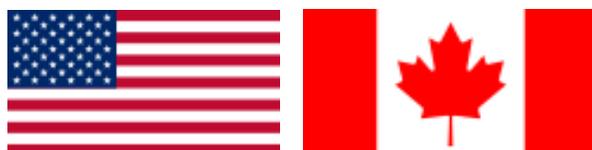


2008 NSDI CAP Final Report

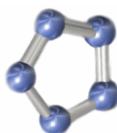
Category 4: Joint Canadian and United States Spatial Data Infrastructure Project



Cross-Border Content and Services for Critical Infrastructure Identification

<http://www.thecarbonproject.com/crossbordersdi.php>

Submitted By:



The Carbon Project

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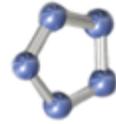
In Partnership With:



CubeWerx

15 Rue Gamelin, Suite 506, Gatineau, Quebec, Canada, J8Y 6N5

cwinfo@Cubewerx.com, www.Cubewerx.com



1. Cross-Border SDI Project Summary

The Carbon Project® is pleased to submit this 2008 NSDI Cooperative Agreement Program (CAP) Category 4 Final Report for the joint Spatial Data Infrastructure (SDI) project between the United States and Canada. Since project kickoff in July 2008 the Cross-Border SDI Project made significant progress deploying new online data, services and applications to support critical infrastructure (CI) identification using a common SDI for Canada and the US. In particular, the project has developed and deployed four online services based on OGC Web Feature Service (WFS), Filter and GML standards and CubeWerx software. The services are located in Montana and Quebec and constitute possible initial nodes for a Cross-Border SDI (CBSDI) Network. Each WFS also implements a prototype role-based access control framework - meaning there is a now testbed for a security framework that ensures CI information goes to the people that are supposed to have it.

The project also made substantial progress integrating infrastructure data models used by Montana with the National Infrastructure Data Models (NIDM) from Canada, with input from the DHS Geospatial Data Model - the result of this effort is an integrated "Common" data model and new GML community schema for cross-border infrastructure data exchange called CBSDI GML. The project also pioneered the implementation of dynamic, local-to-community GML schema transformation for infrastructure data – meaning each WFS speaks both its national schema and an agreed-upon community schema (powered by the same underlying databases).

As of September 2009, cross-border SDI users are now able to access the four data services using the free Gaia 3.4 SDI platform from The Carbon Project, web-based applications from CubeWerx, and CarbonArc PRO, an SDI interoperability extension for ESRI's ArcGIS from The Carbon Project.

The project has been successfully briefed in multiple community venues including CANUS, GEOINT 2008, the FGDC Homeland Security Working Group (HSWG), HIFLD, the first Geospatial SOA and Cloud Computing Workshop in Washington, DC, and will be presented at the 2009 ASCE Conference in October. In the future, the collaborative group working on this effort will seek to advance the GML community schema for cross-border infrastructure data exchange, CBSDI GML, and register the Cross-Border WFS with the GOS Portal.

For more information please visit www.thecarbonproject.com/crossbordersdi.php.

1.1. Canadian and U.S. Lead Organizations

U.S. Lead Organization - The Carbon Project

Key Project Contact: Jeff Harrison, President and CEO

Phone: 703.491.9543, Email: jharrison@thecarbonproject.com

Internet Address: <http://www.thecarbonproject.com>

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Canadian Lead Organization - Cubewerx, Inc.

Key Project Contact: Edric Keighan, President and CEO

Phone: 819.771.8303, Email: ekeighan@cubewerx.com

Internet Address: <http://www.cubewerx.com>

Other Project Contacts (Collaborating Organizations):

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Michael Fashoway, Critical Structures Database Administrator

Montana Department of Administration, Information Technology Services Division

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Internet Address: http://giscoordination.mt.gov/critical_infra/msdi.asp

Denis De Gagné, Director, CTIS

Centre for Topographic Information in Sherbrooke (CTIS), Natural Resources Canada

Phone: (819) 564-5600, Email: NTDB@NRCan.gc.ca

Internet Address: http://www.cits.rncan.gc.ca/cit/servlet/CIT/site_id=01&page_id=1-004.html

Maj. Don Christie, Cross Border Project Coordinator

Canada Department of National Defense (DND), Directorate of Geospatial Intelligence

Ed Freeborn, Senior Analyst

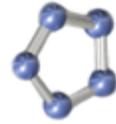
L-3 Government Services in Rome, New York

1.2. Geographic Scope or Area

All Cross-Border Regions between Canada and the United States can eventually benefit from this project through the new WFS and GML community schema for cross-border infrastructure data exchange called CBSDI GML. In the current effort, the State of Montana and Provinces in

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Canada directly across the border are positively impacted by the developed data models, schemas, services and applications.

1.3. Project Background

At 5,000 miles, the United States and Canada share the world's longest common border and identifying critical infrastructures (CI) is a vital function for federal, state, local and private sector organizations in the cross-border region for both security and commerce. However, right now organizations must 'cobble' together information sources like paper maps, spreadsheets, distributed data files and others to accomplish the task – or attempt to gain access to restricted data sets produced for limited audiences. Both processes are not efficient for many organizations and would be facilitated by open or selectively secured online services, software applications and a common Cross-Border Spatial Data Infrastructure (SDI) for Canada and the US.

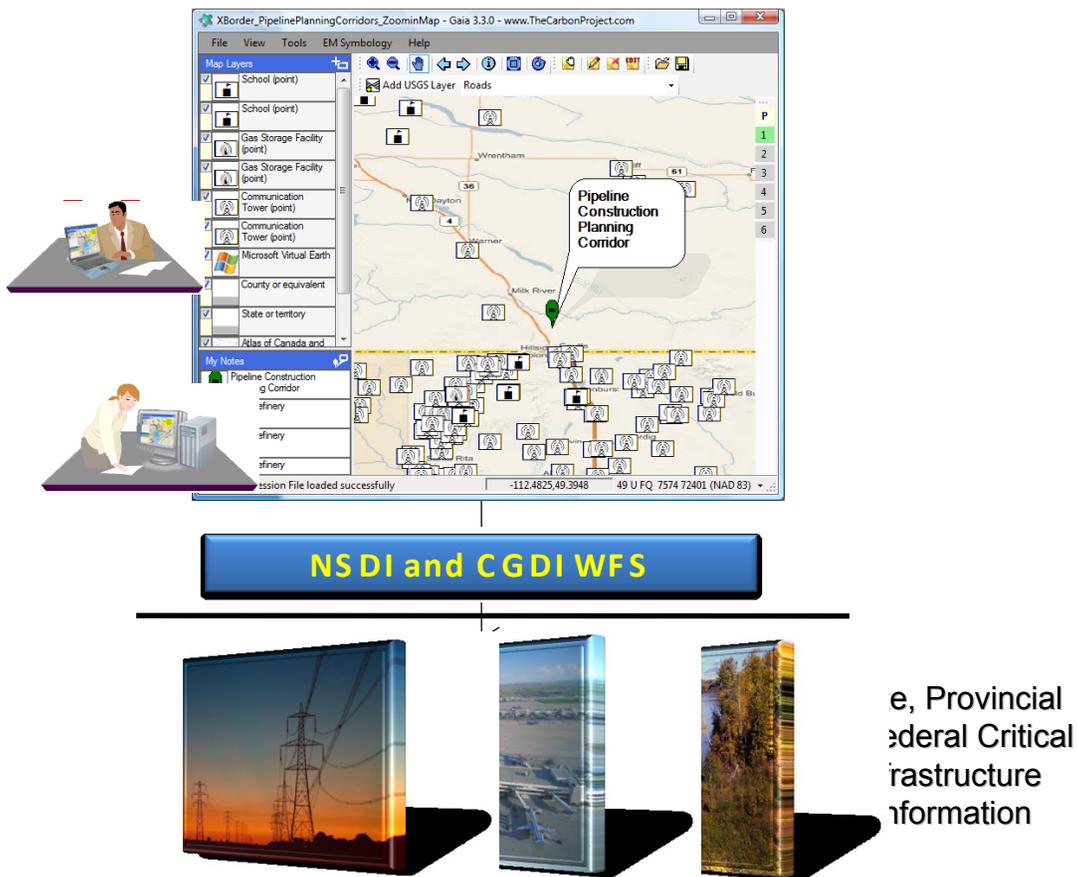
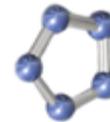


Figure 1 - This project has deployed new online data, services and applications to support Critical Infrastructure Identification using an open, common Spatial Data Infrastructure model for Canada and the US

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To help address these challenges a collaborative group conducted the “*Cross-Border Content and Services for Critical Infrastructure Identification*” project to deploy new online data, services and applications to support critical infrastructure identification using a common spatial data infrastructure (SDI) for Canada and the US. In this project, Critical Structures Databases and Framework Data were deployed as standards-based Web Feature Services (WFS) at state and provincial levels on both sides of the US-Canada border. These resources were integrated with US National Spatial Data Infrastructure (NSDI) and Canadian Geospatial Data Infrastructure (CGDI) WFS resources from federal and provincial partners.

This project brought together a collaborative group committed to joint US-Canadian SDI including the:

- *Montana Department of Administration, Information Technology Services Division*
- *United States Department of Homeland Security, Geospatial Management Office*
- *Centre for Topographic Information, Natural Resources Canada*
- *Cross Border Project Coordinator, Canada Department of National Defense*
- *Industry partners CubeWerx and The Carbon Project*

The project provided significant benefit to the provincial, state and local emergency services, homeland security, planning and public safety communities on both sides of the US-Canada border. Specifically, the project resulted in an online capability to identify critical infrastructure.

Under the effort, the project team deployed distributed data, services and applications based on Open Geospatial Consortium Web Feature Services (WFS), Filter Encoding (FE) and Geography Markup Language (GML) standards, the NIDM, the DHS Geospatial Data Model (GDM), and the latest NSDI and Canadian Geospatial Data Infrastructure Framework Data standards to support critical infrastructure identification. The new services are located in Montana and Quebec. Cross-border users can access the data and services and identify critical infrastructure using the free Gaia 3.4 SDI platform implementing FGDC Emergency Mapping Symbology, web-based applications from CubeWerx, CarbonArc PRO, an SDI interoperability extension for ESRI's ArcGIS from The Carbon Project, or any OGC WFS-compliant application.

2. Project Milestones

The “*Cross-Border Content and Services for Critical Infrastructure Identification*” project was conducted as a series of tasks using an integrated activities framework, an evolution of project management processes developed by The Carbon Project over the course of numerous SDI engineering efforts. The activities framework outlines tasks that can be combined and adapted as necessary to address the requirements of SDI engineering projects, and are executed in a cross-organizational team infrastructure. This framework formed the basis of the Cross-Border SDI Project Work Plan established and consists of three high-level tasks: Development and Integration, Community Outreach, and Project Coordination.

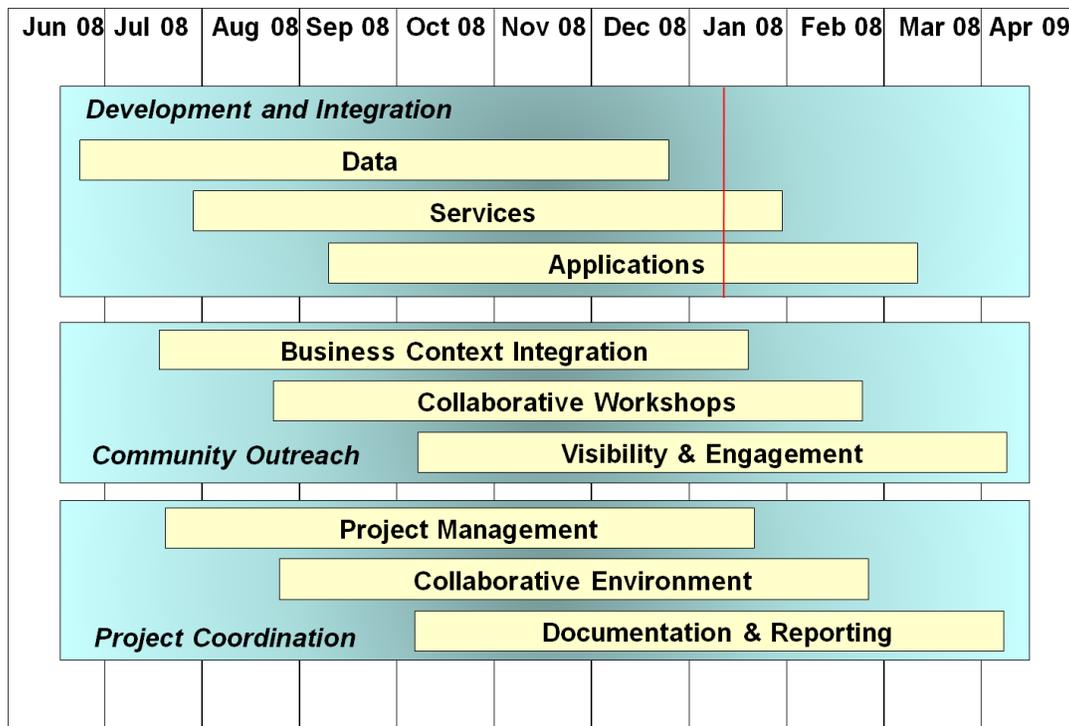
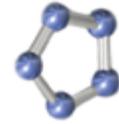
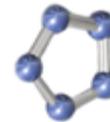


Figure 2 -The project framework for this effort is designed to successfully complete SDI engineering efforts

2.1. Operational Use Cases

As part of the Cross-Border SDI Project we interviewed representatives from Montana and Canadian stakeholders prior to project initiation, at the project kickoff and weekly throughout the project. During these discussions it was confirmed by participants that the capability to efficiently identify critical infrastructures (CI) is not only vital for organizations involved in cross-border regions but leads to the use of an SDI that supports interoperable online services and software applications operating from a common SDI framework between Canada and the US. We also confirmed that the process for accomplishing these tasks with online services, software applications and a common SDI was very similar to previous activities undertaken by GeoConnections for establishing a distributed SDI between the federal government and the provinces in Canada under the CGDI Interoperability Pilot. For this project, a Public-Safety Use Case for data download and analysis was used as a key scenario representative of data infrastructure requirements.



For reference, as brief description of the CGDI Pilot “Public-safety Use Case” is as follows - a client application and server used a simulated release plume polygon in GML to construct new critical infrastructure features such as impacted airports and powerlines. This involved intersecting release plume polygons with the impacted areas. To do this the client application used the capabilities of the distributed CGDI architecture and WFS technology. Specifically, the client application used the Filter Encoding specification and WFS-T services.

Our project process reviewed the following use case in collaboration with end user organizations and confirmed its validity:

Use Case - Emergency scenario for critical infrastructure identification and data download

COP application for analysis using vector data from Cross-Border SDI

Users

A disaster and emergency services community of practice (COP)

Summary

A Community of Practice decision support application accesses data via WFS and performs some analysis on the resulting vector data.

The scenario is a fire emergency that requires the evacuation of communities in its path over time. The requirement is to identify critical infrastructures that may be impacted.

Preconditions

Operators trained in the use of the application.

Triggers

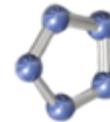
A fire beginning in Montana, near a wildland/urban interface zone on the US-Canada border.

Basic course of events

1. County Emergency Operations Center receives notification of the event
2. Operator accesses the application and navigates an interactive map to the geographic area for the event, in a wildland/urban interface zone.
3. Operator generates a filter for fire stations and in police stations the geographic area for the event.
4. Operator loads the filter into the mapping application
5. Operator performs an intersection of the area for the event with fire stations and police stations and generates a list of GML features using the analytic capabilities of the SDI and displays these features on the map.
6. Operator performs an intersection of the area for the event with schools and state-owned or leased facilities, generates a list of GML features using the analytic capabilities of the SDI, displays these features on the map and styles those features differently in the mapping application. (affected facilities filter)
7. Operator adds a new feature for evolving fire incidents and adds this feature to the SDI service and commits this feature using a transaction. (fire incident)
8. Operator saves the state of the map and sends an email with the filter in it to a distribution list. The filter consists of just five lines and is easily transmitted to all parties.

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9. Operator at another location just across the border in Canada accesses the SDI services in the US and Canada using another application and sees newly added fire features. The operator downloads his email and launches the affected facilities filter and overlays them on another base map
10. Operator in a federal facility accesses the SDI services in the US and Canada using another application and sees newly added fire features and other aspects of the evolving situation. The operator is able to access and download data from online NSDI services at state, provincial and federal levels.
11. Cross-border operations continue as the fire continues to move.

An initial planned user group for this project was predicted to include emergency services responders and coordinators at the “county” level. However, this user group is just the first of many that can benefit from the data, services and applications developed during the project. Based on this premise and discussions with project participants in Canada and Montana a second operational Use Case was added in November 2008. This Use Case was entitled the *Pipeline Planning - 2010 Scenario*.

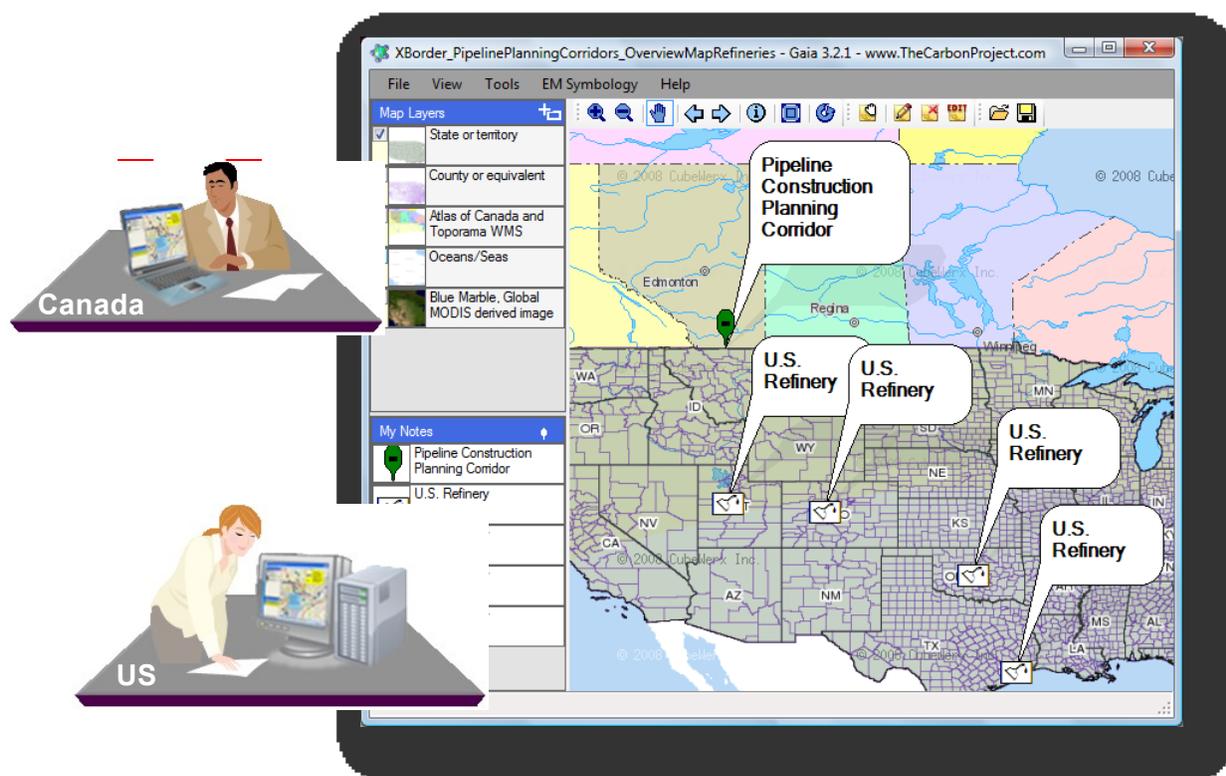
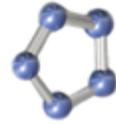


Figure 3 – The Pipeline Planning - 2010 Scenario was added to the project in November 2008 to highlight how Cross-Border SDI data, services and applications can support planning as well as emergency response.

In this scenario a fictional “International Planning Commission” is reviewing plans for a new oil pipeline. The pipeline will carry crude oil from western Canada provinces to refineries in US.

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The Planning Corridor for the pipeline crosses Montana/Saskatchewan border, and the Commission tasked with reviewing infrastructure in Planning Corridor & rapidly developing a report on critical infrastructure in the area. The scenario was successfully demonstrated on Dec 23, 2008, presented to the FGDC HSWG and HIFLD in January 2009 and discussed at the first Geospatial SOA and Cloud Computing Workshop in Washington, DC, and will be presented at the 2009 ASCE Conference in October (Figure 4).

NOTE - This scenario is not meant to correlate to any real or planned efforts. Rather, it is designed to highlight the benefits of the cross-border Spatial Data Infrastructure (SDI) technology for planning purposes.

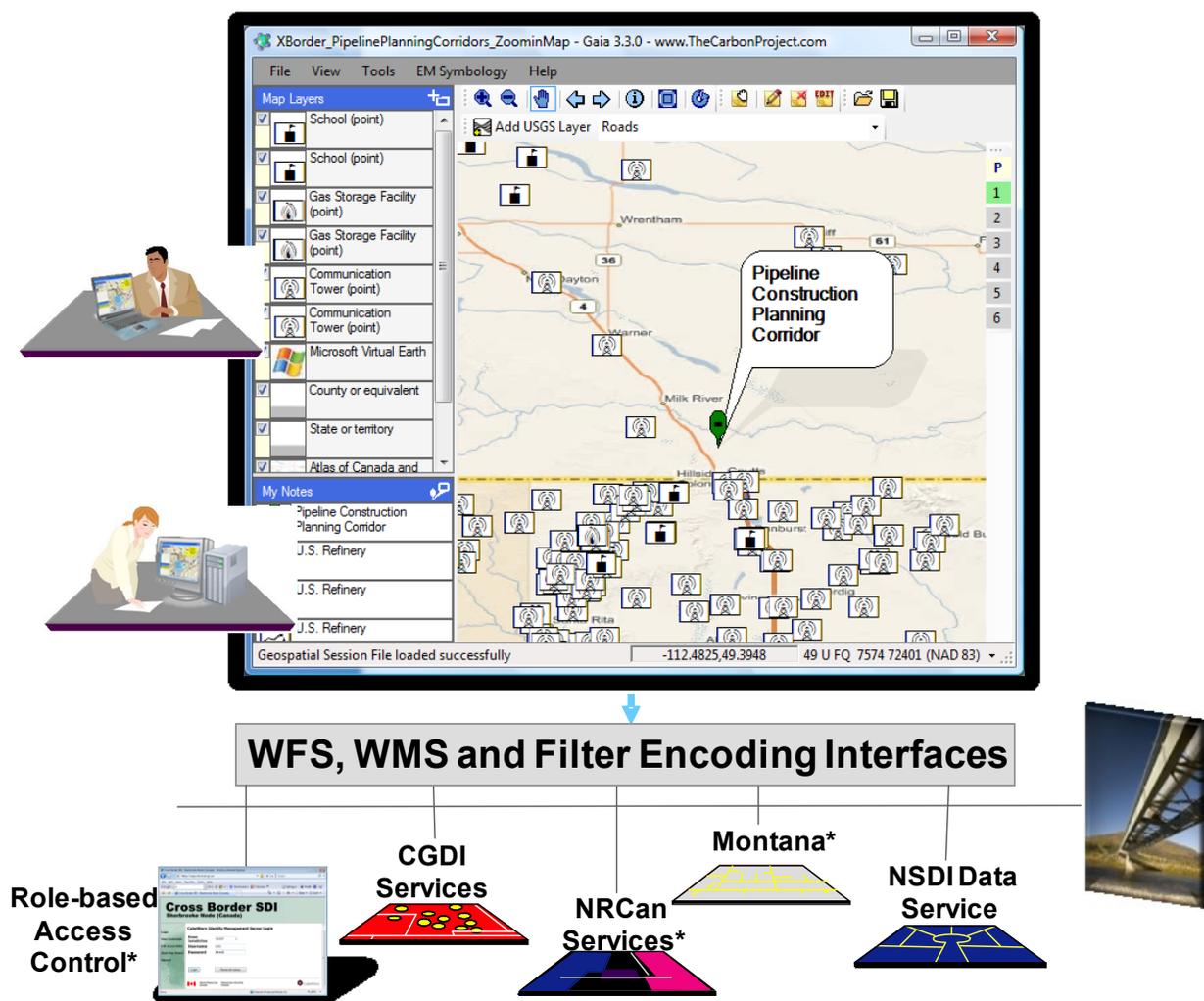
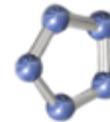


Figure 4 – The Pipeline Planning 2010 Scenario was successfully demonstrated in December 2008 and highlighted the benefits of a Cross-Border SDI for multiple operational uses.



3. Kick-off Meeting

The Cross-Border SDI Project began with a kickoff meeting held on July 3, 2008 at USGS in Reston, VA, USA. The agenda was:

- | | |
|---|------------------|
| • Arrival | 0830-0930 |
| • Welcome & Participant Introductions | 0930-0945 |
| • Application 'Use Case' Review | 0945-1000 |
| • Data, Services & End-User Application Discussion | 1000-1045 |
| • Break | 1045-1100 |
| • Security Discussion | 1100-1120 |
| • Engaging Cross-Border Participants (IBETs etc.) | 1120-1140 |
| • Data Model Cross-Walk Process | 1140-1200 |
| • Lunch | 1200-1300 |
| • CISDM, NIDM, GDM Overviews | 1300-1400 |
| • Data Development Working Session | 1400-1500 |
| • Social at the Lakeside Restaurant | 1600-1800 |

The kickoff briefing is available online for project participants at –

http://crossbordersdi.projectsaces.com/documents/index.php?action=detail&id=109&project_id=6

4. Development Summary

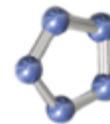
During the Cross-Border SDI project our multinational team made significant progress on Data, Services and Application Development and Integration, as well as Community Outreach. The following sections summarize significant accomplishments and provide details on the development of the CBSDI data model and GML Schema adopted by participants.

4.1. Data Development and Integration

During the project our collaborative team integrated CI data models used by the State of Montana with the National Infrastructure Data Models (NIDM) recently developed in Canada, with reference and input from the DHS Geospatial Data Model. Project participants brought

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together expertise in emergency management, planning and practical knowledge of SDI implementations and deployments to undertake this challenge and adopt a common model for disseminating and accessing infrastructure information between the State of Montana and Canada provinces. While much work is still left to be done in the area of data modeling and outreach to other communities the multinational team was able to clearly demonstrate the benefits derived from the CBSDI data model and GML Schema implementation.

The starting point for data modeling efforts during this reporting period is summarized below:

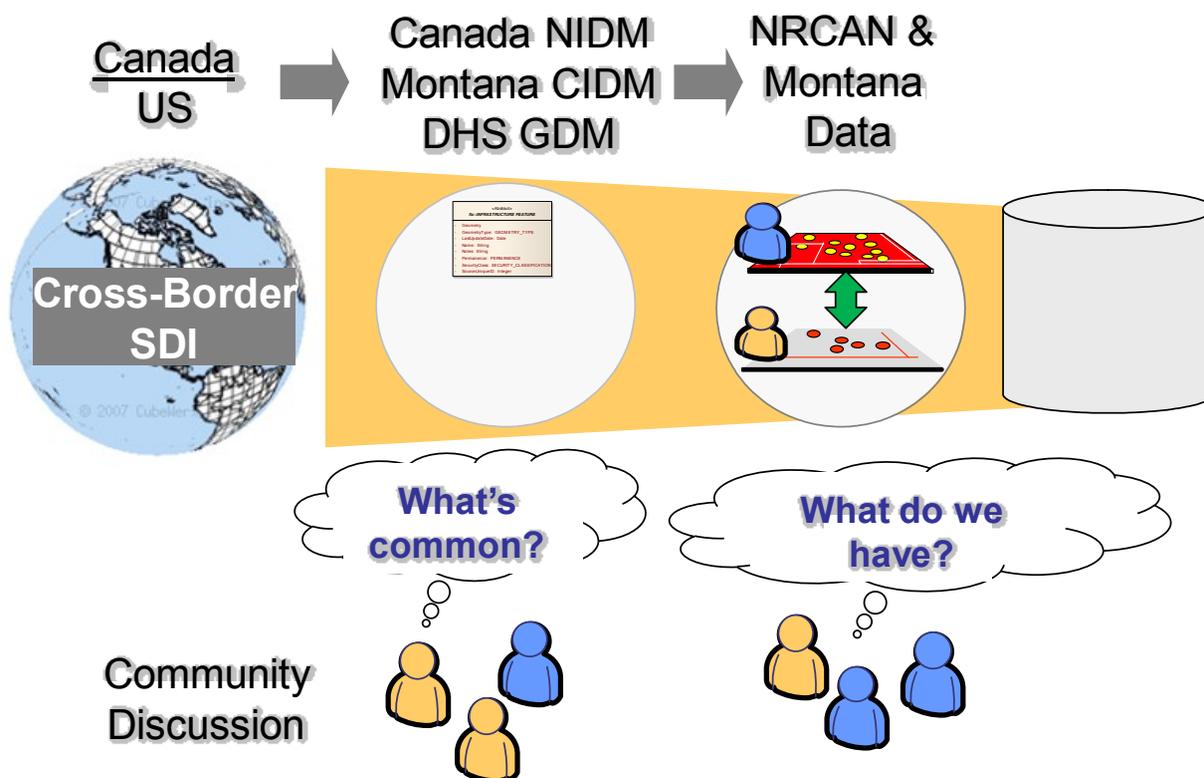


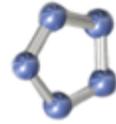
Figure 5 - Cross-Border SDI Common Data Model development process diverged from many geospatial data modeling processes by asking - what infrastructure data is common to both the US and Canada, and what infrastructure data do we have actually have? The result was a practical and implementable Common model.

To establish a Common data model for Cross-Border SDI the project team took an approach that diverged from most data modeling efforts in the geospatial community. Specifically, most data modeling efforts attempt to capture all possible data needs without regard for whether or not participating organizations have the data in hand or resources required to populate and maintain the model – invariably resulting in a data model “mandate” that is not sustainable. This challenge has arisen during many large-scale geospatial interoperability engineering efforts including those supported by US and Canadian government.

To address this situation the multi-national Cross-Border SDI project team adopted a practical approach to developing the Cross-Border SDI Common Model that said:

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- What infrastructure data is common to both the US and Canada?
- What infrastructure data do we have actually to deploy?

The crosswalk process data modeling effort used a series of Microsoft Excel and Enterprise Architecture data model representations (Figure 6) to “cross-walk” US and Canadian data during the project resulting in a model of cross-border infrastructure data implementable by US (Montana) and Canadian (NRCAN) project participants.

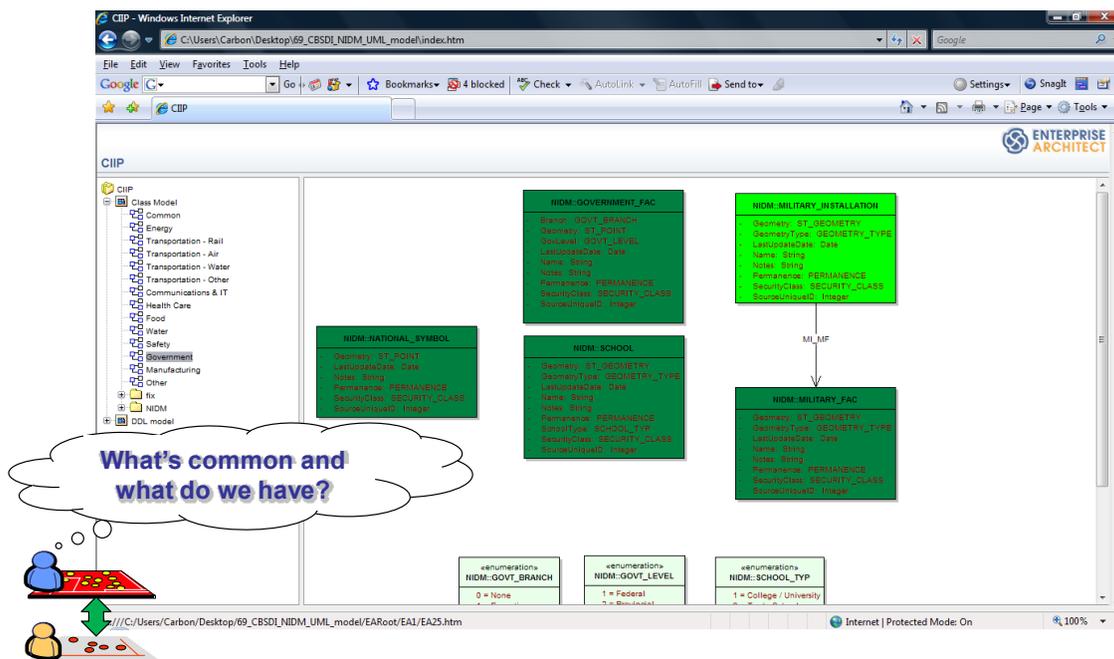


Figure 6 – The project used a series representations to “cross-walk” US and Canadian data models

In addition, the modeling process recognized that WFS deployed would not be used only for Cross-Border purposes. Rather, most of the time they would be accessed by users in either Canada or the US. To address this situation the modeling process included a National model with all the fidelity available in the Montana and the NIDM models.

The end point for the effort is summarized in Figure 7, where each WFS deployed “speaks two languages” – the National model and the Common model for cross-border information exchange.

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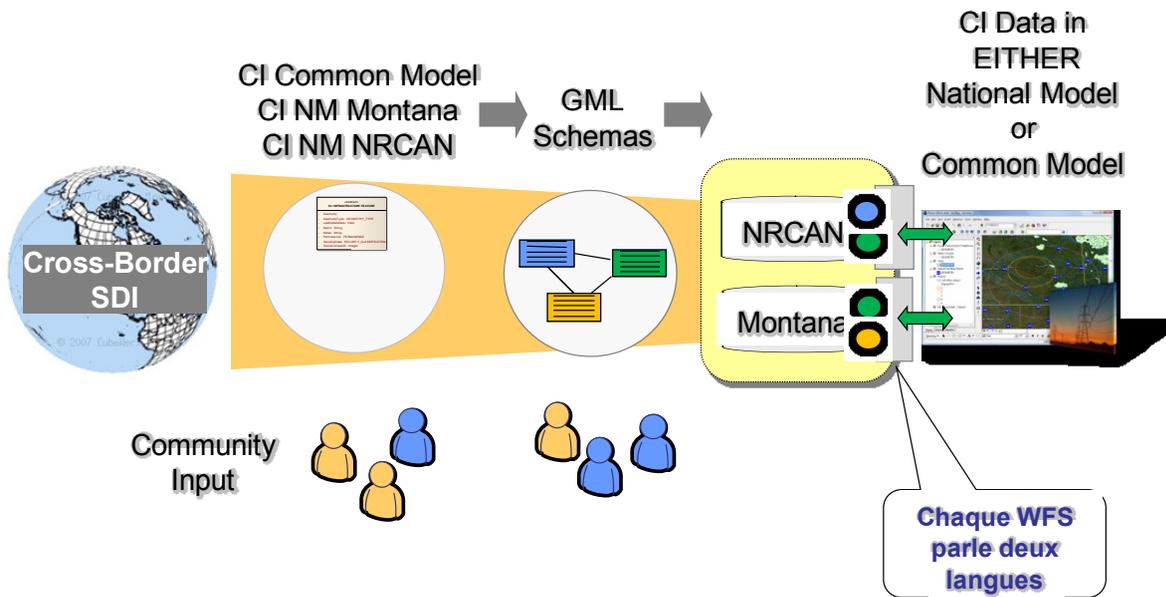
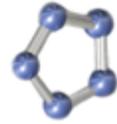


Figure 7 - Each WFS deployed “speaks two languages” – the National model and the Common model

The Common model describes classes and attributes common to both US and Canadian participants. The abstract INFRASTRUCTURE FEATURE represents all feature classes.

The Common Model was organized into eight infrastructure categories including communications and IT, energy, government, health care, safety, air transportation, rail transportation, and other transportation. Specific features deployed are summarized in

Appendix A and a sample set of model outputs is included in Appendix B. Due to the landlocked nature of the Montana border area participants recognize that additional hydrographic categories may need to be added to the model in the future.

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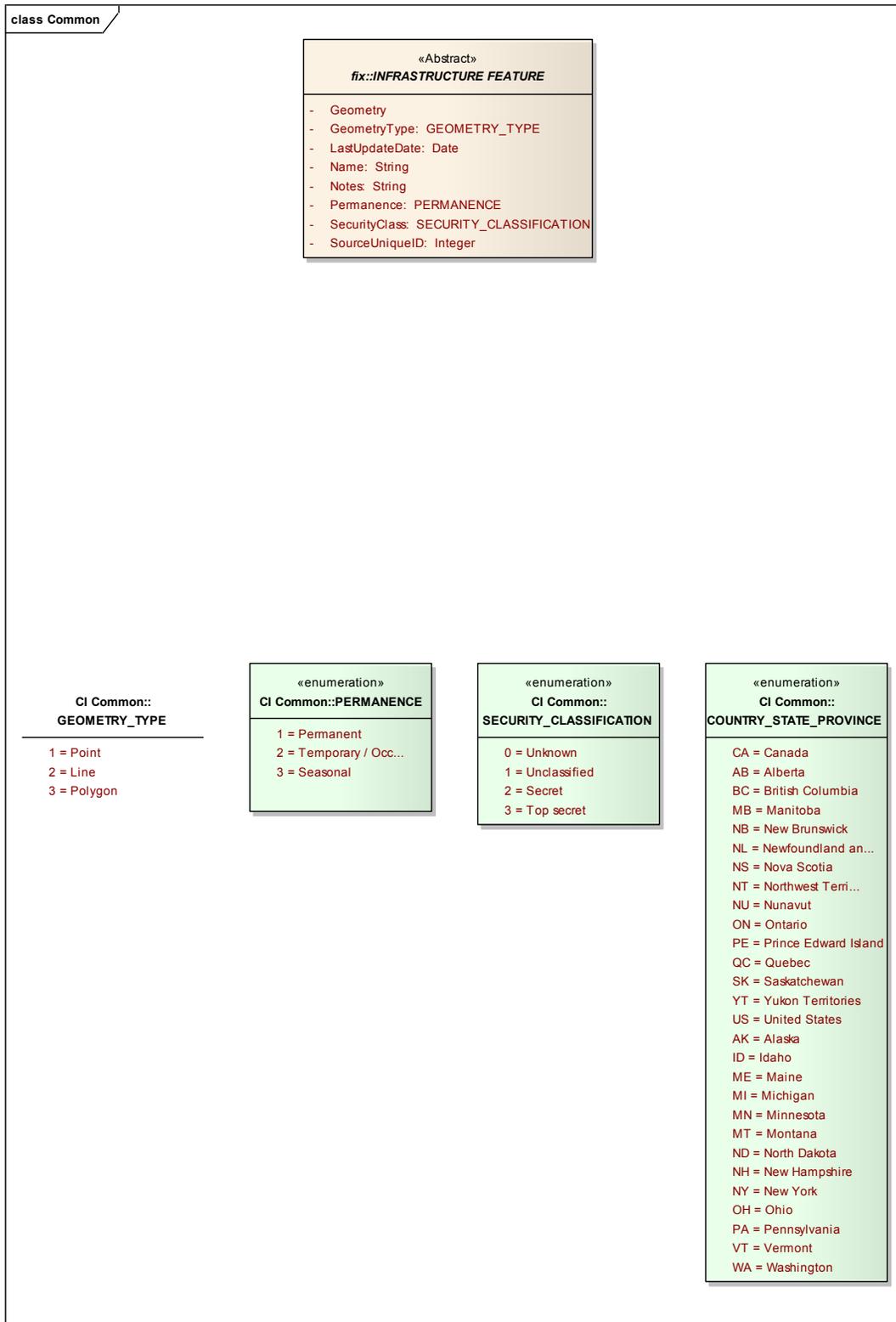
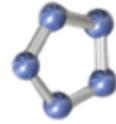
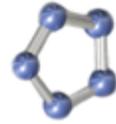


Figure 8 – Common Model abstract INFRASTRUCTURE FEATURE class

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The National and Common data models were converted to a Geography Markup Language for Simple Features (GMLsf) Exchange Schema. Each deployed WFS supports both local and cross-border international SDI use at the same time – with one database supporting both schemas through a Transformational WFS capability (WFS-X). A graphical depiction of the ability of a Cross-Border SDI WFS to provide GML in either the National (“Local”) or International Common Schema is summarized in Figure 9.

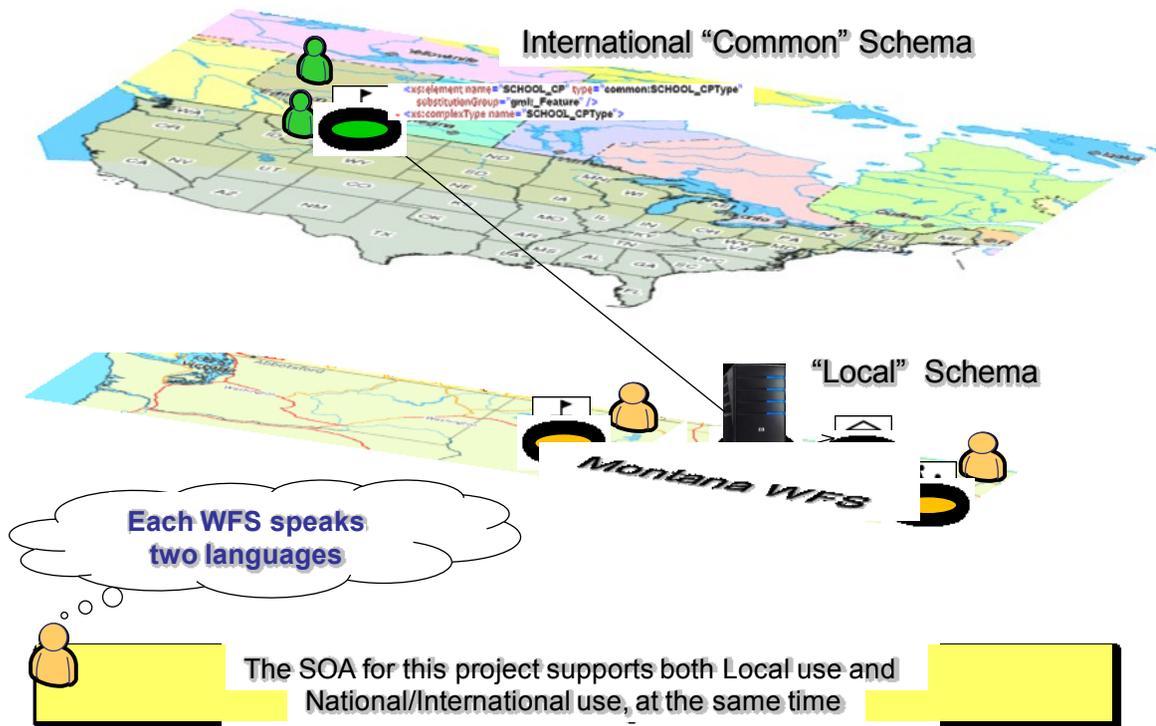


Figure 9 - Cross-Border SDI WFS can provide GML in either the National (“Local”) or International Common Schema

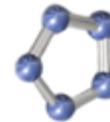
4.2. Services Development, Integration, Deployment

A key focus of this project was to use the results of the data modeling process described above to deploy an operational capability to use Web Map and Web Feature Services (WMS and WFS) software for infrastructure identification. This capability is based on Open Geospatial Consortium Web Feature Services (WFS), Filter Encoding (FE) and Geography Markup Language for Simple Features (GMLsf) standards. As discussed previously, these services provide a common query interface over distributed data sources.

To enable this important part of the project, a substantial portion of the project resources were directed to establishing distributed WFS in coordination with state and provincial collaborators (data providers) in Montana and NRCAN in Sherbrooke, Quebec. Specific WMS and WFS

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deployed are summarized in Table 1. These resources are now integrated with existing US National Spatial Data Infrastructure (NSDI) and Canadian Geospatial Data Infrastructure (CGDI) WFS resources from federal and provincial partners.

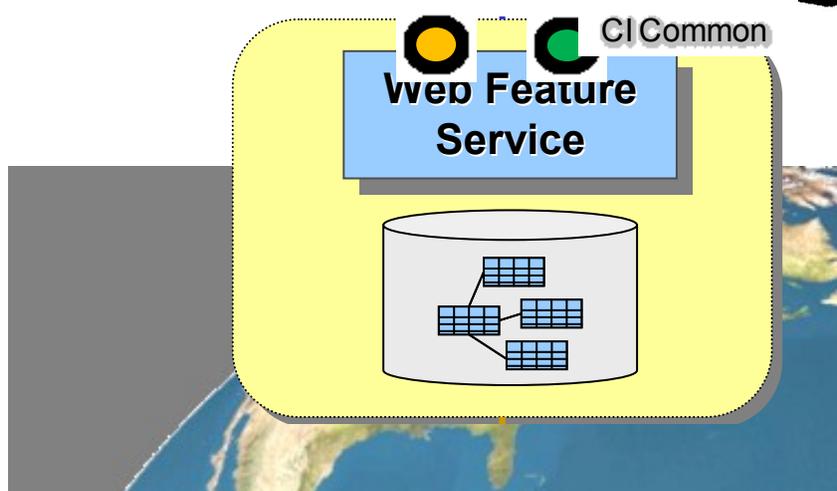
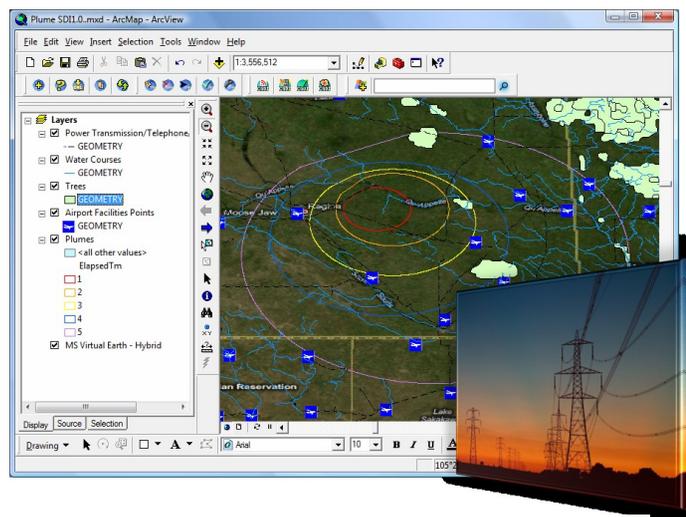
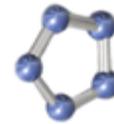


Figure 10 - Establishing distributed WFS in coordination with state and provincial collaborators (data providers) in Montana and NRCan in Sherbrooke, Quebec was a key project focus

To deploy Framework Data and Critical Infrastructure data in Quebec and Montana used the CubeSERV® Web Map and Feature Server from CubeWerx®. CubeWerx is the editor of the OGC WFS and Filter Encoding specifications and has transferred knowledge of the latest specifications into the CubeSERV® Web Map and Feature Server; a scalable, interoperable platform for serving geospatial maps and features on the Internet. CubeSERV fully supports all operations of the Web Feature Server, Filter Encoding and Web Map Server specifications, and implements application profiles of GML that enable deployment of truly interoperable Web Feature Service implementations.

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The Cross-Border SDI WFS are based on a secure, massively scalable online spatial data warehouses. Web Feature Service technology is used for Web-based access – with HTTP as distributed computing platform. Each CubeSERV® Web Map and Feature integrates the CI Common and National Schemas, Secure SDI and Transaction-based updates. In addition, the WFS have the capacity to dynamically translate from one community schema to another – local to national.

Table 1: CGDI/NSDI Data Services Deployed and Status

Data custodian/service provider	Use in application	Dataset name	Type of infrastructure compliant Web service and Status
<i>Montana Department of Administration, Information Technology Services Division</i>	<i>Data visualization</i>	<i>Critical Structures Database (Common and Local Models)</i>	<i>WMS</i>
<i>Montana Department of Administration, Information Technology Services Division</i>	<i>Data access and analysis</i>	<i>Critical Structures Database (Common and Local Models)</i>	<i>WFS</i>
<i>Centre for Topographic Information, Natural Resources Canada</i>	<i>Data visualization</i>	<i>Framework Data Land Features and CI Layers (Common and Local Models)</i>	<i>WMS</i>
<i>Centre for Topographic Information, Natural Resources Canada</i>	<i>Data access and analysis</i>	<i>Framework Data Land Features and CI Layers (Common and Local Models)</i>	<i>WFS</i>

The open WMS and WFS Service URLs for the CBSDI project are provided below:

Montana WMS:

<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=common>

<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=national>

Montana WFS:

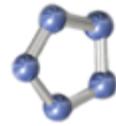
<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=common&service=wfs&datastore=Montana>

<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=national&service=wfs&datastore=Montana>

Sherbrooke WMS:

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=common>

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=national>



Sherbrooke WFS:

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=common&service=wfs&datastore=CrossBorder>

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubeserv/cubeserv.cgi?config=national&service=wfs&datastore=CrossBorder>

As part of this effort, the project team also implemented a prototype distributed security, role-based access control framework based on CubeWerx® Identity Management Server. This was done to prototype the framework necessary to secure CI data that cannot or should not be shared with all parties.

The security framework used Identity Management Server (IMS) technology to provide certificate-based credentials for open geospatial services, including secure Web Feature Services (WFS). From the user/client perspective there are two key functionalities –

- Logging into an Authentication Service to access the credentials needed.
- These credentials are applied to OGC WFS services to enable response to queries with information according to the user rights and access rules.

The IMS technology used in the distributed prototype environment required any software client wishing to access secure data to apply corresponding certificates before access is granted to any server operated by a stakeholder who wishes to secure their data.

To get the required user credentials the client application needs to log-in to an Authentication service. Users open a dialog that requires them to type in a user name and password (See Figure 11). The user then selects the authentication service URL and adds an optional jurisdiction parameter. Once the information is set, clicking on a 'Get User Credentials' button will fetch the list of credentials from the authentication service. This process is done through a simple GET type HTTP request.

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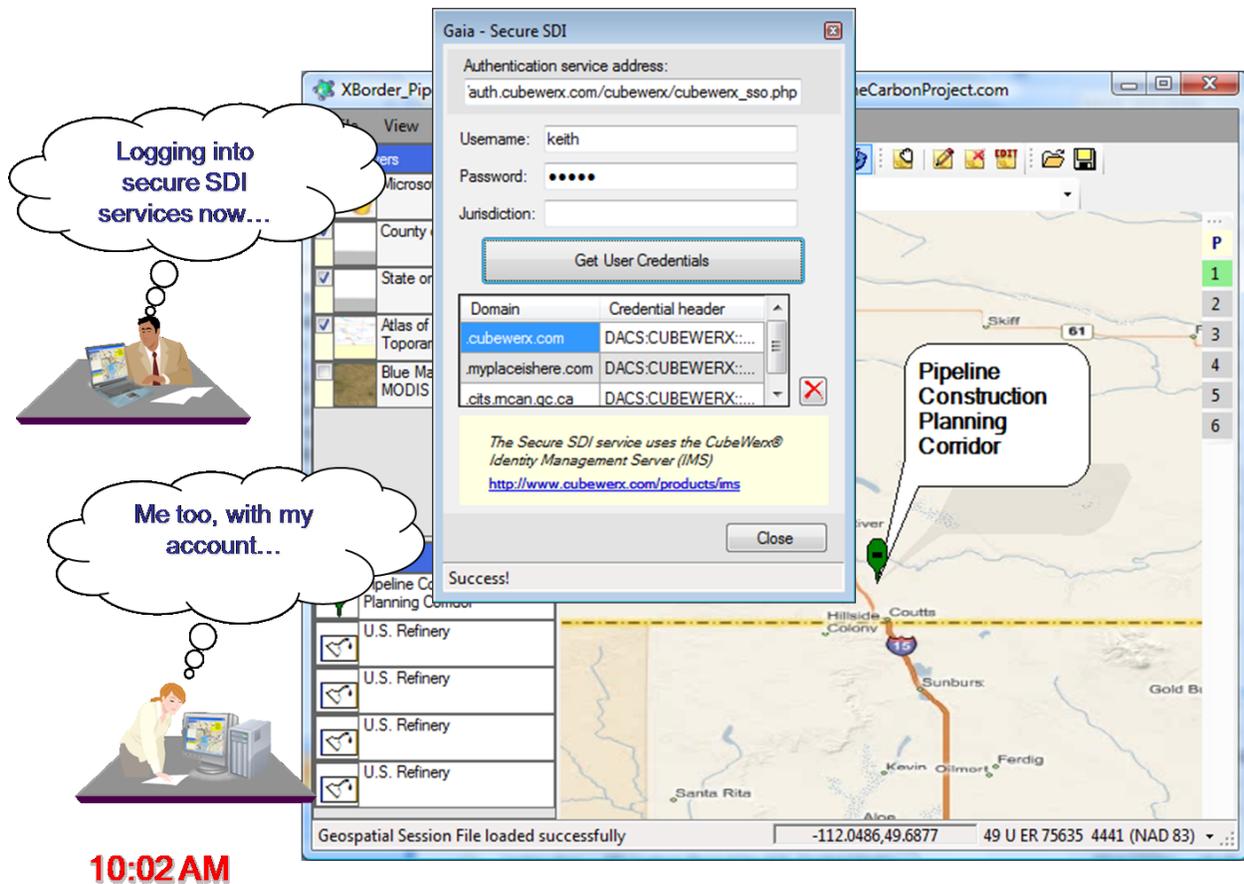
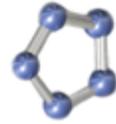
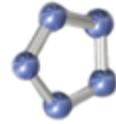


Figure 11 - Authentication Service

Once the service responds the client analyzes the XML payload and the HTTP headers. The XML part of the response contains a 'credentials' reference. This value allows the client to go through the list of HTTP headers and collect the ones that are credentials. Each credential element contains a domain reference and the client adds the information to the CBSDI map client domain-specific headers. The CBSDI map client provides the distinct ability to control the HTTP requests sent to OGC Web Services. This level of control over the communication layer is crucial for the Secure SDI implementation.

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The screenshot shows a GIS application window titled 'Gaia - Add Layer to Map'. It features a list of OGC Services, a 'Details' panel for a selected WFS layer, and a map view. The 'Details' panel shows parameters for a WFS layer named 'common:COMMUNICATION_TOWER_CP'. The map view displays a 'Pipeline Construction Planning Corridor' with various features and a callout box. A thought bubble from a user icon says 'Accessing secure WFS with the single-sign on'. A timestamp '10:03 AM' is displayed at the bottom left. The status bar at the bottom indicates 'Geospatial Session File loaded successfully' and provides coordinates: '-111.7631,48.6753 49 U EP 56173 91645 (NAD 83)'.

Figure 12 - WFS in the security jurisdiction

Once the credentials are acquired they can be applied to any WFS in the security jurisdiction. Since the certificates are inspected and applied at the communication layer of the CBSDI map client, all queries are affected (See Figure 12). Therefore, getting capabilities, features, or performing transactions on a WFS-T will all use the appropriate certificate. Furthermore, if a user has more than one certificate associated with the service, for example by belonging to more than one authentication group, all credentials will be applied to the query.

In case access is not granted the server returns a 'Forbidden' error (403) and a report will be issued on the CBSDI map client internal messages log. This will also result in the CBSDI map client being unable to read the service capabilities or perform any updates on the data layer coming from the secured service. When access is granted the user can access the service normally, allowing capabilities, features and maps to be read. However, the response will take into account the privileges granted to the certificate holder by the management system.

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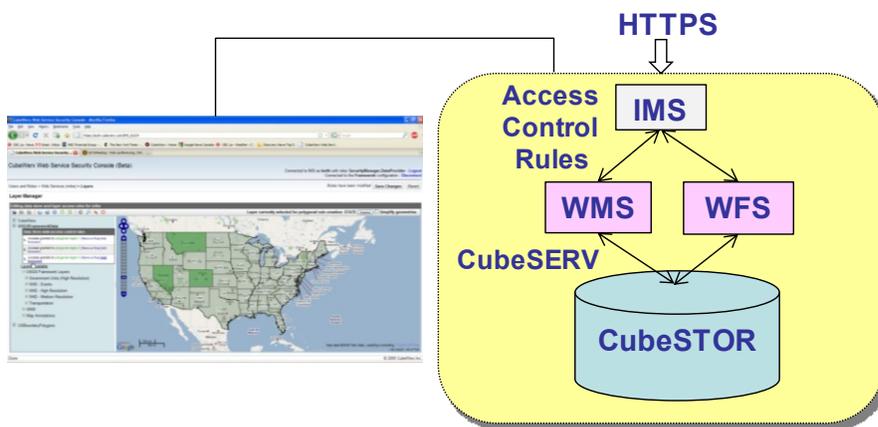
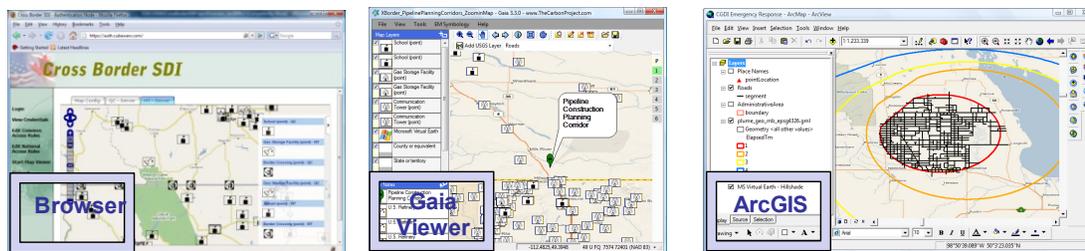
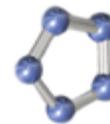


Figure 13 – Role-based Access Control Rules and Identity Management Capability

This project leveraged our team’s investment in developing solutions to solve important security challenges related to collaborative SDI. Specifically, provided an access control framework to facilitate secure sharing web resources and manage the roles of participants. As discussed, the project leveraged CubeWerx Identity Management Service (IMS) to do this. IMS is a framework to manage identities and enforce role-based access control rules on web resources. Rather than dictating policies, its goal is to support policy rules already available in most organizations and provide secure, flexible, extensible, and highly available components for supporting Access Control Rules (ACL). These components are invoked as web services, allowing each trusted organization in a federation to determine its authentication and access control policies.

By specifying rules for web services, the IMS can grant unrestricted access to geospatial SOA resources to some users, limited kinds of access to other users, and completely deny access to yet another set of users. Each access control rule grants (or denies) requests made by an individual or group of individuals, possibly depending on details associated with the request. Referring to one or more web services ("What"), a rule specifies, for a given set of users ("Who"), the conditions under which access is to be granted to them ("How"). A user can be associated with **roles** within an organization ("Michael is a Project Manager") or with a **group** whose membership is known throughout the system (e.g., "Michael is currently working on Project CBSDI"). Access control rules at any CBSDI organization can refer to these roles (e.g., "Grant access to any Project Manager ") and groups (e.g., "Grant access to any member of Project CBSDI ").

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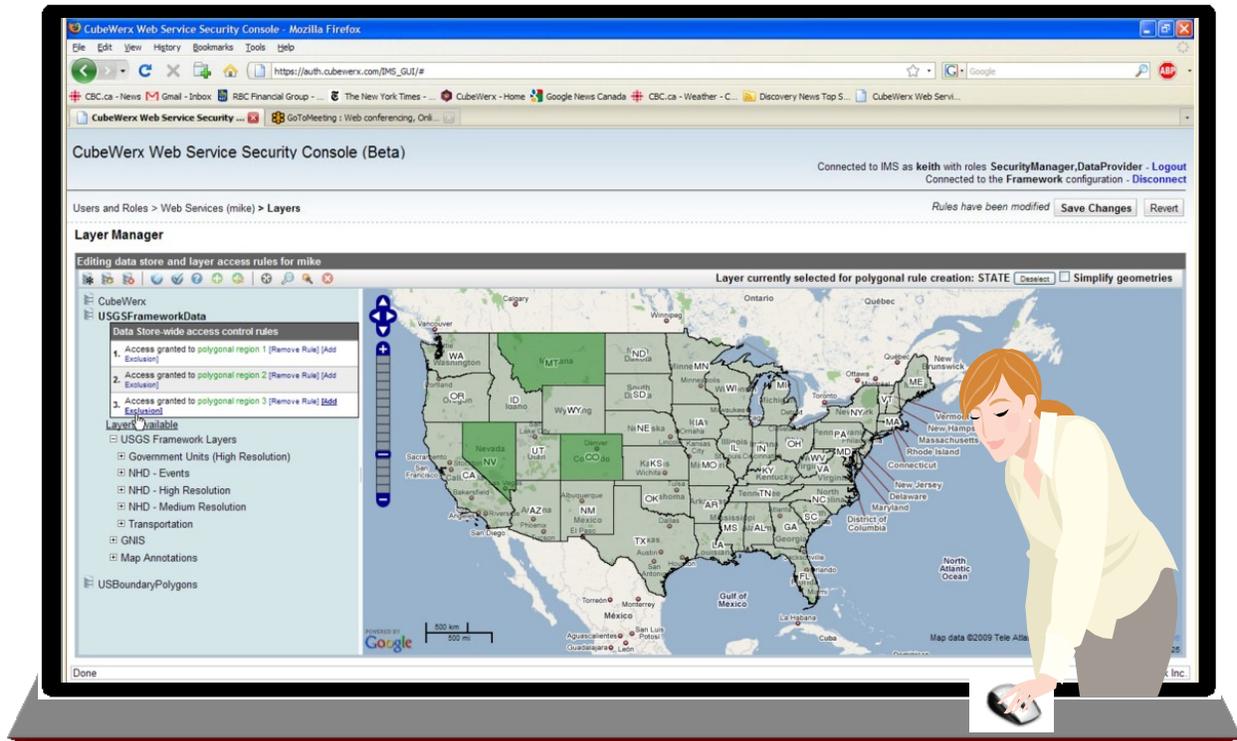
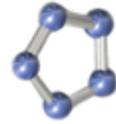


Figure 11 - The role-based access control framework for CBSDI enables a secure collaborative environment for access and update from many partners (multiple states shown for illustrative purposes only)

Because rules refer to user roles and names ("*Michael the Project Manager*"), IMS provides a way to name users and mechanisms to manage user identities, including the means by which users can be authenticated. A person is authenticated and assumes an identity by demonstrating knowledge of a secret (such as a password), or possession of some other information, that is associated with that identity as described above. IMS has a flexible authentication framework that supports multiple authentication methods. To authenticate a user known to an organization, IMS uses systems already used to authenticate users. This allows an organization to use existing authentication methods. A user might be authenticated at an organization by providing a username/password that is recognized in the organization, or via X.509 certificates.

The CBSDI project defined the following candidate roles for secure access:

- Data Provider
- User
- Data Quality Assessor
- Security Manager

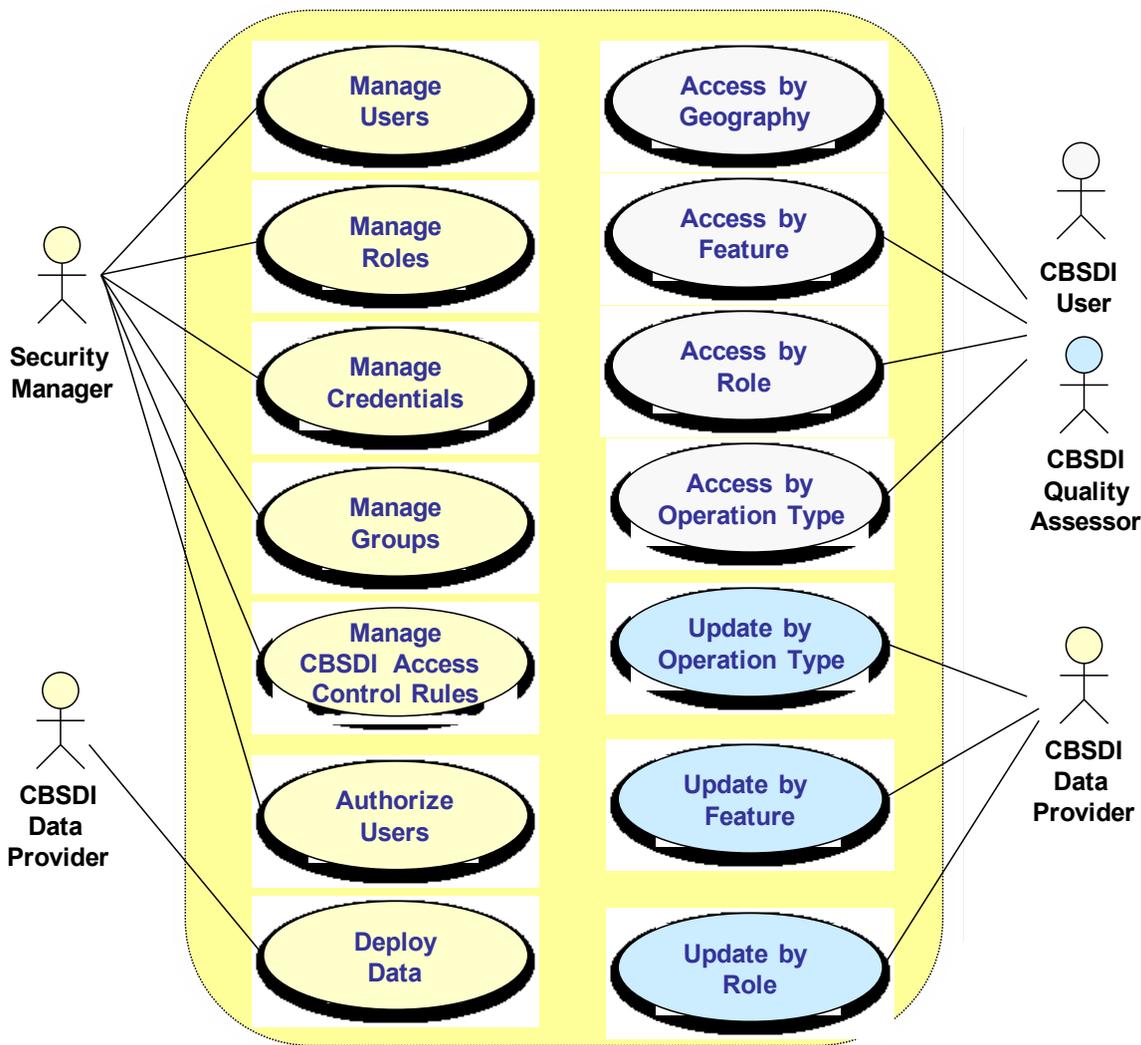
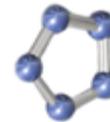


Figure 14 - The CBSDI project defined four candidate roles for secure CBSDI

4.3. Application Development and Integration

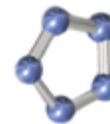
This project is unique since it deploys both online content and services and a suite of applications to use them.

The primary demonstration tool since the beginning of the project has been The Carbon Project's Gaia SDI Platform¹. For this effort new versions of Gaia have been deployed using Gaia Extenders API. Gaia provides a robust and open API that allows programmers to develop Gaia Extenders with or without a CarbonTools PRO license. The Gaia Extenders are light, easy to deploy and can alter Gaia's functionality. For this project, the Secure SDI, Emergency Mapping Symbology, US National Grid were integrated. In particular, the Secure SDI Extender was

¹ <http://www.thecarbonproject.com/gaia.php>

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iteratively tested and enhanced to provide easy access to the secure WFS of the Cross—Border SDI Network.

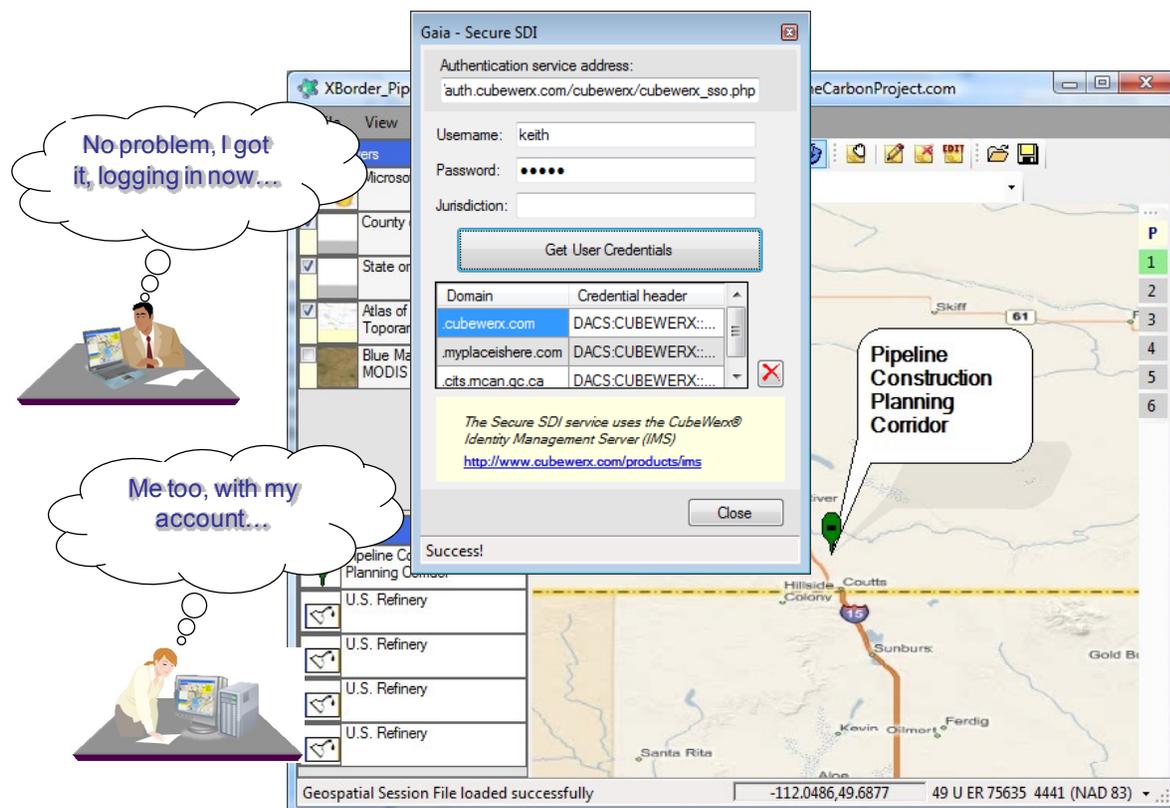


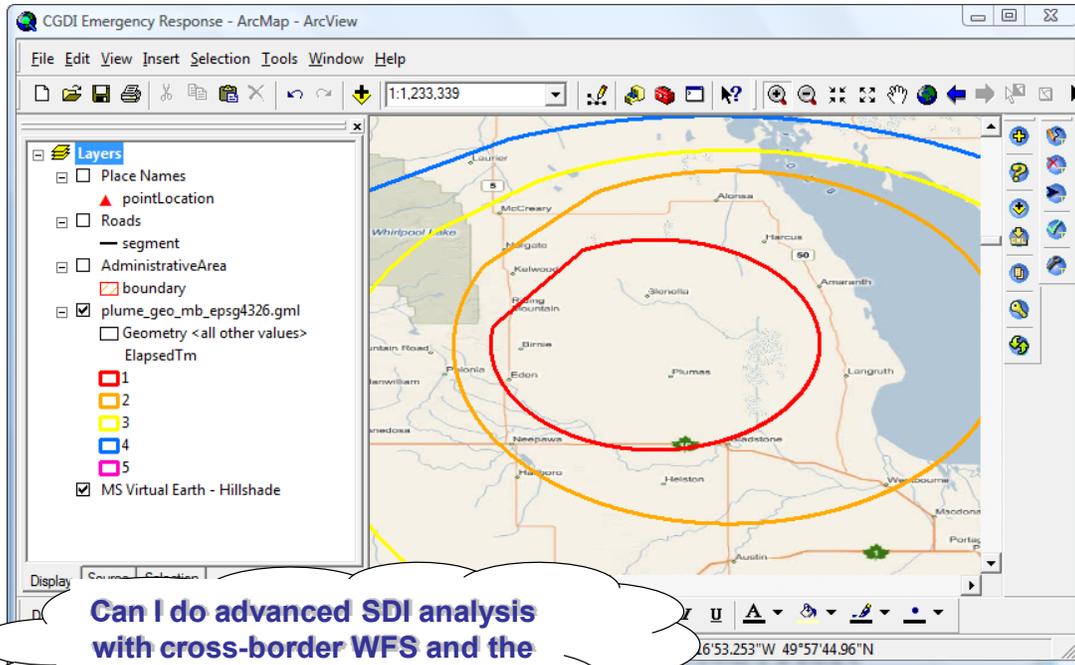
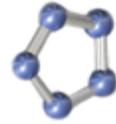
Figure 15 - The Cross-Border SDI Project has implemented a full Role-based Access Control Framework, shown about in use through the Secure SDI Extender in Gaia

To enable ArcGIS to support critical infrastructure identification via a common, cross-border SDI project leverages CarbonArc PRO² Filter Builder tools. Originally, developed as part of the CGDI Interoperability Pilot, this extension supports a Use Case where infrastructure needed to be identified – using the SDI to conduct the analysis. For the CGDI CarbonArc used a simulated release plume polygon in GML to construct new features such as impacted airports and powerlines. This involved intersecting release plume polygons with the impacted areas. To do this CarbonArc used the capabilities of the distributed CGDI architecture and WFS technology. Specifically, CarbonArc used the Filter Encoding specification and WFS-T services – and this same approach is supporting critical infrastructure identification via a common, cross-border SDI. To leverage the common SDI, users access the tools in CarbonArc to create or use an existing feature such as a release plume polygon (or any feature), construct a Filter Encoding request using Spatial Operators (in this case it was the Spatial Operator “Intersect”), then send it to a WFS-T in the SDI and acquire new features such as critical infrastructure from the WFS. All this was demonstrated during the CGDI Pilot using the CubeWerx WFS – and was one of the most popular elements of the project. The Use Case is illustrated below:

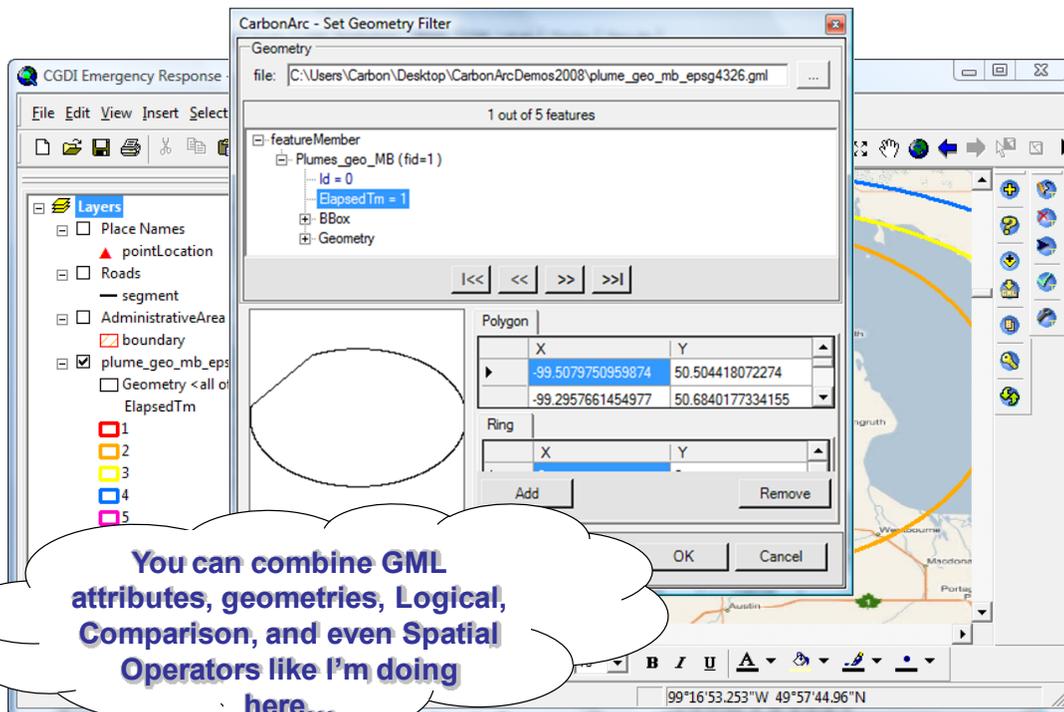
² <http://www.thecarbonproject.com/carbonarc.php>

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Can I do advanced SDI analysis with cross-border WFS and the latest WFS/Filter standards?

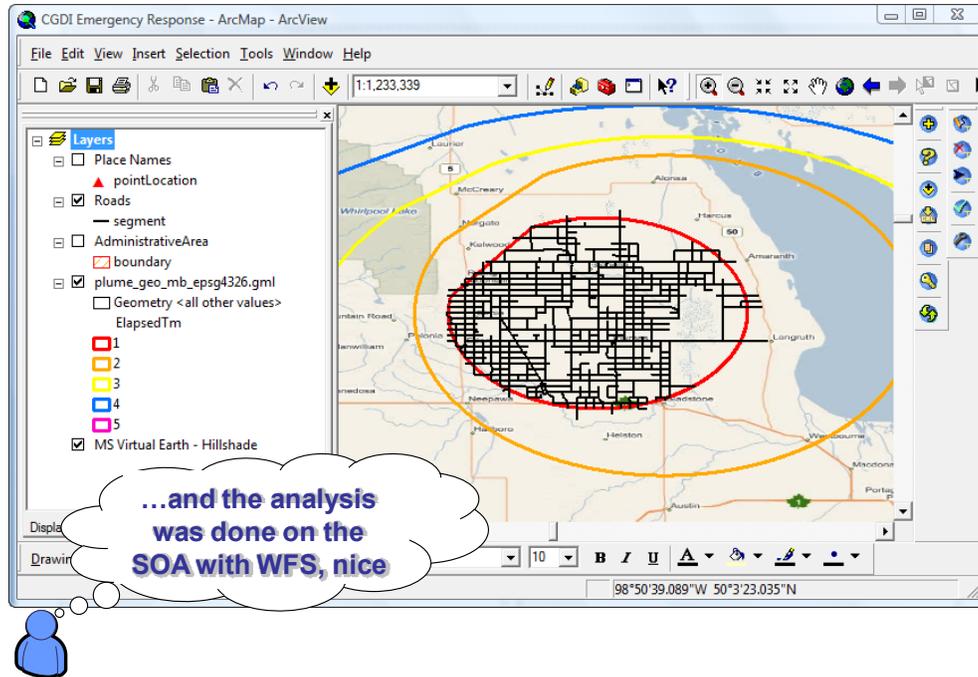
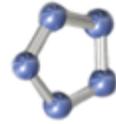


You can combine GML attributes, geometries, Logical, Comparison, and even Spatial Operators like I'm doing here...



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In addition, CubeWerx has developed a web-based application to access the Cross-Border SDI Network (Figure 16).

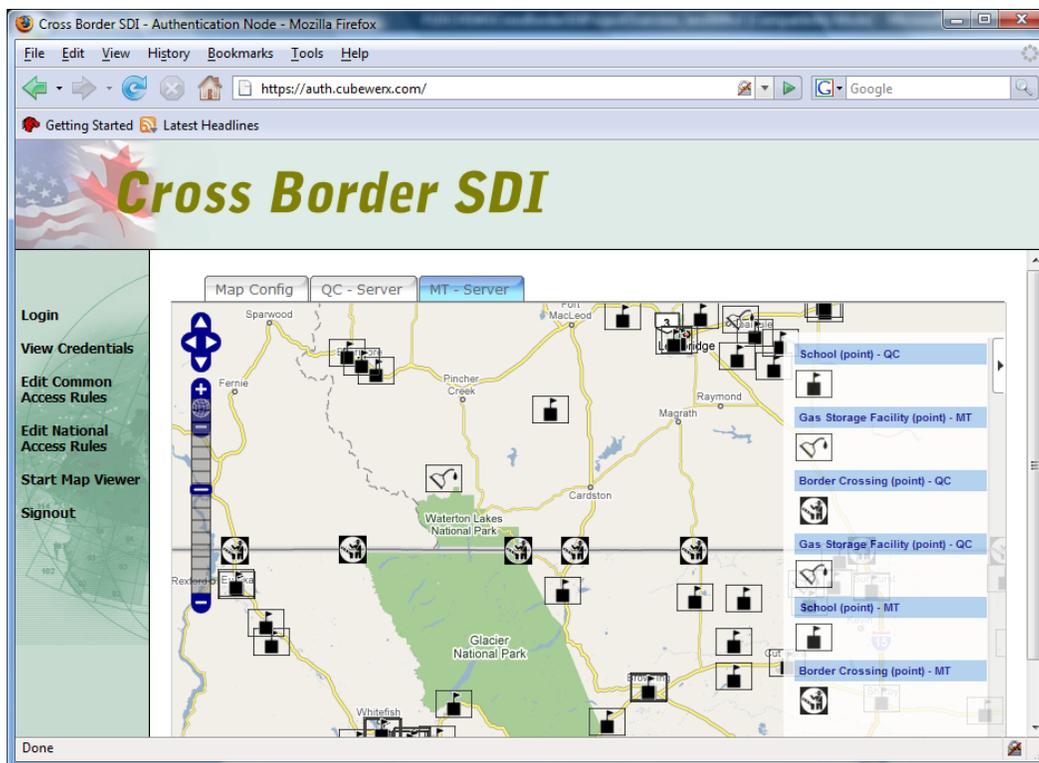
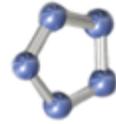


Figure 16 - CubeWerx web-based application used to access the Cross-Border SDI Network



An open access web client from CubeWerx is also available. To Montana access Montana WMS via a Web browser use the following links -

<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubexplor/cubexplor.cgi?config=national>

<https://crossborder.mtbmsc.org/unsecure/cubewerx/cubexplor/cubexplor.cgi?config=common>

To access Sherbrooke WMS via a Web browser use the following links -

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubexplor/cubexplor.cgi?config=national>

<https://wasp.cits.rncan.gc.ca/unsecure/cubewerx/cubexplor/cubexplor.cgi?config=common>

5. Community Outreach Summary

This project has already delivered distributed data, services and applications that can be widely used. All online data, services and interoperable applications are available in non-proprietary formats, including WMS, WFS and GML. The project team has successfully avoided practices that would inhibit the use of the distributed data and deliver short term gains. This project has focused on interoperable SDI solutions and created an environment that will entice additional participation from other communities of practice.

As part of this project, we have engaged in a consistent community outreach program that has reached users in both the US and Canada. A significant component of this community engagement has been our efficient use of weekly online meetings and a collaborative project workspace. The Cross-Border SDI Project includes a simple, secure and powerful online workspace provided by The Carbon Project to help us connect, share and collaborate. The project space is available at <http://crossbordersdi.projectsaces.com>. In addition, we announced the project to both Canadian and US online audiences. See http://www.thecarbonproject.com/news_canadaCBI.php and <http://www.cubewerx.com/web/guest/docs/press/13613>.

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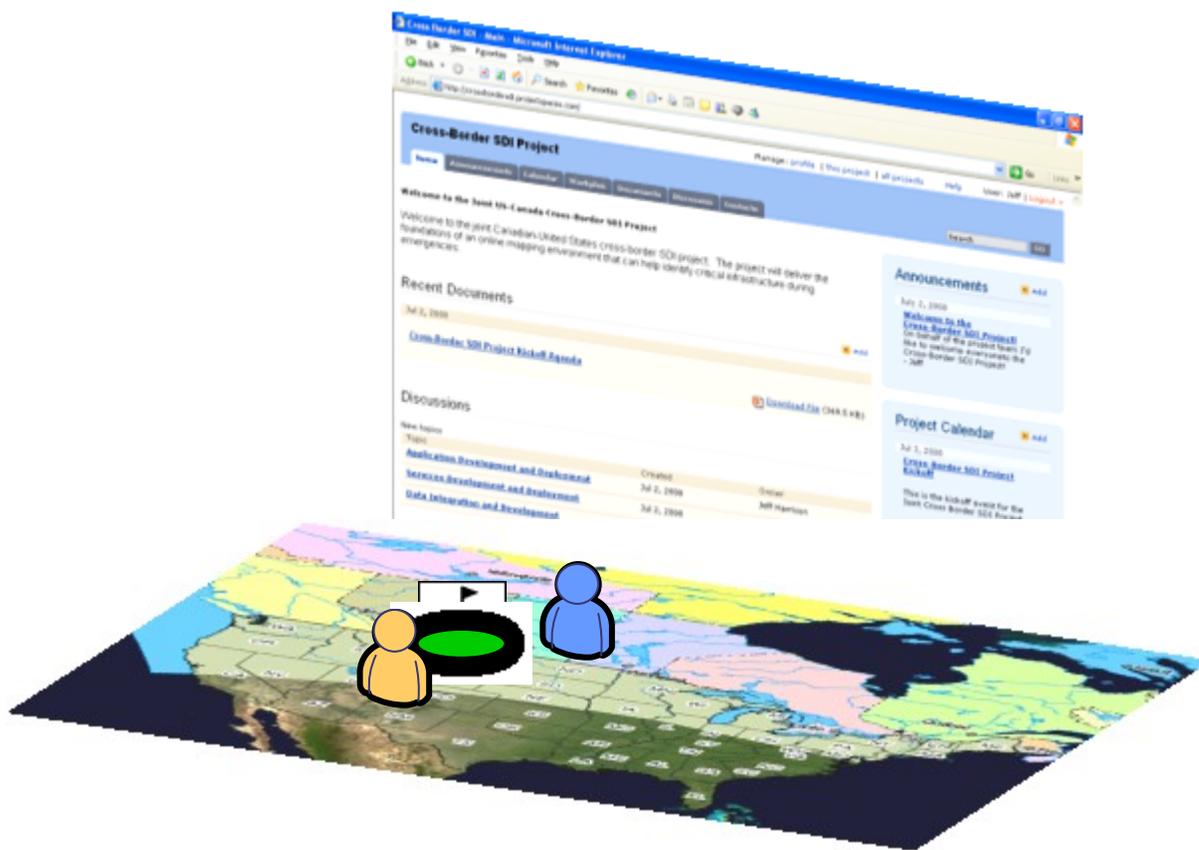
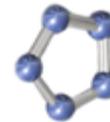


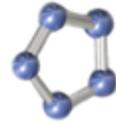
Figure 17 - A significant component of our community engagement has been the efficient use of weekly online meetings and a collaborative project workspace.

During all Community Outreach activities the project team has invited the participation of organizations having similar interests over the project area.

During the project we have successfully briefed the Cross-Border SDI effort multiple community venues including CANUS at NGA in Reston, VA, GEOINT 2008 in Nashville, TN, the FGDC Homeland Security Working Group (HSWG) in Washington, DC, the HIFLD meeting in Colorado in January 2009, the first Geospatial SOA and Cloud Computing Workshop in Washington, DC in June 2009. The Cross-Border SDI effort will also be presented at the 2009 ASCE Conference in October.

6. Summary of Activity

Since project kickoff in July 2008 the Cross-Border SDI Project made significant progress deploying new online data, services and applications to support critical infrastructure (CI) identification using a common SDI for Canada and the US. In particular, the project has developed and deployed four online services based on OGC Web Feature Service (WFS), Filter and GML standards and CubeWerx software. The services are located in Montana and Quebec and constitute possible initial nodes for a Cross-Border SDI (CBSDI) Network. Each WFS also



implements a prototype role-based access control framework - meaning there is a now testbed for a security framework that ensures CI information goes to the people that are supposed to have it.

The project also made substantial progress integrating infrastructure data models used by Montana with the National Infrastructure Data Models (NIDM) from Canada, with input from the DHS Geospatial Data Model - the result of this effort is an integrated "Common" data model and new GML community schema for cross-border infrastructure data exchange called CBSDI GML. The project also pioneered the implementation of dynamic, local-to-community GML schema transformation for infrastructure data – meaning each WFS speaks both its national schema and an agreed-upon community schema (powered by the same underlying databases).

As of September 2009, cross-border SDI users are now able to access the four data services using the free Gaia 3.4 SDI platform from The Carbon Project, web-based applications from CubeWerx, and CarbonArc PRO, an SDI interoperability extension for ESRI's ArcGIS from The Carbon Project.

The project has been successfully briefed in multiple community venues including CANUS, GEOINT 2008, the FGDC Homeland Security Working Group (HSWG), HIFLD, the first Geospatial SOA and Cloud Computing Workshop in Washington, DC, and will be presented at the 2009 ASCE Conference in October. In the future, the collaborative group working on this effort will seek to advance the GML community schema for cross-border infrastructure data exchange, CBSDI GML, and register the Cross-Border WFS with the GOS Portal.

For more information please visit www.thecarbonproject.com/crossbordersdi.php.

7. Feedback on Cooperative Agreements Program

What are the program strengths and weaknesses?

Strengths - Good management, easy to understand the process and become engaged. The program has helped develop key elements of the NSDI and more operational resources are now available to the user community as a result of CAP. The program has been consistent in its support of standards-based services over the last few years and this focus is now yielding tangible results across the NSDI.

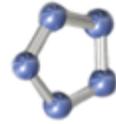
Weaknesses - Additional external Federal engagement (i.e. outside FGDC) in project continuation and partnering efforts should continue to be encouraged. This is occurring but agencies such as DHS, EPA can benefit and should continue to engage more in the process. Specifically, the CAP needs to have continued strong liaison in operational aspects of USGS and with other state, federal, and commercial interests.

Where does the program make a difference?

Overall, the program is making very good progress towards deploying initial NSDI services online. Continued emphasis needs to be placed on promoting an online infrastructure of standards-based location content across the nation that can flexibly support operational

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requirements, and governance of resulting standards for information sharing. We can identify no technical impediments to advancing such an infrastructure. However, we suspect funding issues are holding back development of this online infrastructure.

Was the assistance you received sufficient or effective?

Assistance was very effective in establishing this project and executing it.

What would you recommend doing differently?

The CAP should consider multi-year projects. Right now, the projects only cover small parts of NSDI deployment. More extensive, multi-year projects would enable greater progress to operationalization of NSDI.

The CAP should also consider more projects that are multi-level in nature, meaning local-state-federal levels. To deploy distributed infrastructures local-state-federal levels should be engaged in focused efforts that include both data access and *maintenance in a collaborative manner* at multiple levels. This is happening but it needs to accelerate. The benefit of such multi-level efforts is enormous as they help drive out key technical and policy elements of a distributed NSDI.

Are there factors that are missing or additional needs that should be considered?

The CAP program should consider increasing the pace of development of online infrastructures for standards-based location content by coordinating with local and state organizations for both deployment and maintenance of key framework data themes. For example, there is no reason why a low-cost expanded program cannot provide grant incentives to hundreds of localities across the nation to make their own framework data available via simple Web Map and Features Servers so that these sources can be used for a variety of purposes. This type of investment is a “win-win” for the Nation.

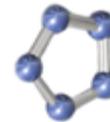
Federal programs also need to consider deployment of some of the key components of the federal infrastructure on cloud-computing platforms. Projects that demonstrate using the cloud for framework data access and geoprocessing in the NSDI could help drive out key IT and cost-benefit analyses.

Are there program management concerns that need to be addressed? Time frame?

No

If you were to do this again, what would you do differently?

Nothing, the partners and the project were worked very well.



Appendix A – Data loaded on both Montana and Québec (NRCan) WFS and available in GML

Montana Server

Common Schema

Tables Loaded

- 1 L_PIPELINE_COMMON
- 2 L_POWRLINE_COMMON
- 3 L_RAILWAY_COMMON
- 4 P_AEROHELI_COMMON
- 5 P_AMBUFIRE_COMMON
- 6 P_BRDRCRSS_COMMON
- 7 P_COMMTWER_COMMON
- 8 P_CORRFACI_COMMON
- 9 P_GASSTORG_COMMON
- 10 P_GOVFACIL_COMMON
- 11 P_MEDIFACI_COMMON
- 12 P_MILFACIL_COMMON
- 13 P_POLISTNT_COMMON
- 14 P_POWRPLNT_COMMON
- 15 P_RADTVBRC_COMMON
- 16 P_SCHOOL_COMMON
- 17 P_SUBSTATN_COMMON

Common Model Defined

- CI Common::PIPELINE
- CI Common::POWERLINE
- CI Common::RAILWAY_SEGMENT
- CI Common::AERODROME_HELIPORT
- CI Common::FIRE_STATION_AMBULANCE
- CI Common::BORDER_CROSSING
- CI Common::COMMUNICATION_TOWER
- CI Common::CORRECTIONAL_FACILITY
- CI Common::GAS_STORAGE_FACILITY
- CI Common::GOVERNMENT_FACILITY
- CI Common::MEDICAL_FACILITY
- CI Common::MILITARY_FACILITY
- CI Common::POLICE_STATION
- CI Common::POWER_PLANT
- CI Common::RADIO_TV_BROADCAST_FACILITY
- CI Common::SCHOOL
- CI Common::SUBSTATION

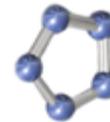
National Schema

Tables Loaded

- 1 L_PIPELINE_NATION
- 2 L_POWRLINE_NATION
- 3 L_RAILWAY_NATIONA
- 4 P_AEROHELI_NATION
- 5 P_AMBUFIRE_NATION
- 6 P_BRDRCRSS_NATION
- 7 P_COMMTWER_NATION
- 8 P_CORRFACI_NATION
- 9 P_GASSTORG_NATION
- 10 P_GOVFACIL_NATION
- 11 P_MEDIFACI_NATION
- 12 P_MILFACIL_NATION
- 13 P_POLISTNT_NATION
- 14 P_POWRPLNT_NATION
- 15 P_RADTVBRC_NATION
- 16 P_SCHOOL_NATIONAL
- 17 P_SUBSTATN_NATION

National Model Defined

- CI National::PIPELINE
- CI National::POWERLINE
- CI National::RAILWAY_SEGMENT
- CI National::AERODROME_HELIPORT
- CI National::FIRE_STATION_AMBULANCE
- CI National::BORDER_CROSSING
- CI National::COMMUNICATION_TOWER
- CI National::CORRECTIONAL_FACILITY
- CI National::GAS_STORAGE_FACILITY
- CI National::GOVERNMENT_FACILITY
- CI National::MEDICAL_FACILITY
- CI National::MILITARY_FACILITY
- CI National::POLICE_STATION
- CI National::POWER_PLANT
- CI National::RADIO_TV_BROADCAST_FACILITY
- CI National::SCHOOL
- CI National::SUBSTATION



Québec Server (NRCan)

Common Schema

Tables Loaded

1	L_PIPELINE_COMMON
2	L_POWRLINE_COMMON
3	L_RAILWAY_COMMON
4	P_AEROHELI_COMMON
5	P_AMBUFIRE_COMMON
6	P_BRDRCRSS_COMMON
7	P_COMMTWER_COMMON
8	P_CORRFACI_COMMON
9	P_GASSTORG_COMMON
10	P_GOVFACIL_COMMON
11	P_MEDIFACI_COMMON
12	P_MILFACIL_COMMON
13	P_POLISTNT_COMMON
14	P_POWRPLNT_COMMON
15	P_RADTVBRC_COMMON
16	P_SCHOOL_COMMON
17	P_SUBSTATN_COMMON
18	A_AEROHELI_COMMON
19	A_AMBUFIRE_COMMON
20	A_BRDRCRSS_COMMON
21	
22	A_CORRFACI_COMMON
23	A_GASSTORG_COMMON
24	A_GOVFACIL_COMMON
25	A_MEDIFACI_COMMON
26	A_MILFACIL_COMMON
27	A_POLISTNT_COMMON
28	A_POWRPLNT_COMMON
29	A_RADTVBRC_COMMON
30	A_SCHOOL_COMMON
31	A_SUBSTATN_COMMON

Common Model Defined

CI Common::PIPELINE
CI Common::POWERLINE
CI Common::RAILWAY_SEGMENT
CI Common::AERODROME_HELIPORT
CI Common::FIRE_STATION_AMBULANCE
CI Common::BORDER_CROSSING
CI Common::COMMUNICATION_TOWER
CI Common::CORRECTIONAL_FACILITY
CI Common::GAS_STORAGE_FACILITY
CI Common::GOVERNMENT_FACILITY
CI Common::MEDICAL_FACILITY
CI Common::MILITARY_FACILITY
CI Common::POLICE_STATION
CI Common::POWER_PLANT
CI Common::RADIO_TV_BROADCAST_FACILITY
CI Common::SCHOOL
CI Common::SUBSTATION
CI Common::AERODROME_HELIPORT
CI Common::FIRE_STATION_AMBULANCE
CI Common::BORDER_CROSSING
CI Common::COMMUNICATION_TOWER
CI Common::CORRECTIONAL_FACILITY
CI Common::GAS_STORAGE_FACILITY
CI Common::GOVERNMENT_FACILITY
CI Common::MEDICAL_FACILITY
CI Common::MILITARY_FACILITY
CI Common::POLICE_STATION
CI Common::POWER_PLANT
CI Common::RADIO_TV_BROADCAST_FACILITY
CI Common::SCHOOL
CI Common::SUBSTATION

National Schema

Tables Loaded

1	L_PIPELINE_NATION
2	L_POWRLINE_NATION
3	L_RAILWAY_NATIONA
4	P_AEROHELI_NATION
5	P_AMBUFIRE_NATION
6	P_BRDRCRSS_NATION
7	P_COMMTWER_NATION
8	P_CORRFACI_NATION
9	P_GASSTORG_NATION
10	P_GOVFACIL_NATION
11	P_MEDIFACI_NATION
12	P_MILFACIL_NATION
13	P_POLISTNT_NATION

National Model Defined

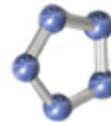
CI National::PIPELINE
CI National::POWERLINE
CI National::RAILWAY_SEGMENT
CI National::AERODROME_HELIPORT
CI National::FIRE_STATION_AMBULANCE
CI National::BORDER_CROSSING
CI National::COMMUNICATION_TOWER
CI National::CORRECTIONAL_FACILITY
CI National::GAS_STORAGE_FACILITY
CI National::GOVERNMENT_FACILITY
CI National::MEDICAL_FACILITY
CI National::MILITARY_FACILITY
CI National::POLICE_STATION

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14	P_POWERPLNT_NATION	CI National::POWER_PLANT
15	P_RADTVBRC_NATION	CI National::RADIO_TV_BROADCAST_FACILITY
16	P_SCHOOL_NATIONAL	CI National::SCHOOL
17	P_SUBSTATN_NATION	CI National::SUBSTATION
18	A_AEROHELI_NATION	CI National::AERODROME_HELIPORT
19	A_AMBUFIRE_NATION	CI National::FIRE_STATION_AMBULANCE
20	A_BRDRCRSS_NATION	CI National::BORDER_CROSSING
21		CI National::COMMUNICATION_TOWER
22	A_CORRFACI_NATION	CI National::CORRECTIONAL_FACILITY
23	A_GASSTORG_NATION	CI National::GAS_STORAGE_FACILITY
24	A_GOVFACIL_NATION	CI National::GOVERNMENT_FACILITY
25	A_MEDIFACI_NATION	CI National::MEDICAL_FACILITY
26	A_MILFACIL_NATION	CI National::MILITARY_FACILITY
27	A_POLISTNT_NATION	CI National::POLICE_STATION
28	A_POWERPLNT_NATION	CI National::POWER_PLANT
29	A_RADTVBRC_NATION	CI National::RADIO_TV_BROADCAST_FACILITY
30	A_SCHOOL_NATIONAL	CI National::SCHOOL
31	A_SUBSTATN_NATION	CI National::SUBSTATION



Appendix B – Sample Common and National Models Features



