Final Report, Version 0.3

2007 NSDI Cooperative Agreement Program
Category 2: Framework Client Development

Framework NSDI and Beyond:

Enhancing the Incident Response Community's Strategic Advantage with Client Tools for Multimodal Spatial Data Access

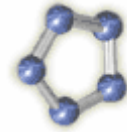**The Carbon Project, a member of the geoLeaders Network**

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Organization:

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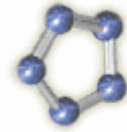**Internet Address:** http://www.thecarbonproject.com

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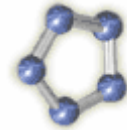
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1. Project Narrative

In this project we implemented lessons learned from the previous versions of Gaia 3/IR developed as part of CAP 2006. The objective was to enhance the popular Gaia client with Incident Response capabilities. Through this project we have developed and tested various technologies, and produced what we believe is not only an improved version of Gaia but the ability for users and developers to grow and enhance the application according to their needs.

We believe the NSDI community will benefit greatly from the new version of Gaia, which we call "Gaia 3.2 with XIR extenders" – and this is a bold statement since community feedback indicates that the version developed during the 2006 CAP and 2007 CAP projects (available at http://www.thecarbonproject.com/gaia.php) is now the world's most popular OGC SDI viewer.

Gaia 3.2 is available as a free download at http://www.thecarbonportal.net.

Our overall focus during this effort was to enhance the Incident Response community's operational advantage and develop a client tool that is light, easy to install and operate and will provide data sharing, universal access to online Framework vector data through OGC services such as WFS, and access to local government and user-generated geospatial content. The target user communities for this enhanced application are public sector organizations across the Nation conducting incident planning and response activities of many differing levels of intensity.

While most of these users do not qualify as high-profile emergency events, State and Local Government Emergency Managers, Municipal First Responders, and the regulatory agencies still need to access a common view of incident information, framework data, background maps and information on toxic and hazardous chemicals. They also must be able to combine Framework data with other information, and to share this information within their organization and with other support organizations. The ability to combine Framework vector data with mapping services implemented by local governments and popular sources like Microsoft Virtual Earth and Google Earth files is vital to situational awareness.

Gaia 3/XIR was developed to access and combine many different data sources, including a variety of framework vector data, tile-based mapping services and emerging framework data sources such as Google Earth KML. During this effort, The Carbon Project developed Gaia 3/XIR to provide the capability to access online Framework vector data from OGC Web Feature Service (WFS) sources with advanced spatial and comparison operator - making online Framework vector data usable on a daily basis. We also provide the ability to:
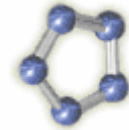
- Integrate Gaia with the EPA Exchange Network through a software module that interacts with the Homeland Emergency Response Exchange[1] (HERE) client.

- Enable Gaia to switch the point symbology for features and note pushpins with the Emergency Management Symbology[2] set developed by the FGDC Homeland Security Working Group.

- Connect the application to a GPS tracking device. When connected to a tracking this extender allows Gaia to set the map according to the received location.

- Enhance Gaia's status strip with a projection of WGS84 coordinates to NAD83 or NAD27 National Grid coordinates.
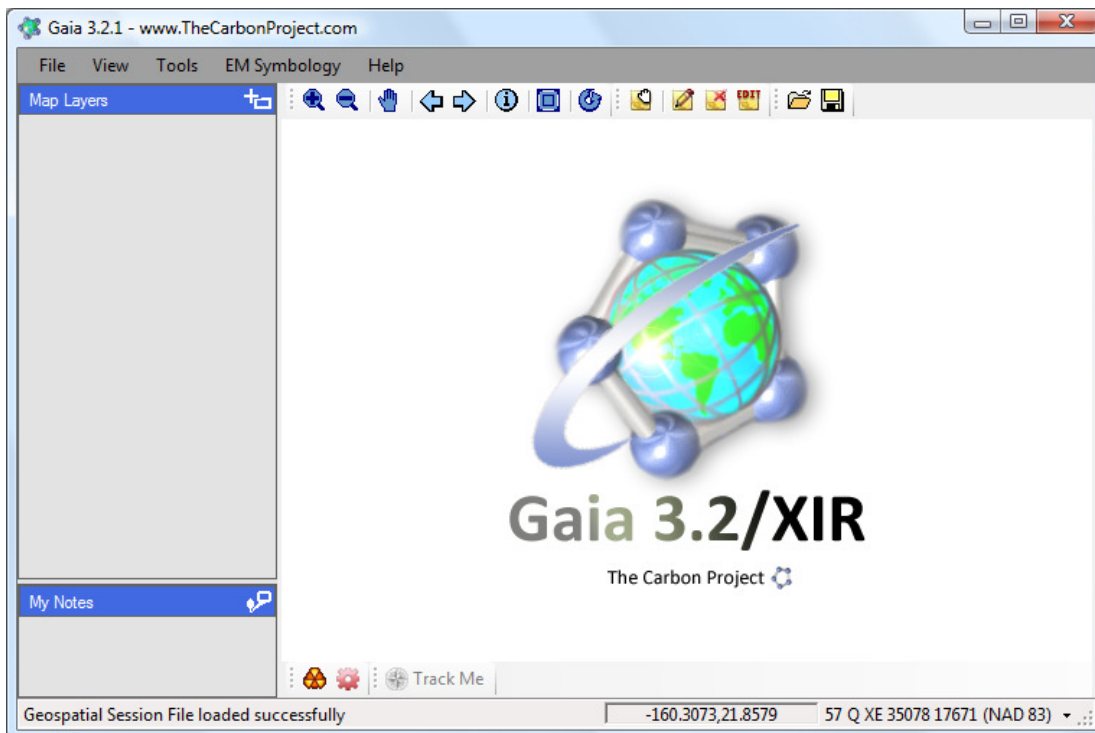
…and more.

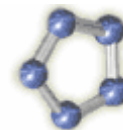**Figure 1 - Gaia 3.2.1 with XIR extensions**

Samples of Gaia in action with the NSDI and other SDI at various community events are visible online at:

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[1] http://herenetwork.org/
[2] Information on FGDC Emergency Mapping Symbology is available at http://www.fgdc.gov/HSWG/ref_pages/DownloadSymbols_ref.htm

http://www.thecarbonproject.com/gaia.php

http://carboncloud.blogspot.com/2008/01/spatial-and-situational-awareness.html

http://carboncloud.blogspot.com/2008/08/gaia-32-is-here.html

http://carboncloud.blogspot.com/2008/08/releasing-gaia-32-with-extensions-api.html

http://carboncloud.blogspot.com/2008/08/inside-gaia-extender-apipart-1.html

http://carboncloud.blogspot.com/2008/05/nsdi-wfs-gaia-gallery.html

http://carboncloud.blogspot.com/2008_09_01_archive.html

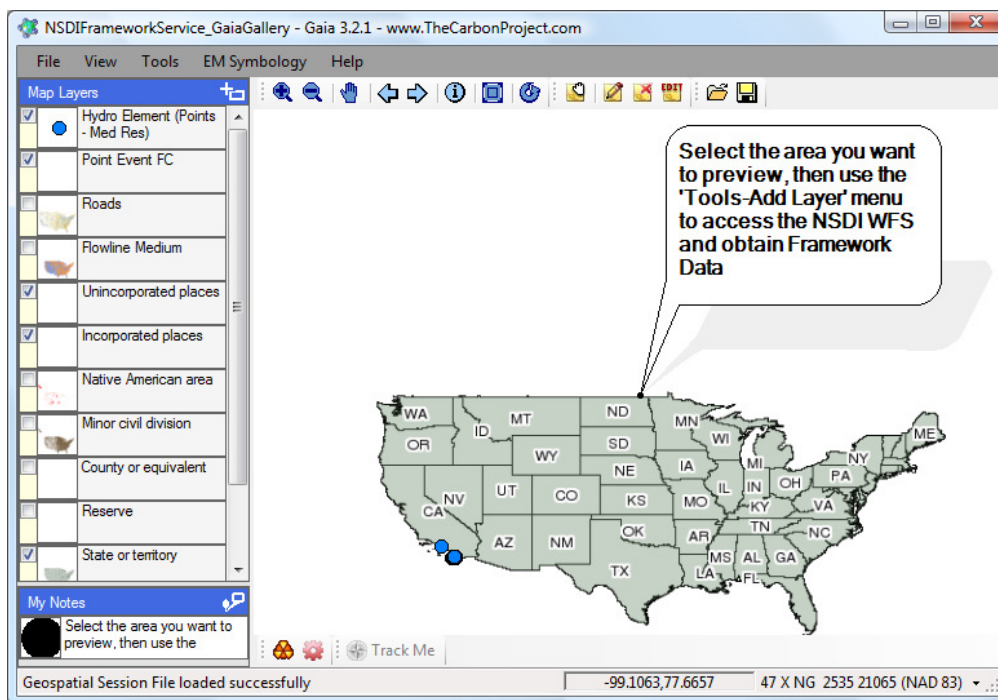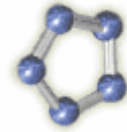http://www.youtube.com/watch?v=YIZLc_qHYZc

Figure 2 - NSDI WFS Gallery displayed with Gaia 3.2.1

A first draft of the NSDI WFS "Gallery" GSF is also available for download at
http://www.thecarbonproject.com/NSDIFrameworkService_GaiaGallery.gsf

The NSDI WFS Gaia Gallery lets anyone access the NSDI WMS, preview the area they want, and then access the NSDI WFS[3]. The Gallery is loaded with an assortment of NSDI WMS layers and a single NSDI WFS layer with just 100 features. This way, both the WMS and WFS service URLs are preserved in the GSF and people can easily tailor their views to whatever they need.

Framework Web Feature Services are offered by the United States Geological Survey (USGS) in support of the development of the NSDI – and Gaia supports full access to this online services. The Framework WFS conforms to the Open Geospatial Consortium's (OGC) Web Feature Service (WFS) and Geography Markup Language for Simple Features (GMLsf) specifications and the FGDC/ANSI Geographic Information Framework Data Content Standards. These services provide query and retrieval of specific Framework features and their attributes into a form usable for visualization and analysis. In addition, a Web Map Service (WMS) is provided to allow users to visualize the data content as a graphical image. The initial data content for the NSDI Framework Data Services includes selected features from the Hydrography, Transportation and Governmental Unit Framework Data Themes.

Challenges in the 2006 Gaia 3/IR version

While the 2006 CAP project yielded the world's most popular SDI viewer, we learned a number of valuable lessons during the development and testing of the 2006 version of Gaia 3/IR. The challenges were mostly related to the p2p network functionality and included –

- Gaia 3/IR installation was difficult and required special Microsoft packages and IT intervention.
- The server-less p2p network made it challenging to find peers at times.
- The server-less p2p network made it challenging for everyday users to understand connection issues.
- The IPv6 based p2p did not work for all systems and did not work well for all security configurations.
- The IPv6 based p2p used two external services on the global network.

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[3] To review the Framework WFS visit http://frameworkwfs.usgs.gov/
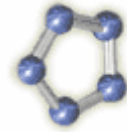
- The IPv6 based p2p had limitations on the number of users in the peer cloud.
- The peers organization mechanism was hard for everyday users to understand.
- The end user demographic was a moving target – trying to adjust this complex system for different users was challenging.
- The application design was focused to a large degree on "GIS" users, which is not the most desirable design since the majority of Gaia users will not be familiar with GIS.

1.1. Challenges encountered during the 2007 Gaia 3/XIR development

During the development of Gaia 3/XIR new questions and concerned were raised:

- How will the peer-to-peer system penetrate the market?
- How will the peer network be deployed, maintained and supported?
- What can we do to increase penetration of the Gaia client?
- How can we address different needs by numerous user and agency types?
- How do we support and extend this standalone client after it is deployed?

1.2. Addressing the Challenges

To address these challenges we decided to move beyond the IPv6-based server-less peer-to-peer architecture. We concluded that this solution has enormous potential for cutting-edge solutions, however it proved too hard to install and use for the average user. Instead, we evaluated a more traditional approach that uses a client-server p2p architecture. This approach mimics the way the world's most popular online chat applications work, such as AOL Instant Messenger and Skype. However, we concluded that embedding a new network in the designated markets had a small chance of success. In addition, we found that a peer-to-peer network already exists in the form of the EPA Exchange Network and achieved some success in penetration (deployed in Iowa, Nebraska, Kansas and Missouri with more to come). An existing client application, called HERE client, has achieved initial success but did not have a geospatial component (it uses Google Earth for map use). We therefore decided to extend Gaia and showcase its ability to integrate with the HERE client and provide a mapping alternative to Google Earth with advance geospatial interoperability features. Furthermore, we now established a direct line of communication with the EPA and the Exchange Network to help advance the network capabilities toward enhanced geospatial interoperability.
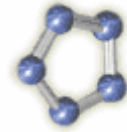
To improve the market usability of Gaia we decided to remain on the Microsoft .NET 2.0 framework and not continue our effort with a .NET 3.x/WPF based presentation layer. The decision was based on the framework dependency within the majority of target organizations, and avoids the potential need to upgrade Windows components on user desktops in order to use Gaia 3.2. Instead we enhanced the existing framework with new and improved presentation tools.

Lastly, we encountered the requirement to support several different versions of Gaia at the same time. While this is a reasonable expectation, it introduced increased engineering overhead. To meet this challenge, we redesigned Gaia 3 to support an open API that allows developers (with our without CarbonTools PRO) to write module assemblies that enhance the Gaia functionality – and for users to add these modules to Gaia 3.2 in seconds. We dubbed these modules as Gaia Extenders.

The extender mechanism provides a way to easily manage add-ons for tracking location with GPS, using US National Grid coordinates reference, working with Homeland Security Mapping symbology, plugging the NSDI into networks like the EPA Exchange and more. It also provides a way for programmers to develop enhancements to Gaia - with or without CarbonTools PRO[4].
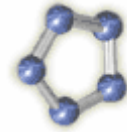
With this technology we could now separate various functionalities developed for the Incident Response community as well as keep publishing new extenders without the need to reinstall Gaia. Now each agency or user can decide what components interest them as well as request or develop new functionalities without needing a unique version of the Gaia application. We also used this mechanism to migrate the various IR components developed for Gaia 3/IR and deploy them as small standalone modules.

The Gaia Extender API uses *Microsoft .NET reflection* to create a contract between Gaia and any assembly (a DLL) that is present at its running directory. Once Gaia detects an assembly that implements a class called *ExtenderImplementer* the assembly is considered an extender and will appear in the extenders list. Gaia will then look for API commands by name to implement the extenders functionality. Extenders can alter the Gaia user interface by adding new tools and items as well as add Gaia event-driven functionality.

The Gaia Extender API is fully documented in the Gaia 3.2 extenders developer guide. This guide provides information on how to develop extensions to Gaia, provided with code samples in C#.[5]

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[4] http://www.thecarbonproject.com/dev.php
[5] http://www.thecarbonportal.net/downloads/Gaia/ver.3.2/Gaia3_2_ExtendersDevelopersGuide.pdf

GaiaToExtenderEvents.SetMapBBox	
Event Type	EventHandler<Gaia.ExtenderHelper.BBoxEventArgs>

Update the bounding box region of the map. This method is activated every time the map region changes, usually due to a pan or zoom event.

```
private GaiaToExtenderEvents gaiaToExtenderEventsHandler;
public GaiaToExtenderEvents GaiaToExtenderEventsHandler
{
    set
    {
        this.gaiaToExtenderEventsHandler = value;
        this.gaiaToExtenderEventsHandler.SetMapBBox +=
            new
EventHandler<BBoxEventArgs>(extenderToGaiaEventsHandler_BBoxEventArgs);
    }
}

void extenderToGaiaEventsHandler_SetMouseLocation(object sender, BBoxEventArgs e)
{    // Do something where e.X0, e.Y0, e.X1, e.Y1, e.SRS are the region coordinates }
```

Figure 3 – Sample Gaia Extender method as described in the Gaia API guide.

1.3. Final Product Description

The Gaia 3.2 product and the suite of Incident Response extenders (XIR) are now freely available online[6]. Key features developed within this project are:

- Redesigned Gaia to support external software modules. Development of such extenders is straightforward and simply requires using specific keywords in the functionality. To use an extender, simply place it next to the Gaia executable file. Through the .NET reflection system Gaia simply recognizes extender assemblies and attaches their functionality (Figure 4). This simple mechanism can be used to extend the user-interface and overall functionality. Developers do not need CarbonTools PRO license for most functionalities, however extending Gaia functions that use CarbonTools PRO components does require a license.

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[6] To download Gaia and the suite of extenders visit: www.TheCarbonPortal.net
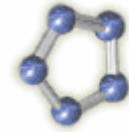
- Published a new Gaia user guide.

- Published a new Gaia Extenders API user's guide. The API is free and open and is explained in details with source code samples.

- Developed and published an Emergency Management symbology extender (Figure 5). This extender uses the FGDC developed Homeland Security symbology set. The can switch between the default Gaia symbology to the full suite of FGDC icons symbology.

- Developed and published a GPS extender (Figure 6). This module allows connecting Gaia to a GPS device and centers the map on the user's location.

- Developed and published a Lat-Long to National Grid extender (Figure 7). This module extends the Gaia status bar to display US National Grid coordinates (NAD27 or NAD83).

- Developed a HERE client extender that reads the KML output and adds it as a Gaia layer (Figure 8).

- Enhanced the Gaia 3 KML to support the HERE client KML format output.

- Added a new legend control to support HERE client KML display.

- Various enhancements and improvements, such as setting WFS spatial operator and enhanced support to WFS 1.1.0 specifications and GML 3.1.

- Established a relationship with the Exchange Network committee. The Carbon Project presented an approach to advance geospatial qualities of the EPA Exchange Network.

Name	Assembly	Description
GPS Tracking	GaiaExtender_GPS.dll	Extends Gaia to support GPS Tracking. When activated the map will ...
HERE Extension	GaiaExtender_HERE.dll	Extends Gaia to support the Homeland Emergency Response Exchan...
Emergency Management Symbology	GaiaExtender_HS_Sym...	FGDC Homeland Security Working Group Emergency Management e...
US National Grid	GaiaExtender_National...	Show lat-long conversion to US National Grid coordinates.
Secure SDI	GaiaExtender_SecureS...	Extends Gaia to support Secure SDI services (using CubeWerx IMS t...

Figure 4 - The Gaia Extenders listing tool allows users to see what extenders were detected and used
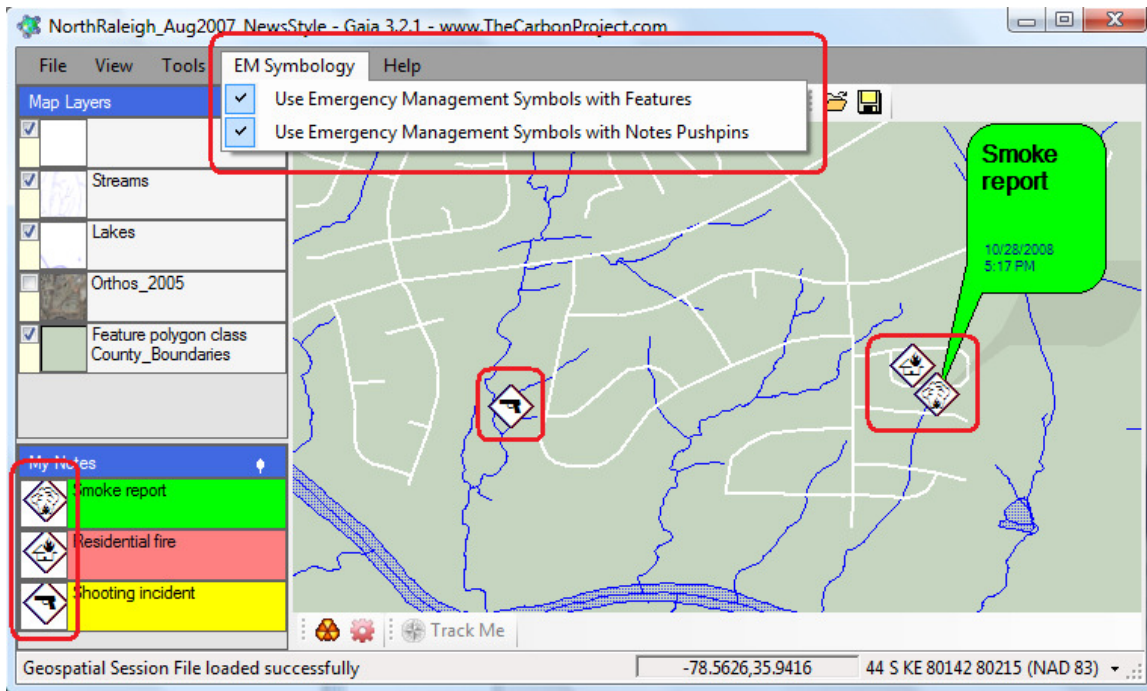
Figure 5 - Emergency Management symbology extender
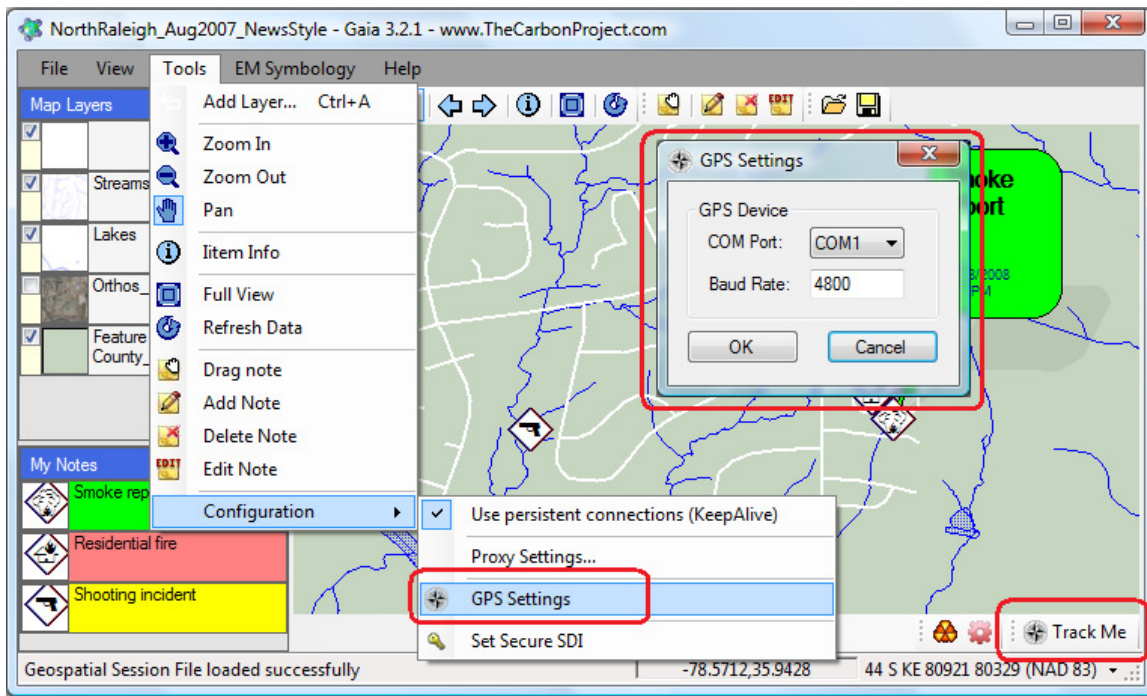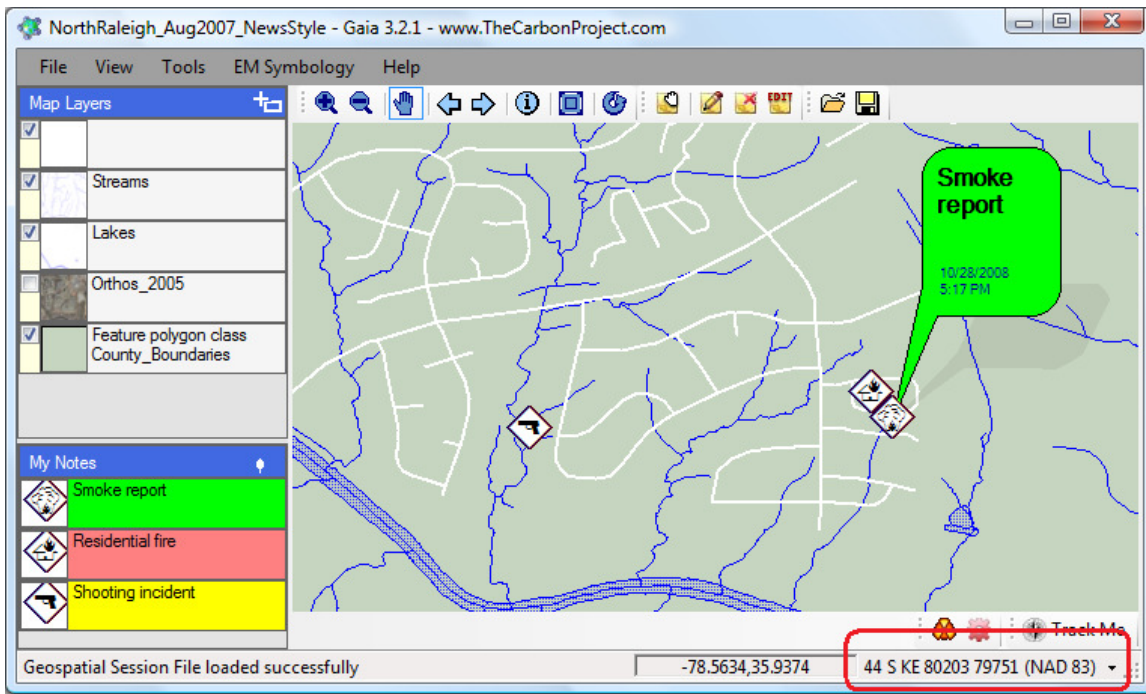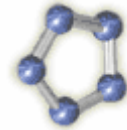

Figure 6 - GPS extender
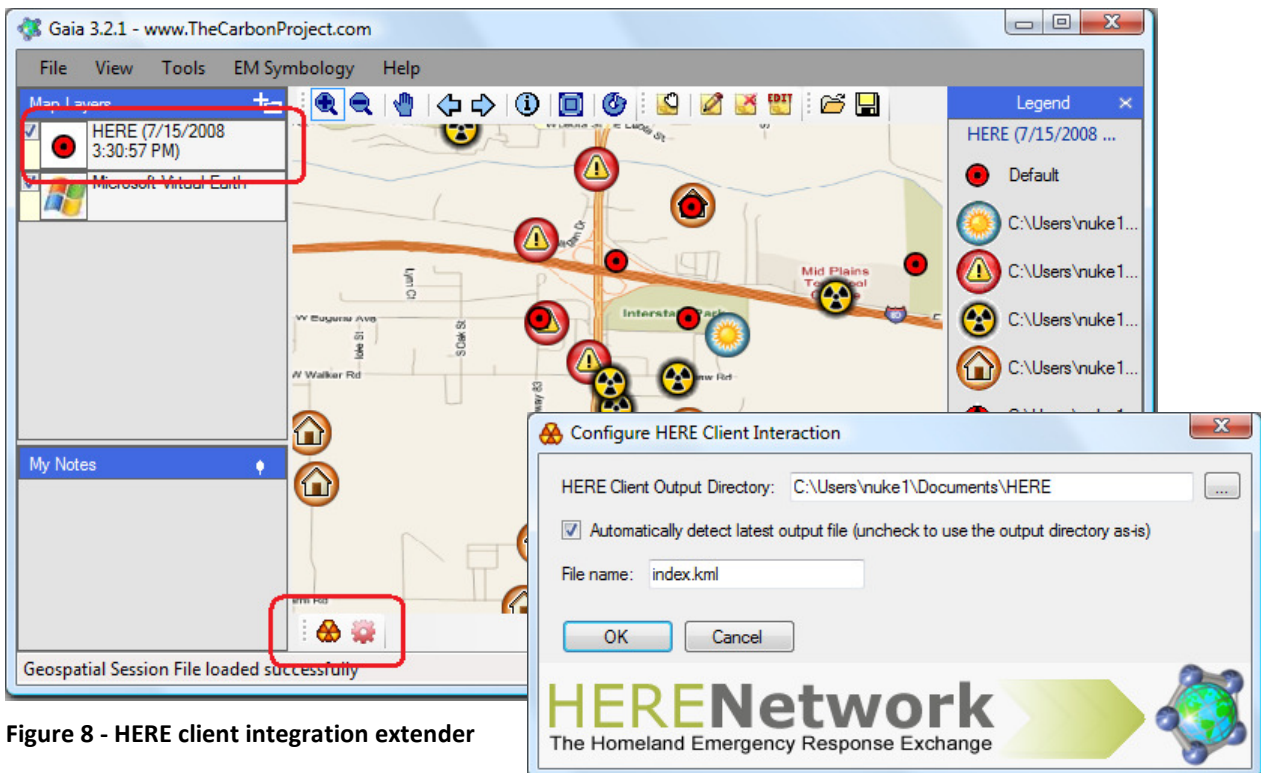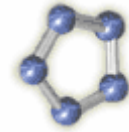
Figure 7 - US National Grid extender

Figure 8 - HERE client integration extender

2. Status of Data Access Activities

What Framework data theme(s) will be accessed under this project?

Our focus is on transportation, hydrography, governmental units Framework data theme(s) from the NSDI WFS.

What is the data volume of Framework data anticipated for access (geographic coverage, dataset size, feature count)?

Hundred gigabytes (or more) of transportation, hydrography, governmental units Framework data from the NSDI WFS and other sources will be accessed via WFS during this project as well as terabytes of Orthoimagery, depending on the needs of Gaia users. However, it is likely that the average Gaia user will access Framework data for local areas, resulting in much lower data volumes.

Who are the primary organizations providing data for this project?

USGS, NCOneMap, The National Map, EPA, GlobeExplorer, Microsoft Virtual Earth, Yahoo! Maps, CubeWerx, USGS, North Carolina localities including Raleigh and Charlotte.

3. Status of Framework Client Development

What is the status of software development?

Gaia 3 and the Gaia 3 XIR extenders suite are now freely available online. The downloadable content also includes a full user's guide and a developer's guide.

How will the client software be evaluated and quality assured?

The Gaia 3 application is being used worldwide by thousands of users. After an intensive QA in The Carbon Project offices we released the application to beta testers. Once cleared of any bugs we released the full application to the community through The Carbon Portal (www.TheCarbonPortal.net). This portal contains a user's
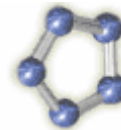
forum where questions are asked and problems reported. In addition our technology office releases every 3-4 months periodic enhancements and updates to the CarbonTools PRO and Gaia software products.

Describe your experience and purpose in accessing the data services?

During this process we tested access to NSDI WFS described at http://frameworkwfs.usgs.gov. A summary of our tests is shown in the figure below.
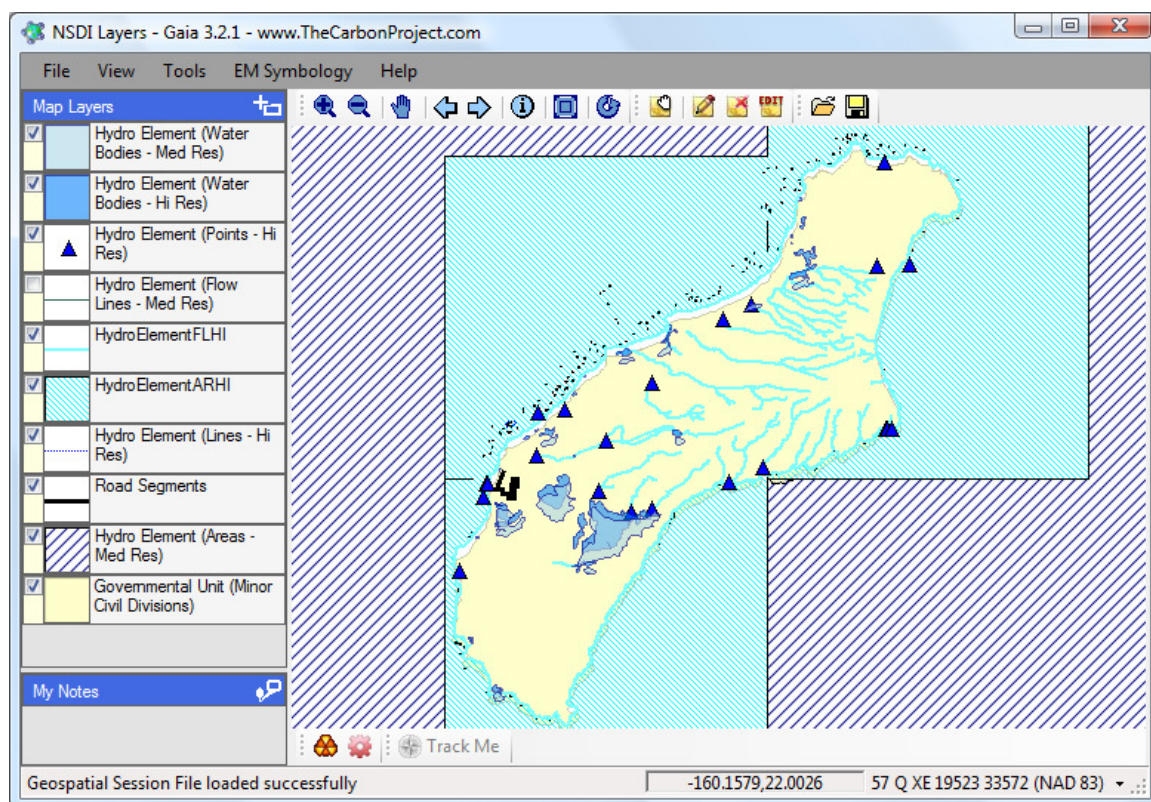

Figure 9 - NSDI Framework Data, including Road Segments and Hydrography displayed in the free Gaia 3.2.1 geospatial viewer application

The result of this testing indicated performance is adequate for accessing hydrography and road network data, however, methods such as GZIP should be considered to enhance performance. Performance enhancements to the Governmental Units data should also be considered, including some type of real-time "geometry simplification".
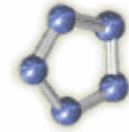
Our testing also indicated that NSDI Framework Services are utilizing nested properties and GMLSF Level 1. This approach is a potential forward step in representing geographic features from archaic methods used by traditional GIS. This is because many real world entities are more effectively described using nested properties. However, this structure may cause issues with advanced analysis functions. Level 1 schemas with nested properties are structured in the following manner -

```
<MyFeature>
  <Prop1>value1</Prop1>
  <Prop2>
    <SubProp2>value2</SubProp2>
  </Prop2>
</MyFeature>
```

During this process the NSDI WFS Gaia Gallery was also developed. The NSDI WFS Gaia Gallery lets anyone access the NSDI WMS, preview the area they want, and then access the WFS. The Gallery is loaded with an assortment of NSDI WMS layers and a single NSDI WFS layer with just 100 features. This way, both the WMS and WFS service URLs are preserved in the GSF and people can easily tailor their views to whatever they need. This is now available as a download at

http://www.thecarbonproject.com/NSDIFrameworkService_GaiaGallery.gsf

Users may point a browser to it and Gaia 3.2 should kick it off, or it can be saved to the desktop and opened there.

We also provided input into the developed of the NSDI WFS Usability Document located at http://geoleaders.com/NSDIFrameworkServices_Usability.pdf.

Describe any internal or external users that are using this client.

The current version of Gaia 3.2.1 is in use around the world by a number of organizations, including personnel from NCOneMap and others. The application will also be available for use a part of upcoming statewide projects hazardous incident response.

Identify plans for promotion and distribution of this software.
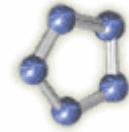
*Gaia 3/XIR is freely downloadable from The Carbon Project website. Outreach
activities to inform organizations of Gaia 3/IR will be conducted by members of the
NC Geographic Information Coordinating Council, via announcements to NC listservs,
and by presentations at community events. We have also engaged in significant
outreach, using Gaia 3.2 a variety on National Forums including GEOINT 2008.*

4. Project Management

Will this project's activities continue in the future?

We hope so. National and international response to the Gaia 3.2 application has
been very positive. We are now in discussions with NC, EPA and the Exchange
Network committee to expand our work integrating Gaia as well as consulting on
how to enhance the Exchange Network with advance geospatial interoperability
uses.

Describe the next phase in your project.

We consider this phase complete. However, we hope that our efforts will produce in
the future a fully functional Exchange Network node that is tightly linked with Gaia.
We are also looking to enhance Gaia with additional functionality such as GML
compression and WFS-Transactional tools.

Requirements (more technical assistance, software, other)?

None.

What areas need work?

*Overall, the application development and the current phase of the project is going
well (challenges have been described in this report)*
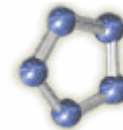
5. Feedback on Cooperative Agreements Program

What are the program strengths and weaknesses?

Strengths-Good management, fairly easy to understand the process and become engaged.

Weaknesses-We would like additional support in project continuation and partnering efforts.

Where does the program make a difference?

The program helps develop key elements of the NSDI. Overall, the program is making good progress but continued emphasis needs to be placed on promoting an online infrastructure of standards-based location content that can flexibly support operational incident response requirements. We suspect that funding issues are holding back development of this online infrastructure.

Was the assistance you received sufficient or effective?

Yes

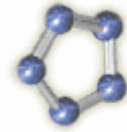*What would you recommend doing differently?*

We recommend maintaining a list of WFS-based Framework Data services. We are not able to identify these services using the GOS Portal. The result our testing indicated performance is adequate for accessing hydrography and road network data, however, methods such as GZIP should be considered to enhance performance. Performance enhancements to the Governmental Units data should also be considered, including some type of real-time "geometry simplification".

Are there factors that are missing or need to consider that were missed?

The CAP program should consider increasing the pace of development of online infrastructures for standards-based location content by coordinating with Homeland Security and critical infrastructure protection functions. For example, there is no reason why a low-cost 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 situational

awareness in times of need, or used to guide tourists to key destinations on most other days. This type of investment is a "win-win" for the Nation.

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 program is functioning well for this project.