Extended Outline for NSF full proposal November 23, 2005

PROJECT DESCRIPTION - "Spatial Visualization of Environmental Challenges: A Digital Toolkit for Informal Education", Proposal # 0553960

INTRODUCTION

Western North Carolina (WNC) is a 23-county region encompassing more than 10,000 square miles. The region is home to the Great Smoky Mountain National Park and the Blue Ridge Parkway (the most visited national parks in the country) and the other natural attractions including national forests and the Appalachian Trail. WNC has the greatest eco-diversity in the country and possesses a delicate balance of plants, animals, geology, water and atmosphere. This great natural beauty draws millions of visitors and thousands of new residents each year, impacting the region through pollution, urbanization and other factors. This has put increased strain on the same ecosystem whose natural beauty attracted these new residents.

The issue of how to balance the preservation of the environment and the sustainability of the local economy lies with municipal and county governments, regional planning agencies, and state-level policy makers. These government officials need access to relevant, applied geographic and environmental data. More importantly, they need a well-informed constituency, which can understand the interaction between—and importance of—land planning, resource management, public health, zoning, emergency preparedness, and environmental issues. This primary audience (our community of knowledgeable citizens who can interpret scientific, technological, engineering, and mathematic (STEM) information related to the environment and assist decision makers at the local, regional, state and national levels) rely on the local Informal Science Education (ISE) community to meet these needs. Key players in the ISE community are represented by our project team:

- The National Environmental Modeling and Analysis Center (NEMAC)
- North Carolina Center for Geographic Information and Analysis (NCCGIA),
- North Carolina Arboretum (NC Arboretum), and
- North Carolina Center for Creative Retirement (NCCCR).

The **goal** of this project is to develop a better ISE tool to support this constituency. To attain this goal, the project team will develop the following digital tools and hard copy **deliverables**:

- Web Deliverables
  - "Virtual World" graphical interface supported by
  - A consistent, updateable Geographic Information Systems (GIS) database that contains the most current and complete environmental data available,
- Exhibits for three local ISE venues (NC Arboretum, Colburn Earth Science Museum, and the USDA Forest Service Cradle of Forestry) with a direct tie to the "Virtual World", thus supporting experiential learning,
- Applied Research for the professional ISE community that can be disseminated nationwide, and
- Community Programs and Workshops offered through the North Carolina Center for Creative Retirement (NCCCR) on the application and use of the "Virtual World" interface.

These tools will have a significant **impact** for informal science education venues and their constituencies:

- It will improve societal applications of geographic and environmental information to real issues in WNC that involve complex issues across multiple disciplines.
- Provide greater efficiency through sharing of data and expertise. Currently, all Western North Carolina informal education venues must create their own environmental education content. Oftentimes, content creators are unaware that a similar or relevant product has been created at another local site, thereby causing them to "reinvent the wheel," creating unneeded expense and inefficient use of personnel resources. This graphical interface will provide an inexpensive, rapid way to develop and deliver key spatial data that can be directly applied by users to their everyday lives. By developing a standardized database within a GIS framework, informal education venues will be able to provide a consistent, integrated, STEM-based story that will be applicable across a broad learning spectrum.
- There will be consistent message reinforcement through application and experiential learning. Informal education research has shown that experience brought into an exhibit plus new information

often requires further experiences to reinforce the learning. When visitors can see the same information, but applied in a variety of venues, a more complete and integrated story is achieved.

- This innovative approach is a way to take an effective online education model (Virtual Worlds) from the formal education world into the informal science education arena. This tool will provide re-usable and sharable content that will be tied directly into NC OneMap (a web deliverable that has been created by NCCGIA). NC OneMap is a subset of the National Map, a United States Geological Survey product developed to provide a consistent GIS for the nation. Therefore, this "Virtual World" interface can be used as a template for every other state in the nation to develop a similar tool.

IMPACT

AUDIENCE

Our **primary target audience** is two fold. The **first group** consists of a **professional audience** of informal educators and exhibit designers at several local institutions. These institutions, described in more detail later in the proposal, include the North Carolina Arboretum, The Colburn Earth Science Museum and the USDA Forest Service Cradle of Forestry. We will also interact with the interpreters at the Great Smoky Mountains National Park and the Blue Ridge Parkway. This group of informal educators will utilize the web deliverable "Virtual World" to determine exhibit content and deliverables. They will be responsible for determining the additional data requirements to make their content effective for their constituency and assist in the evaluation of it direct application and use. This is a small group of professionals at the current time (30) but continues to grow as the demand for informal education grows in our community.

The **second group** of our **primary audience is a public one**. It consists of a growing community of lifelong learners in WNC concerned with preserving the integrity, character and quality of the natural environment. This group is represented by the members and visitors of two of our collaborating partners: the NC Arboretum and the NC Center for Creative Retirement's Blue Ridge Naturalist program.

The Arboretum is a 426-acre site that focuses on education, economic development, research, conservation, and garden demonstration based on environmental conservation with respect to landscape, architecture, and plant sciences. It is sited on the Blue Ridge Parkway, hosts 300,000 visitors annually, and has a large number of members in our primary target audience. Products developed by the Arboretum will not only reach the primary target audience of lifelong learners the live in WNC, but will have the broader impact of reaching tourists that visit our area from across the nation and the world.

To test the efficiency and efficacy of our product, NEMAC will collaborate with the Blue Ridge Naturalist (BRN) group associated with the NC Center for Creative Retirement located on the UNC Asheville campus. This program is an innovative, informal science educational venture designed to ensure the sustainability of the region's natural resources. It is designed to promote awareness, understanding and respect for the Blue Ridge bioregion and train knowledgeable interpreters who may serve as volunteer naturalist educators working with both children and adults through a variety of informal learning venues (including the Arboretum, Botanical Gardens, Blue Ridge Parkway and Great Smoky Mountains National Park). All component programs offered for the fall of 2005 were immediately fully subscribed, testimony to the interest and concern of the target audience (demographics, although weighted toward the typical over 65 group, have a growing segment of "early retirees" in their forties and fifties who are looking to reinvent their selves and their careers).

This group will serve as a "prototype group" of our primary target audience and will test and evaluate our "Virtual World" web application. This will insure that we are meeting our primary audiences' needs. Following the 2005/2006 classes at the Blue Ridge Naturalist program, we will interview the attendees to determine how to best design the digital interface and determine initial content for the GIS database. We will design the tools to meet their needs, and then have an active group in the 2006/2007 session on which to test the prototype and the subsequent release. This will generate a better product, as well as rapidly grow our user base. This group of users, acting as docents and interpreters at the local informal learning centers, will "seed" the technology and get visitors and tourists at the sites to use the interface while visiting an exhibit and hiking a trail, etc.

Lifelong learners interact with extended family groups, school groups and the **local community policy makers and city/county governments**. In building a user base, we are looking to support a well-informed constituency that will support our local policy makers. By providing relevant information to these information education venues in an economical and integrated manner, we will more efficiently relay greater quantities of applicable data to the public. This means that informal education sites will be able to directly access and present a greater amount of key information to their constituency.

Front-end analysis on what information this primary audience requires has already been performed at a recent workshop. The workshop was held by the National Environmental Modeling and Analysis Center (NEMAC) in May, 2005. NEMAC is located on the campus of the University of North Carolina - Asheville (UNCA) and will be serving as the main investigator for this project (see later section on collaborating partners). The workshop was titled "Improving Responses to Regional Storm Events" and dealt with topics related to the floods caused by Hurricanes Frances, Ivan and Jeanne during 2004. The workshop brought together experts from government agencies (US Geological Survey, US Weather Service, National Climatic Data Center, National Oceanographic and Atmospheric Agency), local government officials (North Carolina and Tennessee State Representatives, officials from ten local counties, emergency response teams), six universities, local companies and citizens. **One of the major outcomes of the workshop was the need for an integrated, up-to-date GIS system and an educated constituency who could access the system and make well-informed decisions regarding community planning and action.** This workshop and related audience demand is one of the prime drivers for this study.

Through the tools and deliverables created by this project we will be able to **sustain audience impact beyond the life of the award** by having a tool that is constantly updateable and by getting a growing group of users to be using the web interface as the first place they look for environment-related information. In addition, we will grow the user base of this tool by exposing visitors to our informal education sites to the tool. We will also expand the user base by introducing the tool to all university students studying environmental science in Western North Carolina.

We will reach a multitude of underserved audiences. The Blue Ridge Naturalist demographic is largely composed of senior citizens and they are being trained to serve as interpreters at the Arboretum and similar sites. These newly trained interpreters will directly interact with school children and community groups that serve youth and adults from economically disadvantaged groups. Strategies for outreach and project dissemination include the classrooms located at the Arboretum, Colburn and Cradle of Forestry and special programs at local community groups, schools and summer camps.

We will add to the national audience through our web presence and extended outreach. The discussion in the deliverables section discusses how any of these visitors will be introduced to the web product through the exhibits at our collaborating institutions. Naturally, only a small percentage of visitors to the Arboretum and our other collaborating venues will take advantage of the web tool, so this will initially be a small user group that expands through time. However, because this web tool will tie into a GIS database called NC OneMap, we see this tool serving as a prototype for a national tool tied into the USGS National Map. We will be developing a set of tools that every other state in the union can utilize. Because NC One Map is tied directly into the National Map, and lessons learned in North Carolina in this proposal can be adopted and applied through USGS and other initiatives.

AUDIENCE IMPACT

The three most important intended **audience impacts** are:

1) Increased understanding of the linkage and interaction between people's actions and the environment, with direct application to Western North Carolina –

This will be accomplished through the Virtual World web-interface that has access to up-to-date and complete data. This audience impact is tied to recent U.S. Government research priorities, most notably one that covers "understanding Complex Biological Systems through environmental management and employing data-sharing across platforms and disciplines."

The public will be put in touch with dynamic STEM content, allowing them to understand the implications of, and make better decisions based on, applied scientific data. Policy-makers and community leaders will have access to the same data and an informed constituency that understand the consequences for Western North Carolina (and ultimately, on a national scale). The continuing impact will be felt as a growing group of informed voters and decision makers are assisting the local governments in making better balanced decisions based on scientific facts and not media hype or political platforms.

We want this tool to be the first stop for anyone looking for environment-related GIS information in Western North Carolina. We will measure the increase of new users on the website and categorizing their demographics from their registration information. We will also determine, through exit interviews from the Virtual World and follow-up questionnaires designed by our evaluators, whether the content is meeting their needs. Any shortfalls in content will be addressed by adding that data access layer.

We also want to tie this digital interface into all 3 major campuses in Western North Carolina (UNC Asheville, Appalachian State and Western Carolina University). Because the Virtual World is easily updateable,

any new content created by students or educators can be uploaded and accessed by subsequent users. By exposing a wide range of informal and formal education users to the tool, we will be expanding our users and gaining widespread adoption of this tool.

We will consider the tool a success if we hit a large segment of the target audience and see a three-fold increase in the user base over the first two years. Additionally, we will track the known instances of when information is being provided from the interface to local community leaders for making decisions regarding environmental and land planning issues.

2) Improved sharing, building and learning from the data within our ISE community, with greater efficiencies in costs and time –

Currently, all Western North Carolina informal education venues must create their own environmental education content. Oftentimes, content creators are unaware that a similar or relevant product has been created at another local site, thereby causing them to "reinvent the wheel," creating unneeded expense and inefficient use of personnel resources. This graphical interface will provide an inexpensive, rapid way to develop and deliver key spatial data that can be directly applied by users to their everyday lives. By developing a standardized database within a GIS framework, informal education venues will be able to provide a consistent, integrated, STEM-based story that will be applicable across a broad learning spectrum.

The first measure will be of the content of the GIS and related information in the database. If the information that the user is searching for is not present, then it will not matter how good the interface is. Once we have a robust database, we will measure the use of the interface by polling the local informal education sites and look at the migration from using contractors and GIS experts to the informal educators (and public audience users) being able to easily create these products themselves.

3) Consistent message reinforcement through application and experiential learning –

When visitors can see the same information, but applied in a variety of venues, a more complete and integrated story is achieved. Informal education research by Falk (2001) shows that experience brought into an exhibit plus new information often requires further experiences to reinforce the learning.

This impact will probably be the most difficult to measure and we will have to grow our measurement ideas as we grow our collaboration and cross-experience training. Our advisory panel and outside evaluators should help in establishing these criteria and doing some applied research. Initial ideas concerning this measure relate to structured and unstructured interviews with users from the Blue Ridge Naturalist group and community leaders on the effectiveness of the tool. We will attempt to determine the efficacy of the tool by asking questions based on new points of reference or perspective gained by using the tool. We will consider ourselves successful if a growing constituency relates their findings to this tool and if they use the tool interactively in their presentations to local audiences.

IMPACT EVALUATION

Our **evaluation strategy** is tied to our deliverables and audience impacts. Front-end Analysis, formative evaluation and summative evaluation on the digital "Virtual World" interface and hard-copy products delivered as prototypes to the venues will be tested and coordinated by the co-PI's from each venue with assistance from outside evaluators located both here in Asheville and remotely.

Formative evaluation of data requirements has already begun with the NEMAC workshop mentioned in the previous section. We will build and formalize this evaluation by doing a detailed front-end analysis and planning study with all of the informal educators associated with our collaborating venues, partners and advisory board in the summer of 2006. This evaluation will be jointly led by Elaine Seymour (Director, Ethnography and Evaluation Research, University of Colorado-Boulder.) and Cecelia Garaby (Celina Research, Chicago). The same evaluation team will also interview the participants in this year's Blue Ridge Naturalist program to capture more completely the needs analysis from this primary intended audience.

Coffman and Bohan-Baker (2003) discuss the importance of evaluation on sustainability of a complex project that requires collaboration. We will utilize the same evaluators to help us set measurements and data collection to make sure that we are meeting the audience and other stakeholders' needs.

The more difficult and more important deliverable to evaluate will be the "Virtual World" computer application that converts the GIS data into a graphic format for use by the primary audiences. We will start with formative evaluation and interviewing of the Blue Ridge Naturalist group of primary public audience that our group

of professional informal educators will be hoping to reach. Issues such as "interface phobia" and lack of computer skills will be considered when determining some of the visual interface questions.

Another evaluation will occur one year later and consist of practical application testing and charettes of the prototype Virtual World to examine such issues as user-friendliness, completeness of content, and viability across delivery platforms. In addition, the evaluators will examine the exhibit at the Arboretum (tied to the Virtual World interface) to determine its effectiveness. Serrell et al (2004) have published an excellent tool for determining the effectiveness of exhibits form a visitor perspective. Their topics of "comfortable, engaging, reinforcing, and meaningful" can also be applied to the Virtual World experience and its tie to the exhibits at each of the collaborating institutions.

Summative evaluation at the completion of this project will measure 1) the number of interpreters or training providers who participated and used shared data; 2) number of new data sets added for use by informal education; and 3) exit surveys by end users. The external evaluators will conduct the summative evaluation that strives to determine the extent that experiential learning is occurring in the Virtual World. Based on this data, they will determine if the intended impacts have been achieved, along with any unanticipated impacts. These evaluations will be a primary way of disseminating the research we are doing on applying "Virtual World" technology to the informal science education community and tying in GIS concepts. There will be many lessons learned, both positive and negative, that other users from other states will be able to use as they construct their own tools based on our model and template.

STRATEGIC IMPACT ON INFORMAL SCIENCE EDUCATION

The **critical strategic impact** this study will have on Informal Science Education are the lessons learned in applying a Virtual World for building experiences and therefore applied knowledge in growing a better-informed constituency. This impact ties closely with NSF's goals: developing well-prepared citizens, enabling STEM topics across society, and providing broadly accessible, state-of-the-art information bases and education tools.

Our project will deliver a product that informal educators can use to develop content that is up-to-date and relevant to their constituencies. With this easily accessible data, citizens can make better decisions based on integrating scientific databases more easily and discussing the results in groups. Crane et al (1994) have shown that museums serve as a primary resource for "authoritative information in a setting where people can keep abreast of new developments" and gain enough facts to enable people to make intelligent decisions on their own. By extending this resource to the Arboretum and other informal learning sites in the area and tying them all together in an accessible Virtual World, we will be providing a web access tool with authoritative content. Based on the evaluation of this interface, it will be possible to apply this model quickly outside of North Carolina using the US Geological Survey as the backbone for providing the GIS spatial data.

In addition, we know that learners expand their knowledge through combining past knowledge with new experiences (Falk and Dierking (2000)). These applications often only happen well after a visit to an informal site. By allowing our audience access to a Virtual World where additional information can be accessed easily, these new experiences and connections to previously acquired knowledge will come quicker. In addition, new knowledge can then be captured in the database and passed on to a growing constituency. The additional benefit is that the Virtual World will continue to be update automatically with up-to-date data through its live interface with the State GIS database (NC OneMap). Lessons learned here in WNC can be applied in other states through the USGS National Map. The main data engine driving our application will be North Carolina OneMap, a subset of the National Map. Tools and techniques that we develop for ISE applications will be easily ported onto a national web application. This impact will have to be measured with evaluation and then the results published to insure a broader impact.

Finally, there is a growing body of work on how virtual worlds impact formal learning through college online products and extended learning. We will be applying these lessons learned to the informal learning arena. This study will show how linking to government databases in a much more friendly and experiential manner will improve people's comprehension of related topics. Our study will apply this tool to an issue already identified by formative evaluation – the use of an easily accessible, spatial database of Western North Carolina environmental data to make better decisions related to emergency response to regional storm events and subsequent flooding.

INNOVATION

PROJECT DELIVERABLES

The goal of this project is to create a "Virtual World" graphical interface to STEM-related modules, based on a common GIS database, which will allow enhanced informal science education, economy-of-scale efficiencies for local informal education venues, and improve societal applications of geographic and environmental information. This innovative approach is a way to take an effective online education model (Virtual Worlds) from the formal education world into the informal science education arena.

To attain this goal, the project team will develop the following digital and hard copy deliverables: 1) Web Deliverables including a graphical Virtual World interface supported by a consistent GIS database that contains the most current and complete environmental data available, 2) Exhibit Deliverables for each collaborating venue tied to the web deliverable, thus supporting experiential learning, 3) Research Deliverables and Workshops for the professional community, and 4) Community Program Deliverables tied to the North Carolina Center for Creative Retirement (NCCCR) and others.

Web Deliverables

There are **two key innovations:** 1) Access to reliable, up-to-date spatial environmental information to deliver content that directly supports informal education and 2) Use of a Virtual World interface.

The Virtual World interface will only be effective if the information served is useful and applicable to the target audience. For this reason, let's examine the **up-to-date environmental data** first. A Geographic Information System (GIS) is a computer based technology that manages, analyzes and disseminates geographic knowledge. A GIS represents maps as data layers that can be studied and used to perform analyses. GIS links location to information (such as people to addresses, buildings to parcels, or animals to habitats) and combines that information to give one a better understanding of how it all interrelates. The user or learner chooses what layers to combine based on their purpose.

GIS is fundamentally used to answer questions and make informed decisions. Most computer technology is designed to increase a decision-maker's access to relevant data. GIS goes beyond mining data to give you the tools to interpret that data, allowing you to see relationships, patterns, or trends intuitively that are not possible to see with traditional charts, graphs, and spreadsheets. The user can measure and define changes over time and often determine the causes behind changes. More than that, a GIS database lets you model scenarios to test various hypotheses and see outcomes visually to find the outcome that meets the needs of all the stakeholders.

In recent years, the integration of GIS and the Internet has opened new avenues for sharing and using information. As GIS has matured, costs have dropped, ease of use has improved, more data are available and data are more accessible. The Open Geospatial Consortium (OGC), an international consortium of private industry, government agencies and universities, was established in 1994 to develop common specifications and standards that support sharing of geospatial data in different formats from different software packages across disparate hardware platforms. Progress by the OGC has led to the development of web-based mapping applications that give users the ability to access GIS datasets on a remote host site from a local machine. The true benefit of these advances is that the technology can now be made accessible to the general public and the lifelong learner. An application can be custom designed and tailored to specific tasks and issues. The data and the tools can now be placed in the hands of the lifelong learner, regardless of location. Citizens can use GIS to learn about and understand environmental issues and complex relationships and perhaps even actively participate in the public decision process by using their knowledge to influence decisions that affect their communities and their lives.

NC OneMap, and by extension the National Map, use the power of the Internet to enable access through a single portal to data developed and managed by government agencies, universities and non-government organizations across the State and indeed the nation. The State of North Carolina, through NC OneMap, is recognized as a national leader in supporting the goals of the US Geological Survey's National Geospatial Programs Office. This project will build on the innovation of NC OneMap for geospatial data access to support equally innovative applications for using that geospatial data in a learning environment.

GIS information of specific interest here in Western North Carolina includes spatial distributions of people, plants, animals, natural resources and society's relationship to these natural systems. Formative evaluation with the Blue Ridge Naturalist group and the Informal Science Educators at the Arboretum specifically recognize topics including forest and mineral resources, wildlife habitats, water availability and quality, impact on quality of life of people who live near sources of pollution and compliance issues related to regulations. Formative evaluation through the NEMAC workshop mentioned before identified topics including water and air quality; waste management; the impact of topography and land use on weather patterns; links between economics, consumption,

and environmental impacts; value of wetlands; forest management, for both timber harvesting and conservation; and wildlife management.

In addition, the environmentally aware community is moving from where things are located to questions like "Why are they there?' and "How can this knowledge be applied to predict future distributions and patterns?" Note that the preceding definitions and data needs do not include a way to present the findings to the public through informal education, nor do they discuss the reality or reliability of the data. Therefore, most GIS displays intended for informal education require the informal educator (interpreter) to provide a synopsis, explanation or interpretation with every product. This interpretation usually contains other graphics such as digital photographs or art work to increase the public understanding. This interpretation and accompanying graphics are rarely saved with the data compilation provided by the GIS system, so the next interpreter must start from scratch and reconstruct a new interpretive map and work with a GIS expert to enable this process.

Kirschenbaum and Russ, (2002) showed that the keys to successful application of GIS in community settings are technology, time, staff expertise and funding. Most non-profits and community organizations in Western North Carolina do not have many or any of these factors, and therefore would greatly benefit from a tool like what we are proposing. The community groups like the Blue Ridge Naturalist supplies the data needs and map uses, and our partnership will provide the key data and the easily-accessed interface.

Through this project, we will use the NC OneMap framework to build a complete, consistent database with key ecological and environmental layers needed for informal education requirements here in WNC. This will allow a current product that is accessible and upgradeable by the users. The database will also save and access the interpretation and digital graphics so vital to informal science education and interpretation. This is a substantial upgrade to web-enabled GIS products that the public is currently using, such as Google Earth and Map Quest.

Current environmental and climate research by NEMAC and NCDC researchers will be applied. Through previously funded research, NEMAC researchers have developed a method to generate GIS deliverables from climate data generated and stored at NOAA's NCDC, which is located in Asheville. Because the participating informal education venues do not have environmental scientists on staff, NEMAC will serve as the focal point for providing key educational and research findings for new programs.

The **second part of the innovation is the Virtual World interface**. This deliverable will consist of the development of the interface and related procedures and techniques to turn the GIS data into not only an educational, but also interactive and social environment. Three-dimensional virtual worlds are an emerging medium currently being used in formal education in the classroom and a medium for distance learning. Dr. Stephen Bronack, (a co-PI on this project) and his colleagues at Appalachian State University (ASU) have constructed a Virtual World to power their Instructional Technology Department, a graduate program for teacher education and certification.

Virtual Worlds are a combination of desk-top virtual reality, chat environment and massively multiplayer 3D environment. Many of us will recognize video game titles like Sim City, Doom or Everquest that are embodiments of Virtual Worlds applied to entertainment rather than education. In Bronack's application at ASU, the students and faculty act as cohorts in cross discipline learning. The Virtual World is based on a social-constructivist model where learning is a group activity and always has a social purpose. Constructivist learning (Hein (1998), Dede (1995) and Winn (1997)) states that the focus needs to be on the learner, not on the subject to be learned. Knowledge is acquired through the meaning attributed to experience (constructed) through visits to our collaborating sites and built in the Virtual World through interconnections. The tool is designed to not "guide" the learner but enable them to learn the points of connection in a supporting environment. Learning is a social activity and should be contextual – building on what we already know. Hein (1998) states "It takes time to learn: learning is not instantaneous. For significant learning we need to revisit ideas, ponder them, try them out, play with them and use them. This cannot happen in the 5-10 minutes usually spent in a gallery."

It is hard to appreciate a Virtual World without actively participating, and the reader may want to visit the Active Worlds website (http://www.activeworlds.com/) to fully appreciate the following description. (*Active Worlds is the software engine that Bronack has applied at ASU and the one we intend to apply for this project.*) When you log on the Virtual World, the software engine recognizes your entry and you assume your avatar shape. An avatar is a surrogate persona that you use to interact with others in the Virtual World. You enter the world at a "town square" with your world spreading in all directions around your. The interface is intuitive; you walk ahead or turn by using the arrow keys on the keyboard. The first time user would enter a welcome station with a few simple tutorials and an artificial intelligence avatar to answer questions.

The next stop would be the Town "Map Store". Very similar to map stores in the real world, there would be a whole series of maps that are already made and displayed on the walls or pulled from the shelves. Many users could find exactly what they want by point and clicking and "buying" the map by dragging it to a folder where the

map could be printed or displayed on their desktop or used in another application. The more dynamic interface would be the map table interface. The visitor would drag layers onto the map table from items on a shelf. Much like a light table, each subsequent choice would build on the first. For example, a visitor may start with a state and county outline map. They would then drag a topographic map, followed by streams and rivers. To properly visualize the relationships, they could then turn on the 3D view, and the topographic map would instantly turn into a 3-Dimensional visualization that could be seen from several angles. Wanting to see one more relationship, the visitor and then select a climate map from the shelf before finalizing his purchase.

So what does a person do once he buys a map? He will usually use the map to get to another destination or orient himself once at a location for hiking or sightseeing. The visitor will do the same thing in the Virtual World. They will travel to the Arboretum and interact with the online exhibit and interpretations that the educators have prepared. Much like a visit to a National Park, the interpretation may concern the link between geology and tree type, or proximity of wildflowers to mountain streams. The visitor will be able to add layers to his map at this location, or perhaps pull up digital pictures taken from different vistas at the Arboretum.

Perhaps one of the greatest benefits of a Virtual World interface is the ability to interact with other learners at that same time as interacting with the data. Just as in museums, informal learning online is greatly enhanced through social contact. While in the Virtual World, a user can approach avatars that represent other online learners or even interpreters. Many universities staff online libraries with "virtual librarians" that users can approach and question during certain hours. Our informal learning venues with linked exhibits will do the same, interpreters available online a few hours a day that can answer questions or provide directions. Barab et al (2004) show that online communities support learning across a broader spectrum. This is because individuals come from different sets of experiences and therefore bring a different perspective on the new data presented.

Jolly et al (2004) showed in their study that informal science programs must recognize that they need engagement, capacity and continuity. We plan to have engagement through the tie of real exhibits and online databases, capacity through a growing database of factual and up-to-date information, and continuity by tying the experiences together at multiple informal learning centers.

Many of the building blocks are already in place for our application. We will use much of the data that NC OneMap has already catalogued and add multiple layers from past studies that NEMAC has completed related to climate, weather, hydrology and land use in Western North Carolina. We will use the Virtual World framework that Bronack has already constructed for formal learning and apply his lessons learned. Once initially constructed, the Virtual World will actually help build itself. The interface will be intuitive and allow for easy interaction with content, making the tool something that our audiences of professional interpreters and exhibit creators will utilize to quickly develop new exhibits and programs. NEMAC will work with each venue to develop a section of their users' Virtual World location to handle products generated by the group.

Exhibit Deliverables

Exhibits at our collaborating venues will be tied directly to the Virtual World, serving as an extension and another entry point to this tool. We will first discuss the prototype exhibit at the Arboretum, and then briefly discuss similar applications at the Colburn Earth Science Museum and Cradle of Forestry.

St. John et al (1994) explain that the primary role of science museums is the development of relationships. These relationships exist between the designer/educator, the visitor and the content. We want to take this one step further, and allow the regional informal educators build upon content at collaborating institutions to allow visitors to build their own learning experience.

The North Carolina Arboretum is in the process of expanding its onsite education program and building a new visitor center. This project will create a new exhibit at the Arboretum that will allow this visitor to directly interact with maps of the property that include watershed information, flora and fauna recorded by season, topography maps and hikes around the area. The exhibit will integrate graphic panels with a video display of these select GIS layers for the property and surrounding area. Visitors who are interested will interact with this map through tilt-table technology and a touch screen for enabling different data layers. In addition, with the help of an onsite interpreter, the visitor will be able to print a high-resolution map to take with them as they explore the grounds of the Arboretum. This will allow the visitor to choose what data to display, and receive a map to actually go experience the flora and fauna of their choosing. This inquiry-based approach will let visitors determine their learning and entertainment experience for the day, and for return visitors to construct new routes and experiences on subsequent visits.

This interactive and spatial view of the property is important for the visitors to be able to orient themselves prior to visiting the rest of the property. Because the Arboretum is in a closed valley and tall trees often obscure the

ridgeline and other points of reference, visitors often have a hard time determining their exact location while exploring the large 426 acre property. Studies show that informal education works best when the visitor can properly orient themselves and place their experience in a learning context (Crane et al (1994)).

As an extension to this exhibit, the Arboretum will develop an educational program using hand-held GPS units to go onto the property and collect new data layers for the database. These new data layers could include bird sightings, local tree species, or even watershed issues. While on the property, the visitor will see signage and digital graphics that tie to the same content they saw at the visitor center, and a map with a "you are here" locator that they can once again orient to their handheld self-generated map and GPS unit.

The Arboretum will use the Blue Ridge Naturalist group as a test case to see how effective this program is. Local experts on different topics will lead the group through the Arboretum and facilitate the data collection. Later, they will have access to a virtual tour on the web and be able to transfer the data collected with their GPS units into internet applications. This data will then be uploaded to the NC OneMap system as a layer of information that could be utilized by the same group later or by other study groups looking to access similar information.

The true innovation here is the tie from the real exhibit to the Virtual World online. Once visiting the Arboretum, the user could go online and reconnect to the same look and feel they experienced at the visitor center. They could build on their understanding by seeing where similar environmental conditions exist, say on the Blue Ridge Parkway, and visit other sites and gain a deeper understanding of related concepts. Johnson (2004) shows that in informal learning environments, people learn best when encouraged to move freely around the environment and respond to a variety of stimuli. What better way to learn than to visit one physical location, be exposed to a concept, visit this idea in the Virtual World, then go to another physical location that will support and expand this understanding?

Bransford et al (2000) showed that learning is greatly influenced by the context is which it occurs. The Virtual World will allow connections to live locations in the outside world that can support the core learning values presented in the Blue Ridge Naturalist program. In addition, the "graduates" of the Blue Ridge Naturalist program can use the Virtual World as a tool to interpret concepts for visitors or school groups to the Arboretum or other sites.

The Forest Service will use the application to design a walk-through interactive exhibit at the Cradle of Forestry showing the different forest types in Western North Carolina related to topography, elevation and change over time. Another product will include visualization kiosks to show trails, depicting elevation changes, view-sheds, etc.—allowing people to map out their hike according to ability and desire. A forest health unit could use the database to show future movements of insect pests such as the hemlock wooly adelgid, the effects of weather events, and how continuing urbanization will affect natural resources.

Similar products will be developed for the Colburn Earth Science Museum, relating geology to local environmental concepts and soil management. For example, a key product for the Colburn is an integrated landform, stream and weather product to simulate a flood. The Colburn Museum is a good example of a small, local science museum that operates on a small budget yet reaches over 10,000 school children each year through its educational programs. Providing such sites with dynamic content allows them to use their limited non-profit dollars much more efficiently.

We would then examine what UNC Asheville would require from NCCGIA to create these products. Once we have a list of proposed deliverables, we will construct a prototype, and then develop a pilot product to test the system.

Research Deliverables and Workshops

During Years One and Two of the project, we will conduct an annual seminar for all regional informal education content creators/providers. The seminars will communicate how to use both the interface that composites GIS content and the other interface that creates graphic content. The seminars will use the products developed in the pilot and prototype stages as examples for the types of products that can be created, and then follow-up with a discussion of additional data and functionality that need to be added to the final version.

Additional goals for the workshops will be tied to the evaluation. Evaluators will be able to actively determine how effective the interface is for new users. This evaluation will not only help in moving from prototype to final product, but will also provide good data for publishable research material tied to this new approach and lessons learned.

Community Program Deliverables

The Blue Ridge Naturalist (BRN) program at the NC Center for Creative Retirement is an innovative, informal science education venture designed to ensure the sustainability of the region's resources. The fact that all the component programs offered for the fall of 2005 were immediately fully subscribed is testimony to the interest and concern of residents of Western North Carolina, both long term residents and relative newcomers who range in age from 29 to 81. The program provides adults of all ages with an array of short term core science courses, field studies, and other educational opportunities. The topics of "Discovering a Sense of Place" exposes the participants to a variety of environmental topics including tree identification, tagging of butterflies, ecology of the Blue Ridge, birding , wildflowers and geology. The field trips include visits to the Arboretum, Blue Ridge Parkway, Botanical Gardens and the Colburn Earth Science Museum.

We will tie all of this material into the content offered online, and the registrants will serve (on a voluntary basis) as a prototype test case for the Virtual World. They will also be one of the test groups for the Arboretum activities that will be tied into the new exhibit.

One of the goals for the BRN is to have graduates from the program use the knowledge they gain to serve as volunteers with science education programs in local schools and community organizations. Therefore, this group will serve as a seedbed for a growing group of users in our community and the core of the informed constituency that will support local community leaders and policy makers.

An incidental group of uses will be the students in environmental classes at our collaborating local universities. We will employ both undergraduate and graduate students in the development of the Virtual World interface and the population of the GIS layers. These students will become users of the Virtual World and can train new users in the tool as they move out into the local community or further afield.

PROJECT DESIGN

Our **Project Design** is based upon the redesign of a key process that exhibit designers and educators are already using. The local venues are already constructing exhibits, videos and websites that use GIS based products as a portion of their input. We know it is expensive and time consuming to always be recreating the content and to keep it current. We also know that there is much content overlap (satellite imagery, digital topography models, location of key landmarks, etc.), and that informal education venues would benefit from having a central repository of data.

The project actually already started earlier this year with the NEMAC workshop titled "Improving Responses to Regional Storm Events'. Front-end analysis associated with this workshop highlighted the need for an integrated, up-to-date GIS system and an educated constituency who could access the system and make well-informed decisions regarding community planning and action. The workshop also brought this project team together to find a way to solve this problem.

Upon funding in later Spring, 2006 the team will go through an initial planning phase and then start down three parallel paths: 1) GIS and data issues that are going to be handled by Tom Tribble, 2) Virtual World interface and design by Stephen Bronack, 3) Audience Needs and Formative Evaluation headed by John Bubany and Jeanie Martin working with the outside evaluators. Jim Fox will be integrating data from each of these groups and working with the advisory group. The plan is to study the process of the creation of these past products, and work with NCCGIA to design a GIS database that provides a consistent product that has all of the layers of information needed for the informal education venues. One of the key pieces missing is weather and climate data. NEMAC and NCDC, working collaboratively, have completed research on how to provide meteorological data to GIS standards and will work with NCCGIA to port this data into this new system.

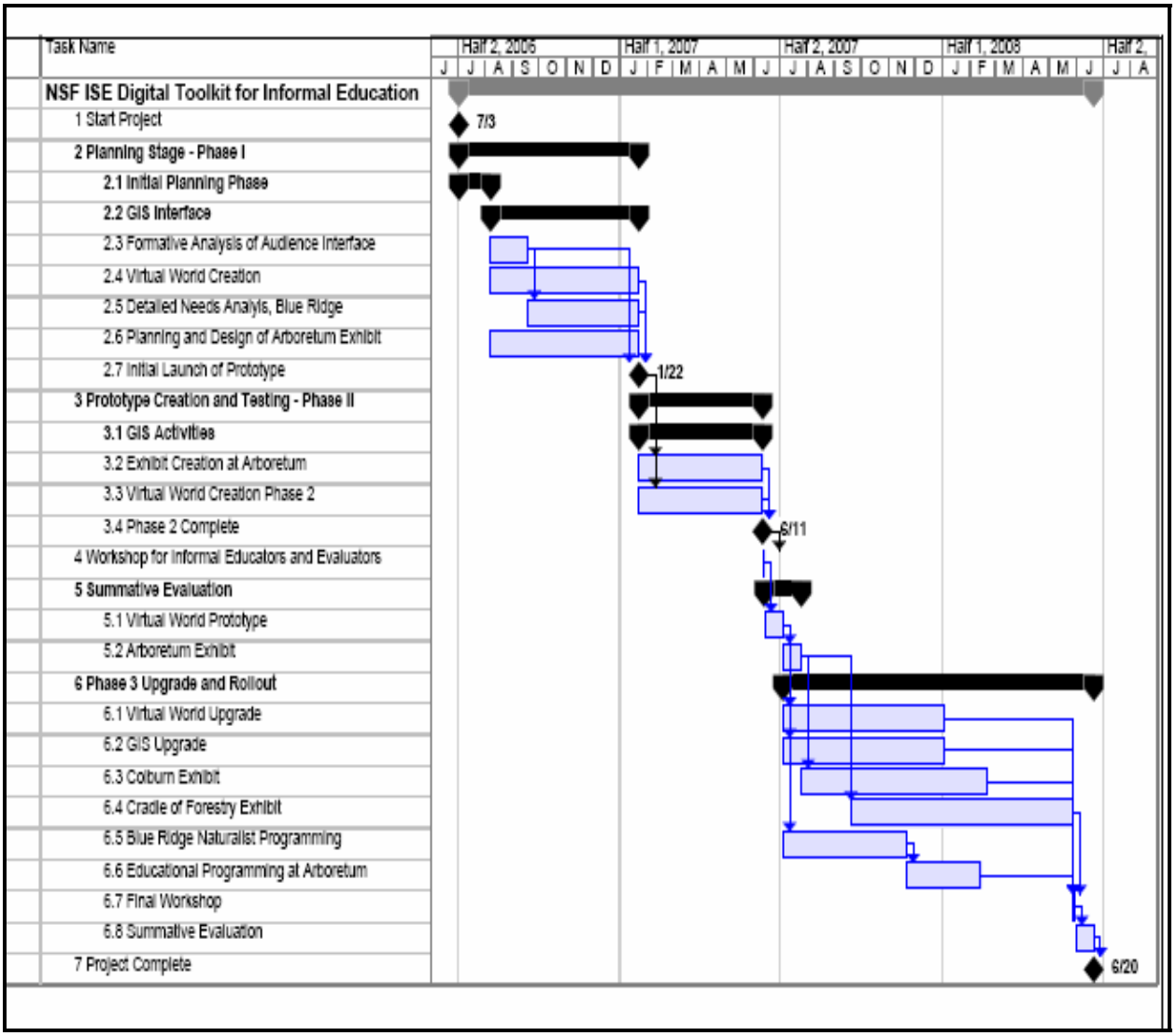
By early 2007, we will have the prototype architecture designed, a clear idea of audience needs, and a list of key GIS products and data layers needed. Early 2007 will see us integrate these ideas and create not only a prototype of the Virtual World but also the accompanying exhibit for the Arboretum. Both of these tasks will need to be completed prior to our first users' seminar and workshop in the summer of 2007. This will also be a key time of intensive evaluation. Many of the assumptions made based on front-end analysis and formative evaluation will have to be tested on the intended audience. Results from this stage of the project will be critical before finalizing design.

One issue that we have already recognized from analysis relates to the GIS databases. While it is beneficial to allow users to input new data into the database, accuracy of the content that is being tied to state databases is an issue. In order to keep quality high, we will keep local databases separate until independently confirmed. This will necessitate having a separate regional server for this data, a cost included in this proposal.

Once we resolve any identified issues, Phase III the project will occupy the final year of the project with the finalization of the Virtual World deliverable and the creation of the other two exhibits at the Cradle of Forestry and the Colburn Earth Science Museum.

Once completed, the interface will be maintained and populated by NEMAC. It is anticipated that community and university funds will be accessed for this purpose. In addition, we believe that the US Geological Survey will promote the product to other states and we will work on collaborations to implement the tool in multiple other locations nationwide.

Risks associated with this project are largely tied to audience perception and adoption of the tool. There is little risk associated with the technology that will support the application, the greater risk lies with using the technology in the appropriate manner to meet audience needs. To meet this risk, we may need to move more funds to the evaluation and prototype testing category. If this is the case, those funds would probably have to come at the expense of one of the two subsequent exhibits from Phase III.



STEM CONTENT

By forming our association with the NC Arboretum, Colburn Earth Science Museum, National Climatic Data Center, NC Center for Geographic Information and Analysis and three local universities, we have access to most of the local science experts and informal educators in Western North Carolina. Key topics of interest in our community range from environmental sciences and geology to biocomplexity in the environment. In addition, NEMAC is leading the way in our region in Scientific Visualization and application to weather and climate issues.

Our partnership with Dr. Bronack at ASU and two education advisors, Richard Hartshorne at UNC Charlotte and Eddie Case at Western Carolina gives us the skill sets necessary for delivering this content appropriately to our target audiences. By using the Virtual World model, we are also reaching a segment of the population that learns in a different manner than most scientists do, and are therefore broadening our reach.

EDUCATIONAL RESEARCH AND PRIOR WORK

Chittenden (2004) describes lessons learned by the Museum of Science in Boston in integrating exhibits and the web to create engaging content based on real time data. Science museums and other informal learning venues are attempting to make science more interesting by applying principals to topics that their visitors can relate to.

We see the same thing here in Western North Carolina. Visitors are constantly coming to the Colburn Museum and asking the curator and educators to discuss topics like the recent tsunami in SE Asia or the flooding due to Hurricane Katrina and its relevance to Western North Carolina. The museum has responded through integrating local earthquake and hurricane damage to the same scientific principles. Jim Fox, serving as New Exhibits Project Manager, has taken visitor surveys and audience needs analysis to design two new exhibits. The newly opened History of Mining in Western North Carolina has taken a lot of the rocks out of the cases to allow visitors to touch and explore their properties, tell people's stories through narratives to bring the geology alive, and installed an interactive mine exhibit where children can simulate a mine explosion and explore newly unearthed gem pockets. These concepts build on what Crane et al (1994) have shown is effective – the exhibits must be attractive and exciting in order to survive, and must be designed to generate interest and excitement rather than providing the "right answers".

We would apply this learning to our Virtual World. Informal educators will use this digital tool to clearly illustrate some connections and in other instances let the visitors find some other connections on their own. The interface and utility of the Virtual World interface is critical, and why we are relying on Dr. Stephen Bronack's expertise and years of experience on getting this tool to work in the area of Informal Education.

Finally, we are already learning a great deal about the changing and ever growing demands of our target audience. The Blue Ridge Naturalist program continues to exceed our expectations on the technical savvy and interest in science that our retirement community possess and want to share with others. By bringing this audience together with science experts in new experiences that combine exhibits with exciting web interfaces, we believe that we have an exciting new vehicle for Informal Science Education for STEM topics.

Collaboration

Collaboration will be critical for this project, at three levels: the creation of the database, the digital packaging of the materials, and the distribution to the various informal educational sites (users)

The National Environmental Modeling and Analysis Center (NEMAC) in collaboration with the North Carolina Center for Geographic Information and Analysis (NCCGIA), Appalachian State University, the North Carolina Arboretum (NC Arboretum), and the North Carolina Center for Creative Retirement (NCCCR) are the key players in this proposal. They are supported by an Advisory Board that represents three additional universities (UNC Asheville, UNC Charlotte and Western Carolina University), the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC), and the U S Forest Service.

NEMAC is a University of North Carolina Asheville Center. Its mission is to conduct basic and applied environmental modeling research and technology development. Through collaborations with academic, governmental, commercial, and non-profit organizations, the Center provides multi-factor analytical, visualization, and prediction capabilities to advance public education, health, welfare, and the economy. NEMAC personnel will oversee and coordinate all collaborative activities.

Jim Fox, a Research Associate at NEMAC, will serve as principle investigator for this project. He will be responsible for ensuring each of the collaborative teams are interacting and communicating with one another. He has a strong background in project management, GIS technology applications, and development of informal education content.

NEMAC's environmental, climatology, and multimedia experts, and UNC Asheville students will: 1) determine what type of environmental and climate data are required for the NC OneMap product; 2) determine display and update information; 3) develop graphic and multimedia utilities to transform the GIS data into usable graphic products; and 4) generate the pilot and prototype files for each of the informal education venues.

Stephen Bronack (co-PI) and a group of graduate students at Appalachian State will develop the Virtual World based on past experience and use the framework and template designed for formal education to be applied for this informal application.

The NCCGIA group, creators of NC OneMap, will design and implement the interactive web tool to pull all of the current data into a web portal. They are a key collaborator because they are the official developer and provider of GIS information for North Carolina. Tom Tribble (co-PI) is Field Office Manager in Asheville. In addition to his role in project management, Tom works closely with members of the GIS community in North Carolina, particularly local governments, to promote the more effective use of geographic information technology, to build partnerships and to collaborate on data collection and sharing efforts.

Another collaborating group, consisting of a number of small teams, will be the informal education venues. John Andrew Bubany (co-PI) is Exhibit Programs Coordinator for the NC Arboretum and former Director of Exhibit Development for the Franklin Institute Science Museum of Philadelphia In these positions, he has been responsible for youth educational programming and the development of a series of traveling exhibits.

Jeanie Martin (co-PI) is the Program Coordinator for the Blue Ridge Naturalist Program at the NC Center for Creative Retirement. She is certified as a Master Gardener; leads nature walks for the NC Arboretum, teaches Anatomy and Physiology with a local school of herbal medicine, and is active in several local environmental groups.

These partners were chosen for the quality and sustainability of their current ISE programs. It is through their testing of the prototypes to be developed during the course of this project that we will be able to share the final products with a much larger audience.

The advisory committee will be chaired by Dr. John Stevens, Executive Director of NEMAC. His specialties include a strong STEM background and the formation and care of large collaborative networks across universities and communities. Serving on the advisory board will be two educational specialists from the region. Richard Hartshorne is from UNC Charlotte and Eddie Case represents Western Carolina. They bring not only their educational expertise but also a network with their respective campuses. Additional advisory board members are Ron Manheimer (Director of the Center for Creative Retirement), Julie Vidotto (Education Program Manager at the Arboretum and past participant in many NSF funded studies), Adam Smith (National Climatic Data Center Meteorologist), Zoë Hoyle (Communications specialist and educator for the US Forest Service) and Brandie Fariss (Assistant Professor of Environmental Education and GIS at UNC Asheville).

COLLABORATION PROCESS

Collaboration across such a diverse group of specialties will be a challenge, but NEMAC has significant experience managing large, multi-disciplinary, multi-institutional projects.

NEMAC personnel currently administer and participate in three federal- and state-funded programs. The NEMAC-led Atmospheric Science Tools for Energy Conservation (ASTEC) program is in its second year of Department of Energy funding (total to date: $1.6 Million via Oak Ridge National Laboratory). ASTEC includes four individual projects performed by one private-sector firm and two universities (UNC Asheville, UNC Charlotte). The Scientific Innovations in Numerical Modeling, Digital Visualization, and High-speed Connectivity in Western North Carolina (SIMVaC) program is funded by the University of North Carolina Office of the President ($600,000 over two years) and includes 10 individual research, education, and economic development projects performed by two universities (UNC Asheville, UNC Charlotte) and one community college (Asheville-Buncombe Technical Community College). NEMAC also provides administrative and research support for the Total Value Assessment Tool for Farmland (TVAL-Farm) project, funded ($390,000) for three years by the US Department of Agriculture. TVAL-Farm research is performed by two universities (UNC Asheville, Appalachian State University) and private consultants.

In addition, Jim Fox has a strong background in Project Management. He served as project leader for a large industry group that had participants in five companies on three continents. In addition, he has served on multiple conference chair committees to organize industry and academia to present scientific results at numerous conferences relating to the Earth Sciences.

The key collaboration tools will include extensive planning by the co-PI's during the initial stages, and then the use of the newly built Virtual World. The Virtual World has the benefit of experience gained from Dr. Stephen

Bronack's work related to online and distance education. We will utilize the online chat rooms, data posting areas and virtual experiences to allow team members to communicate using a diverse set of graphical and verbal tools.

Collaborations between the Blue Ridge Naturalist program and our web deliverable will require considerable effort in the planning stage and throughout implementation. According to the work of Mattessich (2003), factors that must be considered are environment, membership, process, communication, vision and resources. The bottom-line for an effective collaboration is to make sure that cooperating across corporate and academic boundaries is more valuable to the individual team members compared to just working within their typical work boundaries. To succeed in our ever evolving social and business world, most professionals are finding it very rewarding to participate in collaborations because they have access to skill sets and ideas that they cannot get within their own entities.