthophoto mosaic (built as part of the initial work for DIS) will be extended to accommodate all current orthophotography, thereby increasing its relevance to many users interested in the new data.
- Increased number of data types will be supported, these new types to include satellite imagery and stereo pairs.
- The lossless data compression such as JPEG2000 will be implemented to reduce storage requirements.
- Metadata based on ISO/TC211 standards will be put in place to facilitate better exploration and access by managers and users alike.
- An update process will be built that will allow for new raster data, and its corresponding metadata, to be added readily to DIS system environment and image warehouse. This will be through implementation of the Raster Management System (RMS).
- Dynamic generation of derived imagery will support resampling and reprojection, thus eliminating the need to store multiple versions of the same data at different resolutions and in different projections.
- The access time to raster data will decrease measurably because of higher performance software, thus improving the user expectations and experience.
- The use of digital control chips will reduce time and money to extend control points using photogrammetric aerial triangulation techniques.

All of the above will lead to an effective management process for Terabytes of Imagery (1,000 GB), and able to handle ongoing maintenance, while improving accessibility to a variety of users within and outside of government. DIS system will also help ensure that the considerable investment that the Province has made in Raster data will be managed appropriately on an ongoing basis. Finally, a number of capabilities that could only be handled clumsily, if at all, will be realistic to carry out for DIS users.

By following through with the full development of DIS and in Particular, RMS, the Ministry will be able to meet its mandate to manage massive raster data collections on behalf of all provincial agencies. CRGB, ILMB has developed specifications for DIS image warehouse and continually receives data from other resource based Ministries. However, its ability to manage such volume of data needs to be greatly improved to meet the ongoing business needs of government associated with fire protection, emergency response, forest management, regional and local planning, treaty negotiations, cross-border interaction, and the like. DIS program will provide us with the necessary mechanism to meet these needs.

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15. ACKNOWLEDGEMENTS