NSDI Cooperative Agreements Program
Data Infrastructure Project
Final Report
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Executive Summary

The Cross Border Mapping Project led by the New Brunswick Lung Association and the American Lung Association of Maine created a seamless web-accessible interactive map of Maine and New Brunswick. There were two main goals of the project: 1) To develop and improve web-based GIS technology using tools that met international mapping standards (OGC compliant) and 2) To map health data across the international border. While the map has many layers of data, the focus of the project was to portray influenza hospital admissions and related health system and critical infrastructure data with a view to using the map in planning and preparedness for a possible pandemic.

This project, for the first time, developed new mapping technology so that health information could be viewed by public health and safety end users. The technology was used to support an Emergency Measures-coordinated exercise that engaged various government agencies in the United States and Canada, including the military, health authorities, as well as academia, local governments, industry, to name a few. See Appendix 2 for the list of the 100 exercise participants.

Presentation of map functions during pandemic simulation

Operations center for pandemic simulation

<u>The project demonstrated the large potential of this technology to:</u>

- Portray various types of data in a spatial context on a website
- Integrate different data layers for thematic visualization
- Provide interactive mapping, graphs and charts of data
- Show time-series (trend) maps useful for historical data and predictive modeling
- Provide communication and information sharing technology so that users in different locations can collaborate simultaneously and asynchronously
- Create multi-level partnerships
- Use WMS services available in the Canadian Geospatial Data Infrastructure and the USGS (e.g. University of Southern Maine, New Brunswick Lung Association shared WMS services to provide seamless maps of influenza).

- All of this across an international border

Challenges that were overcome were:

- Differences in data collection and portrayal in the two jurisdictions
- Differences in geospatial alignments of standard features such as roadways and railroads
- Differences in health care systems
- Concerns for privacy regarding health data accessible over the internet (this was done by portraying metadata at a level where individuals could not be identified, and by developing legal confidentiality agreements between parties)
- Legal issues resulting from the sharing of information and risk between two countries

This project will be of interest and advantage in the following ways:

- Because this technology provides a visualization of complex data in a succinct and intuitive way, this cross border map can be used as a demonstration project to advance the use of web- based mapping in a health care context. Introduction to the technology can be taught over the internet to various users for such tasks as primary health care planning, emergency planning, engagement around environmental health issues, education, research and advocacy.

- The technology is useful in many ways but specific to this project can assist in health policy development. It could be used, for example, during the development and implementation of the Maine State Health Plan, which aims to make Maine the healthiest state in the country. It could show the location of health facilities, population distribution, demographics, health outcomes per community, levels of environmental hazards such as air pollution, accessibility to services, etc. As well it can include models to predict future scenarios.

- This tool can be used to unify, coordinate, analyze, portray and track complex projects and plans such as those developed by the New England Governors and Eastern Canadian Premiers for Acid Rain, Mercury, and Climate Change. It is particularly well suited to this due as a result of the work completed on international alignment of data, legal issues security and confidentiality issues.

- Since this technology is accessible over the Internet to a trained user, it can be used for development of proposals for new projects, and for direct research/ analyses of the databases behind the map.

Next Steps

We believe that this project has introduced a new and very important tool for planning and implementing environmental health initiatives. As such, there are both short term and longer term actions the American Lung Association of Maine and its collaborations plan to undertake. These are described as follows.

Short term:

- Norm Anderson (ALA-Maine), David Harris (USM), and Rosemary Mosher (Orbis Consulting), known as the “Follow-up Team”, have agreed to pursue further GIS funding opportunities involving the use of mapping technologies in environmental health research and education.
- The Follow-up Team has established an ongoing communication with the New Brunswick Lung Association in Canada to explore future opportunities for transborder applications regarding health, particularly on problems of bioregional importance such as air quality and infectious diseases;
- The Follow-up Team has met with representatives from the Maine GIS Office, and that office has agreed to provide assistance to us as we develop future health applications using GIS.

- The Follow-up Team has identified two specific areas in which to focus our attention: 1) using GIS in the assessment of the current and project impacts of outdoor air quality on human health; and 2) the use of GIS mapping in K-12 curriculum development for environmental health.
  - We are responding to a Request for Proposals recently released by the U.S. Environmental Protection Agency ("Innovative Approaches to Particulate matter Health, Composition, and Source Questions"), focusing on how changes in particulate matter air pollution within a community can affect health care utilization and costs.

Intermediate Term:

- The Follow-up Team will partner with ongoing research efforts underway in Maine that are examining the relationship between chronic health effects and proximity to vehicle traffic;
- The Follow-up Team will be working with agencies involved with Maine's school laptop computer program to develop environmental health applications using GIS mapping;
- The Follow-up Team will be seeking funds to develop mapping tools to assist Maine communities in planning actions in response to climate change impacts

Longer Term

- Through a combination of specific research applications and continued dialogue with collaborators in Maine, we hope to further the overall interest and use of GIS mapping technology within Maine's public health community.
- Through existing collaboration and communication mechanisms, we anticipate effective dissemination of these applications throughout the region.
- Ultimately, our goal is have our activities in Maine and the surrounding region serve as a "demonstration hub" to motivate more widespread national and international applications in the health field.

1. Project Summary

1.1 Introduction

This project has introduced the important technology of web based mapping to the field of public health planning. In this specific application funded jointly by the U.S. Geological Survey and GeoConnections Canada, it has addressed the need to understand and plan for infectious disease outbreaks that affect both Canada and the United States. Maine and New Brunswick share a common, highly traveled border, and infectious agents are easily carried from one jurisdiction to the other. Through the deployment of web mapping technology and collaboration tools, this project enabled cross-border data integration, visualization, analysis and sharing, for disease monitoring and control in the Province of New Brunswick and the State of Maine.

The system is able to integrate health data (*e.g.*, progress of infectious disease outbreak) and spatial data, to create a common operating picture – a seamless view of framework and thematic data to facilitate evidence-based decision-making. The pandemic model developed during this project to support Exercise 'High Tide' is based on a multidimensional database that enables users to select parameters such as time/duration, location, risk factor, disease type, etc. The pandemic model is also able to monitor the supply of food and fuel, cold medication, school absenteeism, and hospital bed shortages. The same database can support historical maps on seasonal influenza to help authorities identify vulnerable populations.

The system uses OGC / open standards that can share maps related to public health and safety between web-mapping services across jurisdictions. The system enables users to visualize a simulated pandemic over 122 days, but can be deployed for other health emergencies as well. It should be noted that for real-time surveillance, Health Departments must be fully engaged in the data integration process – therefore real-time surveillance of infectious disease outbreaks is not currently available in the system since the data-sharing infrastructure does not yet exist.

1.2 Public Health Importance of this project.

We chose pandemic flu simulation as the prototype application because it provided the best opportunity to develop a mapping system covering a wide range of different datasets into a single platform. For example, the simulation required the development of a relational database involving: 1) health care utilization (e.g., hospitalizations, emergency room); 2) heath care capacity (e.g., number of hospital beds, flu vaccines); 3) location, size, and absenteeism rates in schools (for early disease detection and emergency response); 4) transportation, fuel, and food infrastructure. The reason for this extensive array of data is due to the fact that the worst case scenarios for the flu pandemic can affect up to 25% of population. Such an attack rate can place extraordinary demands not only on the health care system, but also on our basic economic infrastructure.

In addition, because this is a public health application, a further level of complexity is added by the need to provide for data confidentiality and also to restrict certain types of data only to the public health and emergency response authorities.

Finally, because there is much disparity between Maine and New Brunswick (and by extension, between the United States and Canada) in how geographic and health data are organized, resolution of these differences through a common data dictionary was required before the application could be tested and implemented. (See Appendix 4 for more detail on the data dictionary.)

The project coordinators chose to address these multiple challenges by establishing four inter-related committees (list of participants attached). These committees functioned not only to address the technical and policy barriers to successful implementation. Through their very formation, we started the process of establishing a multi-disciplinary communication and coordination network for future cross-border public health work in this area.

While challenging in many respects, we believe that the prototype we developed through this project can form the basis for future cross border initiatives in the public health field. These could include problems as diverse as routine infectious disease surveillance (e.g., seasonal flu, rabies, pertussis), assessing the health impacts associated with regional air quality problems (ozone and particulate matter), or emergency planning and response associated with severe weather events (storms, hurricanes, flooding).

1.3 Summary of Work Completed

1.3.1 Exercise High Tide

The pandemic flu simulation, Exercise High Tide, was the culmination of this project. Individuals from both sides of the border participated in this project. Representation included public health, emergency preparedness, academic, military, and non-governmental agencies. For the exercise, the web mapping application and map services from Maine and New Brunswick were used to assist with identifying "triggers" for planning and response by the Provincial Emergency Action and their respective Departments. In addition, it provided useful information for making decisions relating to the societal impacts of a pandemic. Finally, the collaboration forum allowed distributed users to communicate, share information and maps, and collect data for operations, communications, and coordination, and inclusion of in Situation Reports and Briefings. Each discussion group had access to an internet-connected PC and overhead projector, in order to facilitate visualization of the pandemic model by each group. Remote observers were able to access the applications and share their comments. The description of this exercise is contained in Appendix 1.

1.3.2 Coordination of User Needs Assessment, Data Model Design, Exercise, and Legal Committees

Much of the groundwork required for the simulation was done through the coordinated efforts of four committees: 1) User Needs Assessment; 2) Data Model Design; 3) Exercise Simulation; and 4) Legal. ACT Teleconference services were used to coordinate the four committees. Minutes and documents were compiled for the initial and subsequent teleconferences for each committee and are compiled in a 4-binder project file. Detailed technical documentation, prepared as part of the ongoing development process, was used internally for day-to-day operation of the project. Information on the Committees is contained in Appendix 2.

1.3.3 Data Model Build Report

The data model standardized the different spatial and temporal data elements of Maine and New Brunswick within a single seamless framework. The Maine and New Brunswick data were stored in separate locations, but the mapping system had the ability to upload the necessary information when needed. This is the first time that public health data has been integrated into a single cross border web based mapping system. The specific accomplishments of this data model are described as follows.

- Accommodated different resolution of spatial / temporal entities for spatial-temporal analysis and queries.
- Met the data model requirements of designed functions to create charts on map and utilize WMS time tag.
- Stored data separately in the USA and Canada –model was designed accordingly.
- Met the requirements of simulation (extra data sets).
- Wrote DDL (data definition language) for tables' creation.
- Designed data uploading routine from .shp file, MYSQL database and MS Access database.
- Statistics data pre-computed prior to being served as maps
- Designed procedures for future data updating.

1.3.4 Implementation of Software Licenses and WMS Sharing

The License for Software was agreed to in the CARIS letter of support for the project. The New Brunswick Lung Association and the University of Southern Maine have enabled WMS connectivity to share maps across the border. Cross-border WMS connectivity was demonstrated during the Exercise High Tide which provided participants with access to maps from both Maine and New Brunswick.

1.3.5 Implementation of Legal Documentation

Non-disclosure agreements, privacy statements, data license agreements: Privacy statements and disclaimers were published on the New Brunswick Lung Association's website and in the CARIS SFE Public Module. A Memorandum of Understanding was developed with the New Brunswick Emergency Measures Organization to continue to provide WMS services beyond project completion.

1.3.6 Powerpoint Presentations, Trainings, Meetings

A PowerPoint presentation was developed for the training seminar and for a presentation to the GeoConnections-sponsored workshop in Ottawa on Web-Based Spatial Analysis for Disease Surveillance.

1.3.7 Training Seminar and Evaluation

Three training seminars were conducted with the New Brunswick Emergency Measures Organization staff and exercise participants: March 9th, 12th, and 13th. Although the training sessions were useful, EMO staff indicated that more training would be needed for them to completely familiarize with the technologies. Participants provided their feedback after the Exercise through a Hot-Wash (oral feedback), that will be compiled into an 'After-Action Report' by the Emergency Measures Organization. The training seminars are available to the Maine participants as well in preparation for future projects.

1.3.8 Exercise Evaluation Report

The simulation Exercise (High Tide) represented the culmination of this project. As per the point above, the Emergency Measures Organization will compile an after-action report evaluating the exercise. Feedback was provided during the Hot-Wash and in written form for evaluating the mapping system. Written feedback is in the process of being collected. Due to timing problems associated with the delivery of the software, as well as technical problems experienced during the simulation exercise itself (High Tide), there was limited opportunity for evaluation by the US participants. Despite these obstacles, however, evaluations from US participants showed that the exercise was a valuable activity and important for future public health planning efforts. Had time and resources permitted, we believe it would have been highly useful to repeat this exercise on the US side.

1.3.9 Public Access Module

As discussed in section 1.2, the software needed to include both a propriety as well as publicly accessible module. Launch of CARIS SFE Public Access module.

1.3.10 Resources Published

New resources published to CGDI and are also available to US participants as well. They were available online during the course of the project

1.3.11 Minutes / Action Points

Minutes and powerpoints were developed for four Committees: User Needs, Data Model, Legal Advisory and the Simulation / Exercise Coordination committee. Teleconferences and technical discussions with key partners that did not require detailed minutes were also conducted.

2. Project Outcome and Results

2.1 Review and Refinement of User Needs for Database and Application Design

The New Brunswick Lung Association, American Lung Association of Maine, University of New Brunswick and the University of Southern Maine consulted with end-users and prepared synopsis of user needs. See Appendix 3 for more detail.

2.2 Cross-Border Data Assessment

The New Brunswick Lung Association and University of Southern Maine developed a Data Dictionary of health, points of interest and boundary Shapefiles for Maine and New Brunswick. A thorough assessment was conducted to determine alignment potential (e.g. administrative boundaries) on both sides of the border, gaps in thematic data (e.g., health), and misalignment in framework data (e.g. roads). A thematic influenza data model was created for Maine and New Brunswick using historical and simulated data (influenza pandemic). A Relational and Hierarchical Data Model was developed and included in previous Milestone Reports. The conceptual data model was used to developed triggers and procedures in the database, leading to a final table build and populating it with data sets identified in the dictionary – table format was designed to accommodate multiple feature attributes for querying, visualization, and classification in CARIS SFE.

2.3 Database and Statistical Design

We developed a database reflecting relational, hierarchical, temporal triggers & procedures.

- Design and building of a spatial-temporal database (Oracle)
- Design and building of pre-computed pandemic map sequence (MySQL)
- Historical prevalence of influenza; pandemic simulation

2.4 Visualization

We developed visualization and statistical procedures for modeling annual and pandemic influenza.

2.5 Design and Building of Web Mapping Services and Client Applications.

Two WMS were implemented – in NB and Maine. One client application (CARIS SFE) is hosted at the New Brunswick Lung Association offering access to both WMS and other resources in the CGDI. A Quick Map Viewer was developed by the University of New Brunswick and New Brunswick Lung Association and hosted on the NBLA website.

2.6 Implementation of Data Licenses and Non-Disclosure Agreements, MOUs, Disclaimers, and Insurance Policy.

The Legal Advisory Committee held teleconferences with legal advisors from the University of Southern Maine and University of New Brunswick, as part of reviewing data privacy requirements on both sides of the border. As a result, Cox & Palmer (formerly Cox-Hanson O'Reilly Matheson) produced Non-Disclosure Agreements (internal and external), template MOUs, legal disclaimer, privacy statement, and reviewed the Lung Association's Insurance Policy to ensure the WMS resources were included.

2.7 Software Development and Integration

Database Model, Collaboration Tools, and Wireless Technology: Components of our system were developed independently then integrated onto a single web server at the Lung Association for demonstration purposes. As part of the development process, partners discussed software integration – and developed the necessary code to enable data and command sharing between applications.

2.8 Implementation of Fiber Connectivity, DB and Web-Server Infrastructure

IT and GIS staff at the New Brunswick Lung Association, NB Emergency Measures Organization, University of Southern Maine, and CARIS worked together to implement fiber connectivity and web-server infrastructure on both sides of the border.

2.9 Pilot Test and Demonstration: Exercise High Tide

Recommendations were made during Exercise High Tide to the Provincial Emergency Action Committee to work toward real-time data integration, data sharing agreements, using sentinel-information systems, and WMS-based mapping of serious viral outbreaks.

2.10 Final Software Build

Final software build implementation and publishing of metadata and WMS resources in the CGDI: Completed March 26-30, 2007.

2.11 Project Evaluation

This report and supplementary materials have been reviewed and compiled by numerous partners. Evaluation was also conducted on two occasions with the USGS and GeoConnections. Many positive outcomes from this project have accrued to project proponents, exercise participants, and fund-providers as well. A thorough assessment of technical aspects was conducted after Exercise High Tide. A quick summary of features that were implemented as part of the cross-border mapping applications is included here.

- Visualization (thematic and framework data)
- Display of data using pie charts, bar graphs, polygons, symbolization (WMS enabled)
- User-driven classification and pre-defined classification
- Map saving, retrieval, and sharing
- Advanced collaboration forum with dynamic map and data storage capability
- Dynamic layer legend and legend URL tag enabled as part of WMS implementation
- Layer selection control (drop down menu) for attribute data retrieval
- Statistical query functionality
- Query by multiple parameters
- Query by select
- Automatic time series visualization – using WMS time tag specification
- Access to Quick Map Viewer (light user interface), SFE public module (as described in SOW – complex user interface), Collaboration Forum, Web-published maps and WMS access, and wireless end-user applications that access our database and WMS resources (demonstrated during Exercise High Tide).
- Points of interest
- CGDI and USGS gazetteer searches
- Metadata configuration manager

3. Recommendations for Distributed Thematic and Framework Development

3.1 Short Term Development Goals

The Maine Project Team will continue to draw from the accomplishments of our Canadian partners, and align our spatial data infrastructure projects with theirs. As noted, it would be particularly valuable to conduct future simulations on the US side with a focus on the public and emergency response communities. Limitations in timing and resources precluded this from happening.

3.1.1 CGDI Leverage

The project resulted in the full implementation of the WMS standard, including time tag and style tag. We introduced the style-tag to allow graph/chart overlays on the map using WMS. We implemented WMS-based services at the Lung Association and University of Southern Maine. We used WMS services of the Lung Association, University of Southern Maine, and National Atlas. Several other WMS connections will be established after project completion – e.g. with Public Health Agency of Canada.

We implemented the following software/technologies:

- CARIS Spatial Fusion Enterprise (OGC compliant WMS)
- Oracle 10G Express Edition
- MySQL Database
- PHP (for collaboration forum)
- Java (J2EE)
- HTML + Javascript
- ESRI Arc-GIS

3.1.2 CGDI Gaps Identified

There are multiple parameters for mapping health data. The WMS standard endorsed by the CGDI does not allow multiple parameters to be passed – so the CGDI should work with the health community to identify the requirements for new WMS protocols that would enable transfer of parameters for advanced selection, querying, classification, and visualization of statistical health data.

3.1.3 Recommendations for CGDI Development and Direction

The New Brunswick Lung Association and American Lung Association of Maine worked together to ensure all resulting deliverables would benefit the CGDI. Given the increasing demand for health applications in the CGDI, we propose that the CGDI develop a Health Advisory Task Force to create a cohesive national strategy for development of public health applications, services, standards, and technology.

4. Assessment of Project Success

4.1 Technical Issues

4.1.1 OGC WMS Specification

During the course of development, we discovered that the current OGC WMS specification (and software built on this standard) is unable to pass parameters other than location and time. We developed a method to pass parameters (selected by the user) to trigger statistical algorithms, database procedures, queries and thematic classification. We used the WMS layer request (name convention) to pass parameters in code form, so that our database would recognize the request passed from Spatial Fusion services, and populate data tables that exist for each new WMS layer created by user-driven requests/parameter selection.

4.1.2 Database Software Limitations

Our Database had two key limitations: memory available for user sessions and size of data files that are query-enabled from the CARIS SFE client interface. To overcome this barrier, we reduced the size of data files and limited their availability in Oracle 10G Express Edition, identified manual and automatic sessions-cleaning procedures, identified service initialization / boot requirements, increased available memory (in configuration and in memory slots), and distributed our database in Oracle, MySQL and published as map layers in other WMS services (e.g. University of Southern Maine, and the old WMS server of the Lung Association – from the environmental-health mapping project).

4.1.3 Data Availability

No real time access to health records data. The New Brunswick Lung Association and University of Southern Maine decided that in order to fulfill the project milestone deliverable of seamlessly mapping thematic data across the border, we would use historical hospital discharge data for an equivalent 5-year period. This provided a high-resolution thematic layer of influenza frequency and normative distribution at the Dissemination Area Level. The Pandemic Model was simulated using statistical procedures that reflect the best-available medical science on influenza. The Lung Association and USM have data licenses with health data providers, for the existing data resources used in this project, and for future updates.

4.1.4 Map Application / Interface Design and Integration

Given the highly diverse user group that was identified: from advanced medical geographers, to health practitioners, chief medical officials, the public, and government decision-makers, it was decided that two application interfaces would be required. We developed a Quick Map Viewer to allow easy access to maps. The Quick Map Viewer provided access to maps showing facilities, infrastructure, administrative and census boundaries, influenza frequency/distribution, base-map, and charts/graphs – all WMS layers. We developed the CARIS SFE Public Module to offer advanced user access to the tools for creating custom maps, adding points of interest, querying, classifying, information sharing, and building a personalized map library.

4.1.5 Data Model Complexity

In order to accomplish this project's goal of seamlessly mapping thematic and framework data into a WMS environment, the project proponents developed a data model including the following components:

- Hierarchical
- Temporal (time tag)
- Query-enabled (Parameters / Variables such as disease type, age, etc)
- Statistical (pre-computed and computed on the fly)
- Distributed Database Resources

Some key challenges included the rendering of statistical data on the fly at multiple geographic scales and time patterns. In addition, the database needed to be query-enabled and return feature attributes that belonged to various tables, from distributed sources.

4.1.6 Integration of WMS Services

Integration of WMS with other WMS services within Government Departments of Safety, Health, and Environment. Due to security, privacy, and firewall issues – the Lung Association and University of Southern Maine were unable to connect with WMS resources that do not exist in the CGDI and belong to various government departments at Provincial, State, and Federal levels. Instead, the Lung Association has a Data License Agreement with the Public Health Agency of Canada and is in the process of establishing secure network connections with PHAC for access to WMS resources. NB Emergency Measures Organization provided additional data resources in soft-copy so we can host them in our WMS (not including classified information). The project proponents under License host all health data.

4.1.7 System Performance

System Performance, Memory, and Web Services for Mapping and Collaboration – In a production environment or small-demand (day-to-day) operation, our system satisfies the performance requirements (of memory, speed, and accessibility). During unusual circumstances where demand increases exponentially, our system would have difficulty maintaining services in a quick and accessible way. Therefore, as a result of Exercise High Tide, the Lung Association has endeavored to improve system performance by reconfiguring software on three servers.

4.1.8 Data Privacy and Security

Non-Disclosure Agreements were signed by all project staff and partners in order to ensure privacy and security of data. The Lung Association and University of Southern Maine understood the requirement for maintaining data privacy and ensuring that health records information was not available at the individual level. Therefore, we created an aggregate model using statistical and normative procedures, and provide access to thematic maps and aggregate data, not to health records as provided under license (at the 6-digit postal code level)

4.1.9 WMS Time Tag

The implementation of WMS time tag is valuable for health mapping, allowing users to visualize the spread of a pandemic and trends in infectious disease (influenza) in Maine and New Brunswick. The implementation of the style tag was very useful to visualize charts/graphs (from WMS) so that attribute data could be quickly assessed and correlated. OGC / Open Standards have been crucial to the success of this project – and in support of Exercise High Tide.

4.1.10 Oracle 10G Express Database

The Oracle 10G Express Database we implemented on our server in order to host the WMS layers and database for the project has a 4GB limitation on the amount of data we could store. Since our data model and WMS layers added up to more than 4 GB, we distributed some of the WMS layers to our old WMS server, and to the WMS server in Maine, and cut down on the number of layers available during the exercise.

During the Exercise High Tide, the Oracle Database was not closing user sessions once the user logged out of CARIS SFE. When the sessions reached the 100+ limit (using all available memory), the database connections for SFE stopped functioning, effectively shutting down our web map service. The problem was addressed within the Exercise by manually restarting the service and clearing user sessions, while providing users access to secondary Web Map Services and published map images on the website. The New Brunswick Lung Association and CARIS are investigating methods to automatically clear sessions so the new WMS can operate with minimal downtime.

4.1.11 CARIS SFE Application

The CARIS product was delivered in early March, a delay of 4 weeks from the planned delivery date, it was necessary to postpone training and scale-back the amount of features/data we would provide during the Exercise. The Exercise helped us to identify system/software weaknesses and strengths, so that final implementation of the CARIS product and all resources being published in the CGDI can be accomplished by March 31st, in a stable server environment. By moving the Database (Oracle and MySQL) into a new server, we free up resources for the CARIS SFE application on the web-server – the transition of our Database to a new server was not part of the original deliverables, however its implementation was started on March 23 and will continue beyond project completion, providing 500GB of space for spatial data sets and WMS resources.

4.2 Pandemic Model Design

Seasonal / Annual Influenza has a well-developed body of medical and epidemiological science whereas pandemic influenza models are less frequent. The model needed to take into consideration many parameters and estimations by the Public Health Agency of Canada and Center for Disease Control for infection, health outcomes, risk groups, transmission vectors, and public health system impacts. Other impacts were modeled including fuel and food supply / retail, school absenteeism, and demand for flu medication. The pandemic model is non-predictive – and should not be used as the only model or scenario upon which authorities base pandemic preparedness plans.

4.3 User Familiarity / Training

In order to ensure administrative staff at Emergency Measures Organization, and the participants of the Exercise, had become familiarized with the application, the Lung Association held several training sessions and web-conferences for demonstration. The level of familiarity with the applications was increased in terms of new users, but their understanding of the full capabilities of the applications remains low. This means that the project proponents will need to work with the end-user community to increase awareness, practice, and use of the application to meet ongoing health and safety needs.

4.4 Collaboration Forum

The Collaboration Forum developed during this project was very useful for communication and collaboration for disaster management such as pandemic. We learned that a ‘chat’ style interface would improve the Collaboration Forum for real time emergencies, but the existing forum meets the project requirement of sustaining health research, disease monitoring and control. The project proponents worked in an open and collaborative style with all sub-contracted partners. The ongoing communication and exchange of materials between partners made project coordination much easier across the international border.

5. Issues, Difficulties, and Challenges

5.1 Familiarity and Timing

The most significant challenges were that 1) the application did not arrive and training did not commence until near the end of the project (March); and 2) the lack of familiarity with this application on the part of most public health and emergency preparedness personnel on the US side. With further trainings and demonstration projects, US personnel should develop a greater familiarity with the application and, consequently, a greater appreciation of its value. This, in turn, should create a positive dynamic in which the WMS will find itself increasingly used for public health purposes.

5.2 Technical Issues

The development of a data dictionary, while time consuming, was a necessary step in meeting the technical challenges of merging data sets from two sides of an international border, This aspect of the project was made all the more challenging by the fact that the healthcare systems are different in the US and Canada.

In some instances (e.g. roads and railroads), spatial data sets had to be altered slightly to achieve “seamless” integration across the border. To optimize the usefulness of these data sets, it is important that the exact nature of these alterations be documented so that the resultant data will be useful in future projects. Ultimately, it probably makes most sense to develop and use merged data sets of roads and railroads.

As is the case with any computer application, the ones developed for this project had specific “preferences” for other software (e.g. web browsers) and requirements for hardware (e.g. amount of RAM). Once these are clearly established, they should be published with the application so that the user can be sure that they have the software and hardware needed to optimize performance.

6. User Requirements for Data in an NSDI Infrastructure

Perhaps the most important user demand is for a system that allows multiple levels of spatial analysis. Depending on the nature of the actual challenge being faced and the specific user, it might make most sense to use the state, county, city, or even census block as the unit for spatial analysis. These units differ in size by several orders of magnitude. Using too large a spatial unit results in inadequate resolution to address the question at hand. Using too small a unit necessitates unnecessarily large amounts of computation. This project dealt with a specific threat and had spatial analysis appropriate for that threat. To generalize this work to other threats, it may be necessary to determine the areal unit that is optimum for analysis of those other threats.

7. Plans for Follow-On Activities, Including Outreach

7.1 Maintenance

The WMS resources developed during the cross-border mapping project are published in the CGDI. The Lung Association will continue to provide these WMS resources, maintain the database and administrative modules, and support the NB Emergency Measures Organization in future training and exercises. EMO provides continual fiber connectivity to the Internet to achieve hi-speed access to our services.

Having concluded Exercise High Tide, where the WMS and pandemic map resources were provided by the New Brunswick Lung Association and University of Southern Maine, we have identified the needs for continued maintenance. These include:

a) Moving Database Software to DB-specific server. This was not part of original project deliverables but was a direct result of the pilot demonstration (system performance evaluation) conducted during Exercise High Tide. We started the Database upgrade (new 500GB DB server) on March 23rd, however we do not expect to complete database transfer until 2 weeks after project completion – there is no additional costs being requested from GeoConnections as our project finishes March 31st, 2007. All milestone deliverables are met.

b) Re-installing CARIS SFE (Build #7) and transferring all content. The Lung Association will install the SFE 4.2 release version and subsequent software updates from CARIS starting in May 2007. This will ensure continual maintenance and improvement of the application – the updates are provided by CARIS to all their SFE clients, and all original settings/configuration and database connections are easily transferred between our Cross-Border WMS and the CARIS SFE 4.2 release in May. There will be a maximum of 1-day downtime in early May as we re-start the service to accommodate new software features.

c) The New Brunswick Lung Association has already upgraded the server environment with 10GB memory, new firewall server, Switch and Dual Internet Connection (DSL and Fiber), Production Environment (i.e. PC upgrades) and GIS Software (provided by ESRI).

7.2 Communications

During the Cross-Border Mapping project, the executive and senior management at the New Brunswick Lung Association and American Lung Association of Maine coordinated internal (strategic) communications. The NB Lung Association coordinated subcontracts and internal communications with all partners in US and Canada – including web-conferences and teleconferences facilitating discussion of four committees: User Needs Assessment, Data Model Design, Exercise Coordination, and Legal Advisory Committees, involving over 50 participants.

PowerPoint presentations were also delivered to: Emergency Measures Organization, Services New Brunswick, National Research Council, New Brunswick Department of Health, Harvard School of Public Health (Center for Public Health Preparedness), National Center for Atmospheric Research (US), Canadian Institute of Public Health Inspectors, GeoBase Steering Committee, Provincial Emergency Action Committee, and the North East Border Health Initiative.

The New Brunswick Lung Association developed a website, with the sponsor and partner logos. Links to all applications are accessible there. The website will continue to be hosted by the Lung Association beyond project completion, and new resources may be added.

CARIS will produce a one-sheet describing the CARIS SFE application that was developed as part of the Cross-Border Mapping Project – as a case demonstration for promotional purposes.

The New Brunswick Lung Association presented the outcomes of our project during the GeoConnections workshop “Web-Based Spatial Analysis for Public Health Surveillance” – Ottawa, ON, March 20, 2007.

Kenneth Maybee, President and CEO, presented the results of our project to the Board of Directors, March 24-25, 2007. The Lung Association will discuss Web-Based Spatial Analysis for Public Health Surveillance with colleagues across the country, as part of the National Framework for Respiratory Health, in April. The cross-border mapping project will be used as a case demonstration.

An article prepared by University of New Brunswick and NB Lung Association will be published in **CyberGEO**, an online journal.

7.3 Research Coordination – Maine

This project has served as an excellent springboard for further web mapping research in Maine. The following describes our short range and longer range plans in this regard.

Short term:

- Norm Anderson (ALA-Maine), David Harris (USM), and Rosemary Mosher (Orbis Consulting), known as the "Follow-up Team", have agreed to pursue further GIS funding opportunities involving the use of mapping technologies in environmental health research and education.
- The Follow-up Team has established an ongoing communication with the New Brunswick Lung Association in Canada to explore future opportunities for transborder applications regarding health, particularly on problems of bioregional importance such as air quality and infectious diseases;
- The Follow-up Team has met with representatives from the Maine GIS Office, and that office has agreed to provide assistance to us as we develop future health applications using GIS.
- The Follow-up Team has identified two specific areas in which to focus our attention: 1) using GIS in the assessment of the current and project impacts of outdoor air quality on human health; and 2) the use of GIS mapping in K-12 curriculum development for environmental health.
    - We are responding to a Request for Proposals recently released by the U.S. Environmental Protection Agency ("Innovative Approaches to Particulate matter Health, Composition, and Source Questions"), focusing on how changes in particulate matter air pollution within a community can affect health care utilization and costs.

Intermediate Term:

- The Follow-up Team will partner with ongoing research efforts underway in Maine that are examining the relationship between chronic health effects and proximity to vehicle traffic;
- The Follow-up Team will be working with agencies involved with Maine's school laptop computer program to develop environmental health applications using GIS mapping;
- The Follow-up Team will be seeking funds to develop mapping tools to assist Maine communities in planning actions in response to climate change impacts

Longer Term

- Through a combination of specific research applications and continued dialogue with collaborators in Maine, we hope to further the overall interest and use of GIS mapping technology within Maine's public health community.
- Through existing collaboration and communication mechanisms, we anticipate effective dissemination of these applications throughout the region.
- Ultimately, our goal is have our activities in Maine and the surrounding region serve as a "demonstration hub" to motivate more widespread national and international applications in the health field.

8. Feedback on Cooperative Agreements Program

8.1 What are the program strengths and weaknesses?

The program strength was clearly the introduction of an important web based mapping tool to the public health decision making process. Also, because of its multi-dimensional nature, it brought together partners (specifically those involved in GIS, emergency preparedness, and public health) in the context of an actual collaborative exercise. This is consistent with often expressed state government goals on the importance of cross-sector communication with regard to public health in general, and pandemic flu response in particular. The weakness centered mainly on the unfamiliarity that most participants in Maine had with the mapping tool, the complexity of the tool, and the relatively short period of time in which to receive training on both an individual and group basis.

8.2 Where does the program make a difference?

This project has come along at a particularly opportune time to motivate Maine's public health response capability. Beyond the state level, Maine has been a patchwork of local health planning and delivery systems. These include hospital-oriented health service areas, school districts, health departments in our larger towns, public health nursing service areas, primary care planning areas, and community-based health coalitions. Currently, however, the state of Maine is defining a more coordinated public health infrastructure through the establishment of eight health regions, similar in concept to the thirteen health regions that exist in New Brunswick. In addition, it is refining its health information system that includes the full range of utilization data (e.g., hospitalization, emergency room, physician office visits, pharmacy) as well as a statewide electronic medical record reporting system. A core component of this emerging public health infrastructure is the mechanism by which health data are organized and seen within a consistent temporal and spatial framework. The infectious disease mapping project has provided such a framework.

In some respects, this project may have been a little ahead of its time. GIS is not a routine part of health planning or reporting in Maine. This exercise, however, has demonstrated the potential for the mapping tools to be applied to a wide variety of environmental health problems in the state and the cross border region. Among the many examples are the following:

- Tracking the spread of drug resistant tuberculosis or pneumonia;
- Correlating trends in health care utilization with changes in air quality;
- Predicting and responding to the impacts of climate change events (e.g., sea level rise, flooding, spread of infectious disease vectors) on vulnerable communities and populations;
- Assessing the impacts of catastrophic events on fuel and food security;
- Syndromic surveillance (e.g., asthma, upper respiratory conditions) across the region on a seasonal or annual basis;
- Assessing risk factors for disease morbidity based on geographical variables.

The major challenges ahead involve a combination of competence and enthusiasm for these applications at the state and local levels. The two are inter-connected; the more one realizes the potential uses and value, the more one will see the importance of seeing this tool applied. This dynamic might possibly be the most important outcome of the project, as it could provide the foundation for further training, collaborations, and applications. Furthermore, being a web based application, the value of remote access by individuals over large geographical distances cannot be over-stated. With greater familiarity and appreciation for it functionality, we anticipate that this application will become a core component of Maine's public health activity.

8.3 Was the assistance you received sufficient or effective?

The assistance was sufficient. Given the short time frame of the project and the competing demands on all project partners, however, its effectiveness was not as optimal as it could have been.

8.4 What would you recommend doing differently?

Given the great functionality involved with the mapping tool, a more phased in approach might be recommended, certainly with regard to the training. It might be possible, for example, for asynchronous training and exercises to occur (e.g., regarding health care impacts, food and fuel distribution, mobilization of community resources), which could all be brought together once the specific sub sectors were adequately brought up to speed.