

The Virtual Oregon Map: A Partnership to Enhance Geospatial Awareness and Interoperability for Improved Business Processes and Decision-Making

Narrative Description

(8-page limit according to NSF Program Solicitation 04-556)

The Challenge and Need for Innovation

Digital data sets are growing exponentially nationwide, especially with recent launches of high-resolution satellite systems (e.g., Carlson and Patel, 1997) and the increasing ease with which digital imagery, video, and sound are delivered over the Internet. Digital libraries now enable 24-hour access to digital papers, journals, books, and data [Buttenfield and Goodchild, 1996; Buttenfield, 1998]. And with the steady rise in adoption and use of geographic information systems (GIS), there has been a proliferation of geospatial data available in digital form and a considerable increase in the number of users and producers of these data, making access and effective integration a very difficult challenge [e.g., Nedovic-Bujic, 2002]. All of these developments are literally changing the way people think and work, giving rise to the notion of "digital worlds" [NSF Information Infrastructure Task Force, 1993; Negroponte, 1995].

Indeed, our society has changed from being data-poor to data-rich, but our ability to *derive knowledge and management decisions* from all of these data in an analytical context remains poor. In a perfect world, all decisions would be based on the most complete, accurate, and affordable digital data using the best possible analytical tools. Unfortunately, we all know of documented examples where decision makers were presented with incomplete data, out-of-date data or data sets created at great expense because the creators did not know of the existence of already available data. As data increase in size and complexity, decision makers must rely upon analytical tools to interpret the data. However, because of proprietary issues, complexity of the tools, or simply not knowing the tools exist, researchers and decision makers often do not take advantage of the most appropriate analysis tools.

These issues are extremely important for geospatial data and geospatial analysis. Geospatial data are pieces of information about phenomena organized in a spatial (geographic) frame. This could be a point such as location of sampling point, a line segment such as a road, an area such as the extent of a park, or a raster coverage such as a remotely sensed map of vegetation. Many, if not most, types of applied biological, sociological, and economic data have geospatial components. In many cases, an attribute such as "the Willamette River", "the Pacific Northwest", or "Multnomah County" may be used instead of specific map coordinates. Geospatial analysis involves methods that are applied to specific map coordinates, revealing important patterns and anomalies in the data, add value, and/or support decision- and policy-making.

Because of the importance of geospatial data in such a wide range of issues such as endangered species protection, business infrastructure development, and transportation planning, there is an ever growing demand for geospatial data and geospatial data analysis. In the state of Oregon over the last 2 years, nearly \$500,000 were spent for geospatial data services [Smith, 2003]. GIS departments are common in federal, state, tribal, and local governments and there are numerous commercial businesses that provide data and analysis services. While these developments are positive, the issues of providing the best and most cost effective data and tools still exist.

In part, they exist because of the multi-dimensional nature of the problems where geospatial data are applied. For example, Oregon's Department of Transportation is undertaking the rebuilding of 365 state bridges. Each bridge project requires an environmental assessment that requires data on wetlands, water quality, fish and wildlife, endangered species, historical and archeological sites, local land use and other features. Because of the wide range of data required, it is more effective for the Department of Transportation to combine data from sources that are experts on specific factors. But where do they find the data? If they do locate a suitable data set, how do they know it is the best or most up-to-date data set available? What if they decide to create a data set and then later find out that another agency had already created such a data set? What if they find a habitat analysis tool developed by a university scientist but it only runs with software X and the Department of Transportation uses software Y?

Fortunately, there are efforts underway that are addressing problems with sharing and finding geospatial data [important background discussions can be found in Katz et al., 1991; Masser, 1998; Gärtner et al., 2001; Miller and Han, 2001]. First among these efforts are solutions to the issue of finding public domain or commercial for-profit data. The United States Federal Government, state governments, commercial entities, and universities have worked to create searchable metadata catalogs that enable users to search descriptions of geospatial datasets. Notable efforts include the Federal Geographic Data Committee (FGDC), the Geospatial One-Stop (GOS) Initiative, and The National Map, all of which share the goal of building a National Spatial Data Infrastructure (NSDI) [Mapping Science Committee, 2001; Nedovic-Bujic, 2002; DeMulder et al., 2004], as well as the National Biological Information Infrastructure, and the Geography Network of the Environmental Systems Research Institute (ESRI). Oregon State University (OSU) is just completing a regional metadata clearinghouse called the Virtual Oregon Natural Resource Data Clearinghouse. This effort, led by two of the investigators on this proposal and a foundation upon which we wish to build, has created a regional warehouse of geospatial metadata that enables data owners to inform potential users of a data set's existence [Keon et al., 2002; Fiez and Wright, 2004, <http://digitalcollections.library.oregonstate.edu/virtualoregoncatalog>]. Our approach is based in part on the scientific information model of Helly et al. [2003] for distributed Earth science/natural resource data in both relational databases *and* web links. Establishing well-maintained links over distributed websites and developing methods for rapidly disseminating and integrating data sets are critical to creating a community-wide resource. While we have initially populated the database with over 1200 records, the system also allows the creators of the data to manage their own metadata records. Local or regional efforts such as our Virtual Oregon Natural Resource Data Clearinghouse are essential for populating nationwide databases such as the GOS, which harvests metadata records from local or regional clearinghouses with the expectation that they are much better positioned for cataloging local data.

While the metadata catalogs help end users find data, the data are often in proprietary formats or formats that require specialized software for viewing and manipulating. Two important developments are working to eliminate the need for expensive, proprietary software in these instances. First is the ever growing number of World Wide Web-based mapping sites. These web sites and the server side software supporting them allow users to perform basic GIS operations. For example, see the site developed by the Oregon State University Library to provide natural resources information for the Willamette River Basin of Oregon [Butcher and Fiez, 2004, <http://digitalcollections.library.oregonstate.edu/WillametteBasinExplorer>; click maps link]. Typically, the creators of these sites provide maps/data related to a specific domain. In many cases, the data needs for a specific problem are not matched by one

single web mapping site. One might need some maps from site X and some maps from site Y. While there are some existing desktop software and thick client web tools that can in some cases combine maps from several web mapping sites, the user is forced to more complicated interfaces and installation processes.

Interoperability standards are the second development that is reducing the need for proprietary software. The OpenGIS Consortium (OGC, www.opengis.org), initiated in 1994, has defined a set of standards for distributed sharing of geospatial data. Among the OGC's specifications are a set of web service-like standards called web mapping service (WMS), web feature service (WFS), and web coverage service (WCS) which provide raster maps (images), non-gridded attribute and topology information, and gridded attribute information, respectively. By establishing these standards, the OGC has removed barriers to sharing/exchanging data related to proprietary data formats and communication protocols. Through the OGC's testbed initiatives and published specifications, commercial and non-commercial software developers have created both open-source and commercial software for sharing and integration of geospatial data via WMS, WFS, and WCS protocols.

A web mapping site that consumes WMS's can build a map from multiple web servers so that the user is not restricted to using data from a single server. A WMS delivers a raster map image. As long as the requested map images are in the same projection and cover the same geospatial extent, the web mapping software can overlay the images to make a synthetic map using data from many different sites.

A web mapping site using OpenGIS services solves many issues with sharing and using data from multiple sources, especially if the user only wishes to do simple browsing and querying of the data. However, many geospatial problems require sophisticated analyses. Typically these types of analyses are done using desktop software using built in tools or custom macros. Some web mapping software can be customized by developers to do more sophisticated operations but this then again restricts users of the data to specific websites.

There are some efforts to build web services or web service-like processes that can take OpenGIS services as inputs, process them, and produce a synthetic output. For example, the Canadian National Forest Information System is developing distributed spatial analytical agents (DSAA's) that can process WMS inputs and produce a derived WMS output [Stone, 2002]. These agents will enable buffering, dissolve/merge/mask, median filter, neighbor, and area calculation operations. We do not know of a similar system in the U.S., certainly not in the Pacific Northwest.

The OpenGIS Consortium's current Web Services Phase 2 Testbed includes the development of an image handling for decision support task. This testbed task requires the development of a chain of loosely coupled image manipulation web services so one can build an image handling client that consumes raw data in the form of WCS's from multiple locations, processes them through the web service chain, and displays the resulting image.

The developments above, metadata catalogs, open standards, web mapping systems, and web service-based analysis tools, each individually contribute to the goal of information operability where one can find, use, and analyze the best data for the problem at hand. **However, to fully achieve interoperability, all of them need to come together at the same time, and it is this major innovation that we propose to address in this project.** A catalog is of no use if there are no services available. A web

mapping client is of no use if the users cannot find services to view. Even more important, those with data must be brought into the system development because in the end, the utility of an interoperability data system depends on delivering data, information, to end users.

These challenges have also been identified by the University Consortium for Geographic Information Science (UCGIS, www.ucgis.org), a non-profit consortium of over 70 of the nation's leading universities and research institutions in geospatial theory, methods, technology, and data and the academic voice of the geographic information science community, as a major short-term research priority. In fact, regional partnerships that seek to more effectively deliver data and information, and to guide and/or influence regional planning and urban development have been identified by the UCGIS as critical not only for data solution but for enabling creative solutions to broader environmental and socio-economic problems, for economic development, community service, and even the homeland security issues of responding to threats, disasters, and developing emergency operation plans and procedures [Elmes, 2000; Nedovic-Budic, 2002; Sietzen, 2003]. The situation cries out for innovation, innovation in the way that we catalog, distribute, analyze, and communicate regarding geospatial data.

The benefits of an integrative technology initiative to deliver geospatial data to today's decision makers are clear. We can reduce costs, improve decision making, and foster new business enterprises that assemble, package, analyze, and deliver these new information streams. However, successfully creating the infrastructure and providing the data for an interoperable geospatial data system exceeds the capacity of most organizations especially smaller businesses. We propose that a partnership of software and information architecture specialists, data providers, geospatial consultants, and end users can successfully build an interoperable geospatial data that will support private and government enterprises throughout the Pacific Northwest and serve as a model for such systems nationwide. We note that the NSF PFI program has not yet funded an Oregon partnership, nor one that focuses on geospatial data in the manner that we are proposing. We also have a specific goal of increasing the scientific and technological capabilities of the workforce in GIS and similar geospatial technologies within the state of Oregon, and to more fully meet these important needs through internships with our partners

Our effort will include two primary innovations:

- (1) Develop the capacity to deliver interoperable geospatial solutions throughout the region by training and providing technical assistance in cataloging of OpenGIS services, delivery of OpenGIS services, building web map interfaces, and using and creating geospatial analytical web services.
- (2) Build a Virtual Oregon Map (on top of the existing Virtual Oregon Natural Resources Data Clearinghouse) to provide an open catalog of regional web mapping services, a web mapping tool for viewing services in the catalog, and an introductory set of geospatial analytical web services.

The training and assistance program will provide individuals and organizations with the knowledge to find, deliver and utilize OpenGIS services in general, while the Virtual Oregon Map will provide an initial point within our specific region to find and use OpenGIS services and to prototype a larger developing role for geospatial analytical web services. This feedback loop between training/assistance and improvement of services as they used by partners at varying levels of complexity, will build a community of innovation in Oregon.

(1) Providing Training and Technical Assistance

Key partners necessary to ensure innovation: Alsea Geospatial, City of Corvallis, ESRI, GMT, Willamette Valley Council of Governments, Titan

The training and technical assistance program will use a combination of workshops (see details in Management Plan) web-based resources, an implementation cookbook series (i.e., hands-on tutorials), and individual face to face interaction. Using both national and local expertise, these workshops will provide the participants with the knowledge to go back to their employer and function as an expert in utilizing and providing geospatial web services. We will form a conference organizing committee that reflects the makeup of the geospatial community throughout the region. OSU's multimedia classrooms offer the perfect setting for participants to actually do hands-on computer exercises illustrating the concepts. By holding the events on campus, we will help foster cooperative work between our university, the private sector, and local, state, and tribal governments. Several workshops are planned including:

- Workshop #1 (Year 1) to inform the campus and statewide community of data exchange and distribution efforts to see what everyone is doing and to reconfirm user needs revealed in Virtual Oregon survey of the OSU campus in 2000 and 2001 (<http://virtual-oregon.nacse.org/survey/>), as well as a statewide natural resources digital library survey conducted by J. Salwasser, Information Policy Advisor for OWEB (-oregon.nacse.org/background/).
- Workshop #2 (Year 1) on cataloguing, metadata harvesting and decision support;
- Workshop #3 (Year 2) on interoperability (led in part by John Helly, San Diego SuperComputer Center);
- Workshop #4 (Year 2) on OpenGIS WMS, WFS, WCS focusing on focusing on state clearinghouses in order to exchange ideas with related efforts in Idaho, Montana, Washington, California;
- Workshop #5 (Year 3) on participating in national data efforts such as the National Map, the NBII, and the National States Geographic Information Council (NSGIC).

To provide a continuous non-place-bound educational resource, we will create an Internet portal for geospatial interoperability. This portal will focus on how-to advice and implementation examples. We will post at least one feature type article monthly as well as web logs from developers working on the Virtual Oregon Map project described later in this proposal and from the efforts of our partners. The site will include a newsgroup and we will recruit individuals to actively respond to posts especially in the early stages of the proposed work so those seeking help receive responses.

Using materials from workshop tutorials, web portal feature articles, and newsgroup postings, we will produce how-to cookbooks as downloadable publications. These publications will provide users with step by step instructions on how configure and use metadata catalogs, OpenGIS services, web-mapping clients, and geospatial analytical web services.

The final component of our training and technical assistance program, an internship program, will provide individual face-to-face interaction. We will offer two types of internships. First, we will place trained graduate and undergraduate students at enterprises implementing interoperable data services during the second and third years of this project, for periods of up to six months. These students will bring to the hosting

company the ability to support or lead efforts to implement interoperable data services. We will split the internship expenses with the hosting company so that both parties have a financial stake in ensuring a successful internship outcome.

For the second internship opportunity, we will host individuals from outside organizations in our development labs for up to three months (one quarter of the university calendar). While we will not cover the individuals' expenses during their time at the lab, we will provide them with a faculty and student mentor. We will require that interns in our labs have projects with defined objectives and sufficient resources to implement them. We will provide technical assistance and reference platforms so that they can leave the internship with a functioning prototype.

Through the combined impact of the workshops, web portal, cookbook publications, and internships, we will establish a cadre of geospatial interoperability specialists. Furthermore and equally important, these efforts will establish relationships between working professionals throughout the region and beyond. Relationships such as these are essential in developing interoperable systems as they require more than just software and standards.

There are substantial economic workforce issues as well, as the broader geospatial technology industries (which include GIS, web GIS servers and services, global positioning systems or GPS, relational database management systems or RDBMS, remote sensing, surveying, digital and multimedia cartography, and the like) will continue to grow and require qualified candidates. These candidates must NOT be just button pushers, but geospatially aware people who understand how to think critically about data and the accompanying issues of data quality, data mining and knowledge discovery, data uncertainty, data visualization, geospatial analysis, [UCGIS, 1996], **and how to capitalize on new knowledge produced from efforts such as our proposed PFI partnership.** GIS is now a \$8 billion industry, with 2003 software revenue topping \$1.75 billion, an increase of 8% over the previous year [Daratech, 2003]. ESRI, a major industry partner in this proposal, has software revenues accounting for nearly one-half of that total. ESRI along with literally hundreds of other companies in scores of different industries (e.g., forestry, agriculture, transportation, environmental management, defense and intelligence, telecommunications, banking and insurance, retail and commercial business, petroleum, water/wasterwater, law enforcement, etc.) are looking for individuals with excellent training and practical experience with GIS, and knowledge of interoperability issues critical to successful implementation.

(2) The Virtual Oregon Map

The Virtual Oregon Map will consist of four components. These are

- 1) an OpenGIS service metadata map catalog
- 2) a OpenGIS service map viewer
- 3) a reference set of geospatial analytical web services
- 4) a web portal that serves as the home site for all project web components

The Virtual Oregon Map Catalog

Key partners necessary to ensure innovation: ESRI, State of Oregon Department of Administrative Services (DAS), USDA Forest Service

The map catalog will form the basis of the Virtual Oregon Map. The catalog will contain records of WMS, WFS, and WCS services that users can view and interact with in the map viewer.

We will populate the Virtual Oregon map catalog by searching metadata from the USGS Geospatial One-Stop metadata catalog, NSDI sites and other regional metadata catalogs such as the Virtual Oregon Natural Resources Data Clearinghouse. These sites contain records for many forms of geospatial data. The harvesting process for the Virtual Oregon metadata catalog will only harvest records that cite WMS, WFS, and WCS sites. Because a service specification is not part of the required FGDC metadata specification, we will use appropriate metrics to determine if metadata records reference WMS's, WFS's, or WCS's.

In addition to harvesting, the Virtual Oregon map catalog will allow users to register or nominate WMS's, WFS's and WCS's to the collection. We will also provide a system where users can register metadata catalogs for harvesting by the Virtual Oregon map catalog.

Similar to popular metadata cataloging systems such as ESRI's Metadata Explorer/SDE system, the Virtual Oregon map catalog will store complete metadata records so that users of the Virtual Oregon Map can access detailed metadata as needed. In addition, the Virtual Oregon Map will extract information from the metadata records to help users construct appropriate combinations of data. For example, map scale and accuracy are essential factors in any geographic information system analysis. The Virtual Oregon map catalog will tabulate records on scale, accuracy, data age and other factors that will enable users to make better, more informed decisions about which data sets are appropriate for their analysis needs.

The Virtual Oregon Map Viewer

Key partners necessary to ensure innovation: Alsea Geospatial, ESRI, OWEB, State of Oregon Department of Administrative Services (DAS)

A key component to achieving our overall goal of helping people and organizations make better decisions that utilize geospatial data, the Virtual Oregon Map viewer will provide web-based access to the data referenced within the Virtual Oregon Map Catalog. Users will be able to select which map layers (WMS's) to view, set the display order, and perform all normally expected web mapping operations such as zoom, pan, print, save map image, identify map features, view layer metadata, and query by feature attributes.

We will develop two map viewer interfaces, one for novice users and one for advanced users. For those new to working with mapping software, the novice interface will present a subset of the map viewer's features while the advanced user interface will access all of the GIS capability that we can provide.

Geospatial Analytical Web Services

Key partners necessary to ensure innovation: Alsea Geospatial, Newlands & Company, State of Oregon Department of Administrative Services (DAS)

Geospatial analytical web services will allow the incorporation of advanced features into clients such as the Virtual Oregon Map. Geospatial analytical web services are processing services that allow users of web data streams such as WFS and WCS's to

incorporate functionality that are typically only available in desktop GIS software. The geospatial analytical web services will use WFS and WCS's as inputs and produce WMS, WFS or WCS's as outputs. With WFS and WCS's providing vector and raster data respectively, the operations that geospatial analytical web services could perform are only limited by processor time. For example, the intersection and reclassifying of millions of polygons might take hours of processing time and would not be suited for real time web display.

To prototype and test the functionality of geospatial analytical web services, we will create a set of basic services to perform the following operations:

1. A reporting tool providing summary statistics of WCS and WFS data within a given region.
2. A hazard/suitability assessment tool utilizing WCS's.

Reporting Tool. The reporting tool will summarize attribute data (either polygons or grid cells) contained within a specified area. For each attribute value, the tool will return area and percent of the area specified. These data will allow the client that calls the reporting tool to create summary tables and graphs. For example, prepare a report of current land use within a proposed annexation area. The tool will provide the option of splitting polygons that span the boundary of the specified area so that the area calculations are correct for any arbitrary reporting region.

Hazard/Suitability Assessment Tool. The hazard/suitability assessment tool allows users to combine raster data sets to produce an aggregate 0 to 1 scaled raster data set for analysis and display. The tool will perform the following operations:

1. Transform raster data sets of discrete feature classes into a value or intensity map. For example, transform an agriculture land use map into a map of dollar value per acre by applying a lookup table that equates land use to dollar value.
2. Transform raster data sets to 0 to 1 scale. For example, convert a map of agricultural dollar value per acre to a 0 to 1 index where 1 represents the greatest value per acre.
3. Combine two or more 0 to 1 index maps to provide an aggregate weighted hazard/suitability index such that map $Y = x_1I_1 + x_2I_2 + \dots + x_nI_n$ where $\sum x_i = 1$ and $I_i =$ index data set i (0 to 1 scale) .
For example, produce a land value map by combining an agriculture land value index map with a habitat land value index map.

We will use the OpenGIS's Service Information Model (SIM) to describe our geospatial analytical web services. This model uses an XML vocabulary to describe the service interface so an automated process can utilize the service and additionally describes the data requirements of the service.

Virtual Oregon Web Portal

The Virtual Oregon Web Portal will serve as the entry point to all Virtual Oregon Map Components including the metadata map catalog, the Virtual Oregon Map viewer, user information for the geospatial analytical web services, the geospatial interoperability educational web site, and the hands-on cookbook series.

Management Plan (3-page limit)

Implementation and Administration

We propose to complete the project over a 3-year period with a project timeline as presented below in Innovation Outcomes section. Initial administrative functions of the lead institution (OSU) will include: (a) development of topics, presentation materials and learning outcomes for workshops, with parallel development or compilation of hands-on tutorials; (b) web portal design and creation, newsgroup or Wiki set up and moderation; (c) development of add-on to existing Virtual Oregon Natural Resources Clearinghouse to phase in to Virtual Oregon Map Catalog and accepting additional data and metadata submissions for input; (d) construction of a web client for the Virtual Oregon Map Viewer tracking data sets from initial data gathering through final submission; (e) design and build Geospatial Analytical Web Services; (f) working with data providers (partners) on data quality control and procedures for submitting data and metadata; and (g) disseminating information to campus and statewide communities on additions/changes to the entire project or changes in infrastructure/procedures.

Virtual Oregon team members will meet monthly throughout the 3-year period of the project to monitor and assess progress toward innovation goals, refine implementation plans, discuss roadblocks and their removals (often in consultation with our private sector and government partners), and plan for the workshops and community outreach activities. All Virtual Oregon team members, partners, and interested supporters will be subscribed to a Wiki or listserv to keep everyone apprised of progress on the project (especially as we set up the initial drafts of our web services catalog and viewer). This has been a challenge in our state (i.e., keeping abreast of what others are doing). A representative of each partner will sit on the **Virtual Oregon Center Advisory Board**, which will meet at every two months in Year 1 and at least twice a year in Years 2 and 3. Partners will be invited to all workshops. Internship or job opportunities will be passed on to our students and we will provide you some of our best students using funds from the grant for internships.

Partners and Roles

The respective roles and responsibilities of each of the 12 partner organizations with Virtual Oregon are summarized in the table near the end of this Project Description and in the Supporting Documents. Our Partnership for Innovation is founded on four sectors: private sector (business); state, local, and tribal government; academic; and federal (government lab and national initiative).

Our private sector and NGO partners gain access to new knowledge and a workforce that can capitalize on it, as well as the ability to use the resources and capabilities of academic institutions. They contribute developing and state-of-the-art information technologies and services. Their participation reflects both an interest in the practical applications of technology and a long history of successful research and development programs. Our private sector and NGO partners include **ESRI**, the world's leading GIS company (34 straight years and running) with more than 1,000,000 customers worldwide. It maintains a business partner program with more than 1,500 developers, consultants, resellers, and data providers; a network of more than 75 international distributors with users in more than 220 countries, and invests nearly 20% of its revenues each year in research and development (www.esri.com). **Alesea Geospatial** (www.alseageo.com) is an independent GIS consulting firm in Corvallis, as well as a business partner with ESRI (authorized trainer and reseller of ESRI products), and a leader in public access GIS and interactive mapping. In 2002 it was named ESRI Business Partner of the Year. **Global Mapping Technology** (www.gmtgps.com) is another Corvallis company that excels in the distribution and training of GPS and integrated GPS/GIS equipment and software. They are a longstanding support of OSU and have been critical in

the success of our community outreach events and workshops. This will again be an important role for them in the NSF PFI endeavor. Along with ESRI and Alsea Geospatial, **Titan Systems Corporation** (www.titan.com) will provide valuable consultation on workshops, while continuing as an important collaborator with our State government. Their Geospatial Services Division specializes in the integration of GIS with mainstream RDBMS and other information systems, as well as specifying requirements for various geospatial information, analysis and output, and authentication, platform identification and access control services for databases. **Newlands & Company** provides high-quality illustration, animation, photography, video and multimedia presentation services for architecture, transportation, and urban design. It is also developing capability and innovations in 3-D maps and 3-D GIS analytical models. They will contribute to the effective design of our geospatial analytical web services, and provide student internships.

Local and state government partners gain sustainable development activities and access to personnel and resources to help them reach their goals. They often seek innovative applications of technology to improve public services and government operations. Without a partnership with academia and the private sector, they often find it more difficult to take full advantage of opportunities for innovation. **The State of Oregon DAS** houses the Information Resources Management Division, and within that the Oregon Geospatial Enterprise Office. This entity is under the direction of the Oregon statewide GIS coordinator, and leads or assists in the coordination of GIS activities throughout the state, facilitates communication about GIS issues, and maintains the website that hosts statewide "framework" geospatial data for the State of Oregon (i.e., the most basic, commonly used geographic data such as elevation, geodetic control, street network, and rivers and streams, etc.) (www.gis.state.or.us). **OWEB** (www.oweb.state.or.us) is a state agency led by a board of natural resource agency commissioners and citizens to promote and fund voluntary programs that support Oregon's efforts to restore salmon runs, improve water quality, and strengthen ecosystems that are critical to healthy watersheds and sustainable communities. Previous sections of the proposal have outlined the critical roles that both of these entities will play in the proposed project. **The City of Corvallis GIS** (www.ci.corvallis.or.us) was recently recognized by ESRI with a Special Achievement in GIS Award for innovative field data collection and mapping and the development of GISMO, a customized interface for viewing, querying, report-generation, and simple mapping. As with Global Mapping Technology they have been a longstanding supporter of OSU and will be critical to the success of our workshops and community outreach. We will also seek their input on the usability of our final map viewer. **The Willamette Valley Council of Governments** (www.mwvcog.org) represents 3 Oregon counties, 31 cities, 9 special districts, and the Confederated Tribes of the Grand Ronde. They also coordinate the Willamette Valley GIS User Group, the membership of which includes government workers but also GIS technicians, analysts, and researchers at community colleges, universities, and small companies throughout west-central Oregon. They will play an important role in testing and giving us feedback on our final products from the standpoint of the average user. They, along with **the Confederated Tribes of the Umatilla Reservation** will participate in our training and technical assistance program, particularly as visiting interns to the OSU campus.

Federal partners bring a wide range of expertise in a variety of fields and have very active research and education programs, but sometimes not the infrastructure that is needed to foster innovation. The **USDA Forest Service Pacific Northwest Research Lab** is resident on the OSU campus within the College of Forestry's Forestry Sciences Lab and conducts research in resource inventory and management, land use/land cover, aquatic/land interactions, and ecosystem processes. It will provide a critical researcher to the Virtual Oregon team at no cost (Valentine) and lead in the development of the ArcIMS Metadata Server and Explorer applications.

OSU Research Team and Results of Prior NSF Support

The PFI program solicitation states that “a senior institutional administrator (Dean or higher) in the lead institution must serve as Principal Investigator or Co-Principal Investigator”. As such, our project PI team includes:

- **Gail Achterman**, Director of the new Institute for Natural Resources (INR). The INR was created by the State of Oregon legislature with the Oregon Sustainability Act of 2001, and seeks to improve the sustainability of natural resources within Oregon, and to secure their ongoing contributions to our environments, economies and communities. Achterman will serve as the main INR liaison for the proposed project, the activities of which will fall under the purview of the INR’s “Information Office” (inr.oregonstat.edu). As INR Director, Achterman oversees the development of grant proposals and the projects contracted by agencies to the institute.
- **Karyle Butcher, Donald and Delpha Campbell University Librarian and Deputy Vice Provost for Information Services**. Our University Librarian has direct responsibility for supervision and coordination of The Valley Library (our university library) on the OSU campus and the Guin Library in Newport at the Hatfield Marine Science Center, including cataloguing services and the development of digital library initiatives and resources. Butcher was Oregon's Librarian of the Year in 1998.
- **Curt Pederson, Vice Provost for Information Services**. Our Vice Provost provides coordination, vision, leadership, and advocacy for the effective application of information technologies to the instructional, research, and service missions of the university. He has line responsibility for university computing services (including central web services), classroom support via the Communications Media Center, student computing facilities, telecommunications, television engineering, distributive education infrastructure, and the Valley Library.

Achterman, Butcher, and Pederson will all serve as members of the Virtual Oregon Advisory Board, along with an experienced team of four senior personnel uniquely qualified to complete this project (whose roles, duties, and levels of effort are described in the **Budget Justification**). The Board will ensure that our vision and partnership activities stay on track, while also facilitating the incorporation of innovations in to the policies and practices of the university. The following OSU faculty members round out the PI team:

Tim Fiez, OSU Libraries Willamette Basin Project spatial data research coordinator, will serve as lead PI on the project, working with Wright on overall project management, and overseeing the architecture, programming, and hosting of the Virtual Oregon Web Services Catalog and Map Service. Fiez led the creation of the existing Virtual Oregon Natural Resources Clearinghouse, and will tie this in to the proposed effort, as well as the existing Willamette Basin Conservation Project of the university’s Institute for Natural Resources. He has a varied professional background perfectly suited to this project, having held past positions as a software engineer, a professor of soil science, and a farmer.

Dawn Wright, professor of Geosciences at OSU, will serve as a second lead PI on the project, working with Fiez on overall project management and overseeing workshop facilitation, hosting of partner interns visiting OSU, Virtual Oregon web portal design and implementation, Virtual Oregon Geospatial Analytical Web Services, public outreach efforts (including GIS Day), and supervision of students. She will also provide of budget and progress reports to NSF and annual progress/workshop visits to the NSF PFI program. Wright will also maintain communication with all the partners and co-organize/lead advisory board meetings with Fiez. She was a lead PI during the Virtual Oregon startup phase. Wright is involved in the development and maintenance of several data and analysis portals, and has been a leader for a variety of GIS mapping and process studies of the marine environment, culminating in the publication of the first book on the subject [Wright and Bartlett, 2000]. Her **Results of Prior NSF Support** are outlined in **Supporting Documents**.

Innovation Outcomes (3-page limit)

We propose to support and sustain innovation through a partnership between academe, state/local/federal government and the private sector focused on geospatial operability. This partnership will design and develop (1) a single portal that brings together metadata catalogs, open standards, web mapping systems, and web service-based analysis tools, where one can find, use, and analyze the best data for the problem at hand; (2) the capacity to deliver interoperable geospatial solutions throughout our region by training and technical assistance. The proposed partnership addresses the three goals of the PFI, stimulation of knowledge transformation into innovation, broadening participation to meet workforce needs, and infrastructure development for long-term innovation while addressing the pressing need for better sharing and utilization of geospatial data as follows.

Stimulation of Knowledge Transformation into Innovations

We will stimulate the transfer of knowledge into innovations through the development of the Virtual Oregon Map. The Virtual Oregon Map will serve as a reference system that in addition to stimulating knowledge transfer will help NSF meet workforce needs and develop infrastructure for long-term innovation (described below). The Virtual Oregon Map will serve as one example of the utility of interoperable geospatial systems, but it is not meant to be the exclusive example. The educational and outreach components of this project will prepare our partners and others to take the components of the Virtual Oregon Map, the OpenGIS service catalog, the map viewer, and the geospatial analytical web services, and build new, better, and more innovative services and enterprises. There are tremendous opportunities in helping people find geospatial data on the web (e.g. a geo Google), providing task specific web interfaces, and providing meaning to data through analysis tools.

Monitoring and Assessment. To monitor innovations stemming from the proposed work, we will provide a showcase section on the Virtual Oregon Map web portal where people can promote their work at no charge. Because we are developing interoperable networks, it is not possible to know of every possible use of the system components but the showcase section will provide a voluntary de facto reporting system that will enable us to assess the rate and extent of knowledge transfer.

Broadening Participation to Meet Workforce Needs

Our project depends on broad participation of individuals representing academic, government, tribal, and small and large businesses. Both our educational program and the Virtual Oregon Map require collaborative effort to be successful. Just as the Virtual Oregon Map depends on a network of data providers and analysis services, our educational and outreach program will develop and depend upon a network of geospatial professionals.

Monitoring and Assessment We will tabulate and track participation in all components of our project. We will build from the participants listed in the List of Partnership Organizations and Personnel section. We will monitor participation to make sure we have representation from all types of geospatial businesses and organizations and that we have representatives from all areas of Oregon. We will also use the number of records in the Virtual Oregon Catalog as a measure of broadening participation. Our work should be reflected by an ever increasing number of WMS, WFS, and WCS's online throughout the region. Finally, we will monitor traffic on our geospatial interoperability web site and Virtual Oregon Map viewer to see if we are connecting to users.

Infrastructure Development for Long-Term Innovation

We will develop two types of infrastructure necessary for long term innovation: people and a system implementation for sharing geospatial data, the Virtual Oregon Map. As discussed in the above Broadening Participation to Meet Workforce Needs section, our education and outreach plan will develop the geospatial professionals needed to drive an interoperable geospatial network. Then, the components of the Virtual Oregon Map will provide them with the building blocks for further innovation.

Monitoring and Assessment We will track participants in our workshops and on our geospatial interoperability web portal. These statistics will guide our recruitment, advertising, and outreach efforts and ensure that we are developing the necessary people infrastructure. We will establish a technical project manager for the Virtual Oregon Map and follow a development timeline to ensure that we successfully build and test the Virtual Oregon Map. As mentioned above, we will use web site traffic and the number of services in the Virtual Oregon map catalog to monitor success of the Virtual Oregon Map.

Related Outcomes

Related outcomes that will foster innovation include:

Community Feedback

Any resource intended for wide dissemination and use must incorporate a method to allow feedback from the community. We propose to provide simple online forms that allow users to make suggestions for improvements to the Virtual Oregon Map, inquire about search capabilities or data sets that are not presently available and report errors. A primary function of the Virtual Oregon data librarians and data managers (see project team description below and in the **Budget Justification**) will be to monitor these messages so that the PIs may designate the appropriate senior personnel on the project to address the points that are raised, and in a timely manner. Additionally, we will take advantage of various geospatial data and GIS meetings throughout the calendar year, such as gatherings of the Oregon Geographic Information Council, Framework Implementation Team, GIS Program Leaders, GIS in Action, Willamette Valley GIS User Group, etc. to describe and demonstrate the catalog and portal and solicit suggestions from the community.

Public Outreach

A major outreach component of this project will be the participation of project personnel and partners in GIS Day. GIS Day is a global grassroots event where GIS users, educators, and vendors open their doors to schools, businesses, and the general public to showcase real-world applications of this important technology (www.gisday.com). OSU's GIS Day activities are sponsored by the Department of Geosciences and the College of Forestry, and include map and poster galleries, mapping demonstrations, and open houses. The City of Corvallis will again be asked to provide their mobile wireless mapping truck for an exhibit in the Memorial Union Quad, and industry partners Alsea Geospatial, ESRI, and Global Mapping Technologies will provide exhibits and presentations about their services and products in relation to the proposed work. In addition, several OSU graduate students will also be traveling to local area high schools to make special presentations. A new event planned for subsequent years is a special program for 100 local middle and high school students and their teachers, including a Geography Bowl competition, special videos, and a lunchtime question-and-answer session with campus GIS and remote sensing specialists. Part of this special program will include a "GPS hike" across the OSU campus so that students may learn about the GPS data that are often used in a GIS.

For Long-Term Sustainability

Ultimately our desire is to use the web to access data in real-time using SOAP and more advanced XML technologies, along the lines of the current GOS for national transportation data, and research and develop data mining and knowledge discovery techniques for the Virtual Oregon Map. This will be in the next major proposal that we write to move beyond the NSF PFI effort. One goal will be to discover new patterns in very large, spatial databases (that are "data-rich" but "knowledge-poor"). In addition new methods will be developed for analyzing and presenting data in ways that make sense to non-scientists. Target audiences will include natural resource managers, industry, extension offices, students, and the general public. Research activities will necessitate a collaboration between geographers (led by Wright), library scientists (led by Fiez and Butcher), and computer scientists (led by Fiez and researchers at the Northwest Alliance for Computational Science and Engineering, or NACSE, at OSU, www.nacse.org). Computer science offers a variety of methods to formalize geographic knowledge, but many of them have not yet been broadly applied in geographic information science [Egenhofer and Herring, 1991]. We have already developed fundable, exciting research questions for this next phase that include:

- What is the best way to "mine" semi-structured map or vector data versus unstructured image raster data and can the two mining methods be combined in a single web-accessible system?
- How best to "mine" for data that is not explicitly stored in the database, for instance the position of salmon in a stream at any given point in time
- How can feature extraction be modified to facilitate knowledge discovery?
- How do emerging perceptions of digital (virtual) space map onto traditional conceptions of geographic space and how do we handle their interfaces analytically? [e.g., Janelle and Hodge, 1998]
- Development of data queries and strategies that go beyond just simple retrieval to content-based and knowledge-based retrieval.
- Statistical and classification tools to automate feature extraction and pattern identification, as well as the tools to visualize them in 2-D and 3-D.
- How can we use this to improve delivery of data through digital (virtual) space?

Timeline for Innovation Outcomes

Task	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Workshops			xx				xx				xx	
Educational Portal Development	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Internship program					xx	xx	xx	xx	xx	xx	xx	xx
Virtual Oregon Map Portal	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Map catalog development			xx	xx	xx	xx						
Map viewer development				xx	xx	xx	xx					
Geo. Analytical Web Services Dev.								xx	xx	xx	xx	

List of Partnership Organizations and Personnel (2-page limit)

ACADEMIC		
Partner	Senior Personnel	Commitment/Role
Oregon Natural Heritage Information Center (part of Oregon State University)	James S. Kagan, Director Kuuipo Walsh, Res. Asst. 1322 SE Morrison Street Portland, OR 97214-2531 jimmy.kagan@oregonstate.edu 503-731-3070	<i>Senior personnel on this grant.</i> Contribute large, spatial and tabular resource data, esp. vegetation; innovations in map services for complex data sets; workshop support
Oregon State University	Wright, Fiez, Achterman, Butcher, Keon, Pederson, Williams, 4 others	<i>PIs & senior personnel on this grant. See sections above for description of OSU team</i>
GOVT LAB		
Partner	Senior Personnel	Commitment/Role
USDA Forest Service Pacific Northwest Research Station	Theresa Valentine, Tom Spies Forestry Sciences Lab 3200 NW Jefferson Way Corvallis, OR 97331 theresa.valentine@oregonstate.edu 541-750-7250	Provide critical researcher to OSU team at no cost. Assist in developing web services catalog services and applications
STATE & LOCAL GOVT		
Partner	Senior Personnel	Commitment/Role
City of Corvallis GIS (Benton County)	Alice Grucza, City GIS Coordinator Jon Nelson, City Manager 501 SW Madison Avenue Corvallis, OR 97339-1083 alice.grucza@ci.corvallis.or.us 541-766-6901	Provide internships, workshop presentations, guest lectures in OSU classes; innovation transfer via Dept. of Public Works; GIS Day outreach participant
State of Oregon Department of Administrative Services (Oregon Geospatial Enterprise Office)	Cy Smith, State GIS Coordinator Michael Freese, Chief Information Officer 955 Center St. NE, Rm. 470 Salem, OR 97301 cy.smith@state.or.us 503-378-3160	Coordinate catalog and portal with state natural resources clearinghouse; coordinate with National Biological Info. Infrastructure (NBII) Pacific Northwest Information Node
State of Oregon Office of the Governor Natural Resources Policy	James Brown Governor's Natural Resources Policy Director State Capitol Salem, OR 97301-4047 503-378-3111	Coordinator with Oregon Geospatial Enterprise Office; participate in workshops; beta-tester for catalog and map viewer
State of Oregon Oregon Watershed Enhancement Board (with 89 local Watershed Councils throughout Oregon)	Kenneth Bierly, Deputy Dir. 775 Summer St. NE, Suite 360 Salem, OR 97301-1290 ken.bierly@state.or.us 503-986-0178	Provide input on design and usability of portal, catalog, and map services; disseminate results of project to watershed councils, implement statewide info. sys. strategy
Willamette Valley Council of Governments (includes Marion, Polk, Yamhill Counties; 31 Cities; 9 Special Districts; Confederated Tribes of the	Lesley Hegewald 105 High St. SE Salem, OR 97301-3667 lhegewald@mail.open.org 503-588-6177	Provide input on design and usability of catalog and portal; provide information to university partners on internships, innovation transfer via Willamette

Grande Rhonde Community)		Valley GIS User Group
Partner	TRIBAL GOVT Senior Personnel	Commitment/Role
Confederated Tribes of the Umatilla Indian Reservation	Dan Haug, GIS Manager P.O. Box 638 Pendleton, OR 97801 danhaug@ctuir.com 541-966-2594	Contribute data, internship info; help build local capacity to use GIS through training on reservation, teacher groups, tribal community organizations, related non-profits
Partner	PRIVATE SECTOR Senior Personnel	Commitment/Role
Alsea Geospatial	John Gabriel, General Manager Karen Gabriel, President 450 SW Madison Ave. Corvallis, OR 97339-2380 john@alsegeo.com 541-754-5034	Provide internships, workshop presentations, guest lectures in OrSt classes; technology transfer; GIS Day participant
Environmental Systems Research Institute (ESRI)	Rob McDougald John Sharrard ESRI Northwest Suite 300 606 Columbia Street NW Olympia, WA 98501-1099 McDougald@esri.com JSharrard@esri.com 360-754-4727	Consulting on commercial products underlying project (ArcIMS Metadata Server, ArcSDE, etc.); internships; help to teach workshops; provide software via site license; 2-way innovation transfer; GIS Day participant
Global Mapping Technology	Richard Ash, President 1107 NW Oak Avenue Corvallis, OR 97330 gmtgps@peak.org 541-738-2934	Provide expertise, advice, teaching materials in GPS, incorporation of field GPS data in to map services, service; GIS Day participant
Newlands & Company, Inc.	Donald Newlands, President 1926 NE 10 th Ave. Portland, OR 97212 www.nc3d.com 503-287-8000	Collaboration on innovations in 3-D data and visualizations as part of map, web services, and analytical services; storage and update of 3-D models; provide student internships
Titan Systems Corporation	Roger Crystal, Site Manager Geospatial Info. Systems Division 4099 SE International Way, Suite 206 Portland, OR 97222-8853 rcrystal@averstar.com 503-794-1344	Provide input on effectiveness of catalog and portal; provide workshop, seminar presentation; provide internships; lend homeland security perspective
Partner	OTHER Senior Personnel	Commitment/Role
The National Map, U.S. Geological Survey	Nancy Tubbs, Oregon Liaison, USGS Oregon District Office 10615 SE Cherry Blossom Portland, OR 97216 Nancy.tubbs@usgs.gov 541-251-3210 oregon.usgs.gov	Maintain, update, and make Virtual Oregon data available through National Map; participant and innovation in WMS services; GIS Day participant

Intellectual Property Rights (1 page limit)

The proposed partnership will adopt the Oregon Board of Higher Education's *Policies Relating to Intellectual Property* reproduced in part below and found in full on the OSU Research Office web site at oregonstate.edu/research/TechTran/form1.html. This policy is also in keeping the NSF policy on intellectual property in section 730 of the NSF Grant Policy Manual (NSF 95-26).

Policy

580-43-006 The educational and research activities of employees and partners of the Board of Higher Education and its institutions frequently result in the discovery of new knowledge in the form of invention, technological improvements, and the production of educational and professional materials. It shall be the general policy of the Board that such results be made available to the public in the most expeditious manner.

Stat. Auth.: ORS ch. 351 ; Hist.: HEB 8-1978. f. & ef. 12-5-78

Objectives of Policies

580-43-007 It is the Board's intent to:

1) Provide systematic means of bringing inventions, technological improvements, and educational and professional materials into the public domain; 2) Encourage the development of new knowledge while protecting traditional academic freedom of employees and partners in the publication of materials, development of inventions, and discovery of technological improvements; 3) Establish principles and procedures for equitable sharing net royalty income with employees, partners, and with sponsoring agencies when required by an agreement. Stat. Auth.: ORS ch. 351; Hist.: HEB 8-1978. f. & ef. 12-5-78

Employee Responsibilities and Rights

580-43-011

1. As a condition of employment, all Board and institution employees and partners shall agree to assign to the Board rights to:

(a) Any invention or improvement in technology conceived or developed using institutional facilities, personnel, information, or other resources; and (b) Educational and professional materials, whether or not registered for copyright, which result from the instructional, research, or public service activities of the institutions.

2. Employees shall be responsible for disclosing to designated institutional representatives all inventions, technological improvements, and educational and professional materials conceived, developed, and/or produced during the conduct of normal activities.

3. Employees shall be responsible for cooperating and assisting Board, institutional representatives, and partners responsible for patenting, licensing, registering for copyright, publishing, and generally assisting public access to new knowledge resulting from employee activities.

4. Employees and partners shall be eligible to share in net royalty income from each invention or separate improvement thereof, an amount not to exceed: (a) 40% of the first \$50,000, 35% of the next \$50,000, and 30% of all additional net royalty income received by the Board for inventions and technological improvements; and (b) 50% of net royalty income from educational and professional materials.

5. For the limited purposes of administering the policies under Division 43, persons acting in the following capacities shall be entitled to the benefits and subject to the responsibilities of said rules: Graduate teaching assistants, graduate teaching fellows, graduate research assistants, and student employees.

Stat. Auth.: ORS Ch. 351

Hist.: HEB 8-1978. f. & ef. 12-5-78. HEB 9-1980. f. & ef. 8-20-80. HEB 1-1982. f. & ef. 4-20-82

Reporting of Inventions

580-43-015 [HEB 3-1978, f. & ef. 6-5-78, Repealed by HEB 8-1978, f. & ef. 12-5-78]

Office of Administration Responsibilities

580-43-026 The Office of Administration shall:

(1) Assist institutions in the development of procedures implementing Board policies and managing new knowledge; (2) Monitor institutional application of Board policies; (3) Review and approve institutional recommendations regarding assignment of rights, applications for patents.