Preview of Award 1242122 - Annual Project Report

Cover

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Accomplishments

*** What are the major goals of the project?**

The **goals** of the center are as follows: (1) Conduct synergistic, interdisciplinary STEM research that uses and advances CI-enabled techniques and tools to support collaboration and sharing; (2) Train and educate a new generation of interdisciplinary, CI-knowledgeable professionals who represent the 21st century demographics; and (3) Extend the network of Cyber-ShARE collaborations to include other major cyberinfrastructure projects, international collaborators, and industry partners.

Specific **Center objectives** are associated with each goal. Goal 1 centers on synergistic interdisciplinary research and the objectives are: adopt and disseminate exemplary practices that deliberately support interdisciplinary research teams; serve as an institutional and national resource for effective semantic-enabled tools, resources, and practices; and support the integration of ideas across CREST-funded subprojects. Goal 2 focuses on training and education, and the objectives are as follows: expose middle and high school students in leveraged outreach programs to discovery-based applications that use CI; graduate students with the ability to apply CI approaches that support collaboration, work in interdisciplinary and cooperative teams, and apply cutting -edge techniques and tools for managing data; expand the number of students, especially those from underrepresented groups, who are involved in efforts associated with the Center; and deliver workshops to students, faculty, and professionals in areas that improve their proficiency in using CI and ability to work in interdisciplinary and collaborative teams. Goal 3 focuses on extending the network of collaborators and the objectives are as follows: disseminate Cyber-ShARE technologies to El Paso's city and county governments and

national organizations; and pursue relationships with national and international efforts that align with Cyber-ShARE technologies.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Synergic interdisciplinary research using tools to support collaboration and sharing:

One of our major activities was the development of MetaShare, a knowledge-based system that supports the creation of data management plans and provides the functionality to support researchers as they implement those plans. MetaShare maps the scientific data lifecycle to development of knowledge-based systems and, as a result, is a community-based, user-driven system. The system provides recommendations and guidance to researchers using practices and decisions that have been made on other projects, accumulated in the knowledge base. Using formal semantics provided by ontologies and rules that are stored in MetaShare, the system uses data collection, dissemination, and management tools to facilitate tasks with respect to using and sharing scientific data. MetaShare is being developed on a Web platform, using Semantic Web technologies. A prototype system is ready to begin testing.

We have begun to analyze requirements for extensions to MetaShare that will automatically generate data collection instruments with associated metadata and semantic encodings, and iRods policy implementations, all derived from the data management plan. We are working with Dr. Elizabeth Walsh from UTEP's Department of Biology to develop a use case for these extensions. The use case involves capturing and annotating Gene Sequence Data to be submitted to GenBank, a National Institutes of Health annotated collection of all publicly available DNA sequences. This effort will produce data collection tools in the form of web forms.

A second major activity of the Center is development of a project reporting system. The Center is very active in research and education, and must collect a wide range of information for Annual, CRESTWeb, and institutional reports. We are developing a reporting system to manage this information. The initial system makes use of Drupal's available functionality. In the future, we will semantically-enable the system and make it generic for use by other research projects.

A third major Center activity is anchoring UTEP's NSF-funded **Innovation through Institutional Integration (I3)** program, building cyber-infrastructure, communication, and connections to foster interdisciplinary collaborations on campus that promote student success, integrate research and education, and result in effective education for a diverse student body with particular emphasis in Science, Technology, Engineering, and Mathematics (STEM) areas. The main focus of the program is to facilitate sharing of education-related findings among interested faculty in order to innovate educational practices. As part of the I3 initiative, UTEP is revamping the Expertise System to highlight expertise on campus regarding research and creative activity. The Expertise System consists of the following: Faculty and Professional Staff Profiles, Center Profiles, Research Stories published stories from the university's Communications office and linked to faculty, staff, and centers, and Move

communities that support interdisciplinary collaborations across campus and beyond.

Train and educate a new generation of interdisciplinary, CI-knowledgeable professionals:

Activities regarding training and education are listed in the training section of the report.

Extend network of Cyber-ShARE collaborations

The activities to extend Cyber-ShARE collaborations include the following:

1. Dr. Walsh, Department of Computer Science at UTEP, to provide data management services for her NSF-funded project, “Integrating genetics, life history, and morphology to understand the diversification of an enigmatic metazoan lineage.”
2. Greg Abram, Scalable Visualization Research Specialist, and Brandt Westin, Visualization Manager, from the University of Texas Austin’s Texas Advanced Computing Center (TACC) collaborated with Cyber-ShARE last fall on the configuration of the visualization wall. They also conducted a training session, Introduction to Scientific Visualization, on the Cyber-ShARE Visualization Wall.
3. Dr. Leonardo Salayandia began working with Maria Esteva, Data Manager and Collections group at TACC, to seek feedback on software products being developed at Cyber-ShARE.
4. Dr. Craig Tweedie and his research group worked with artist Francesca Samsel to create a visualization for display on Cyber-ShARE’s 45-monitor tiled display that depicts the interwoven complexities of our environment, from the microbes in arctic ponds to the satellite images beamed down from above. Her work has led to a collaboration with Los Alamos National Laboratory through Cyber-ShARE in which she will work on the foundations for a visualization system that would allow scientists to explore and compare variables within their research through the use of layered transparent graphs or visualizations. The program will enable scientists working on climate change to search for patterns or correlations within their data difficult to uncover with standard methods.
5. Drs. Ann Gates and Aaron Velasco established a collaboration with Dr. John D. Olivas, a veteran of two space shuttle flights and an expert on the effects of entry environments on structural materials, which has led to a strong collaboration with the Center and advanced materials research.
6. Dr. Ann Gates serves on the Advisory Board for the Regional Cyber and Energy Security Center, which is an applied research center at UTEP with the mission to promote economic growth and job creation in areas of smart grid, distributed energy resources, and critical infrastructure protection enterprises.
7. Dr. Deana Pennington established a collaboration with Kaye Gagnon at Raytheon Corporation, to develop a STEM education virtual geocaching game that supports students exploration and study of earth features beginning from satellite imagery and concluding with integrated field data at the earth’s surface.
8. Geothermal : Add

9. CCNY: Dr. Natalia Villanueva Rosales established a collaboration with Jorge Gonzalez and Michael Piasecki that led to a proposal to integrate Cyber-ShARE semantic approaches with sensors databases approaches to data integration, in particular the CUAHSI repository.
10. Dr. Deana Pennington led a successful proposal to the NSF Socioenvironmental Synthesis Center (SESYNC) to bring together collaborators from the U.S. National Council for Science and the Environment and University faculty from Tufts, Arizona State, Nebraska, Michigan State, Portland State, Lewis & Clark, Sydney, and Surabaya to synthesize theory and practice knowledge in order to develop learning models and activities that teach and assess students skills related to interdisciplinary research.
11. Dr. Ann Gates established a collaboration with Smithsonian that led to a successful proposal.
12. Dr. Villanueva Rosales and Dr. Tweedie established a collaboration with Debra Peters from USDA ARS from the Jornada Experimental Range that led to a proposal to integrate Cyber-ShARE semantic approaches for data processing and hypothesis testing.

Specific Objectives: The Center supports three subprojects. The goal of the first subproject, **Knowledge Representation, Negotiation and Integration--Linking Human and Machine Knowledge Models through Semantics,** is to facilitate interdisciplinary community engagement and ultimately knowledge negotiation and integration via semantic approaches. The **objectives** are as follows: investigate the ability of ontologies to represent mental models in IDR teams; facilitate knowledge negotiation in IDR teams through ontology alignment and visualization; and educate students with knowledge in Semantic Web and IDR teams and disseminate results. The activities of the subproject are described next.

Most of the semantic tools being developed by the Center are informed by basic research conducted within our Knowledge Subproject. Students within the Knowledge Subproject investigated semantic approaches to support a wide range of research activities. These include: automatically creating visualizations from scientific data (prototype tool VisKo); visualizing the provenance of derived data (WebProbe); developing a new methodology called CARP (Collect, Annotate, Refine, and Publish) for supporting researchers' sharing, identifying, and querying relevant collections of research resources available on the Web; automatically integrating field data using Semantic Automated Data Integration (SADI) for earth science applications and generating provenance of derived data; developing an ontology of expertise; extending our system for workflow-driven ontologies (WDoIt!); and the integration of satellite with ground data in the Virtual Geocaching game. The CARP methodology was validated using three case studies, one from Environmental Science and two from Geosciences. As a result, scientific collections from these research efforts were created. Scientific collections are not limited to a discipline can be used to create interdisciplinary ontologies.

Knowledge subproject research is being applied in two other projects associated with the Center. The NSF-funded Virtual Learning Commons project (OCI-1135525) applies VisKo and CARP, as well as our expertise in ontology development. The NASA-funded ELSEWeb project (ACCESS-11-0018) is reusing the SADI framework with semantic web services and

ontologies developed by members of the Knowledge Subproject. The Raytheon -funded Geocaching from space project is reusing semantic approaches for the integration of satellite and ground data.

The goals of the second subproject, **Integrated Analysis for Development of 3-D Models of Earth Structure**, is to develop high-quality 3-D Earth models by using a highly integrated, multidisciplinary approach. The approach aims to do the following: (1) fuse different types of information from a variety of sources and with varying accuracy, sensitivity, and resolution and (2) consider available geological and geophysical constraints and uncertainty levels. Incorporating multiple data sources to image the Earth will advance the ability to answer general and specific questions about the evolution of the Earth and its processes. The **objectives** are as follows: expand the joint inversion optimization approach to include potential field and delay travel times; refine model fusion for merging controlled and passive source experiments; and explore the differences between the evolution of the East African Rift System and that of the SRGR and ancient rift systems in Texas.

The subproject is developing high-quality 3-D Earth models by using a highly integrated, multidisciplinary approach. The approach aims to do the following: (1) fuse different types of information from a variety of sources and with varying accuracy, sensitivity, and resolution and (2) consider available geological and geophysical constraints and uncertainty levels. Incorporating multiple data sources to image the Earth will advance the ability to answer general and specific questions about the evolution of the Earth and its processes.

The subproject investigators and students hold weekly meetings to share new results and techniques being developed by students and researchers. Model fusion takes the output of various methods, and merges the output. A theoretical framework has been developed.

Another approach being taken by the group includes joint inversion of multiple data sets for Earth structure. We have developed the theoretical framework for this inversion approach, and are beginning to apply the algorithm to data in Texas, Kenya, and Colombia. Example activities are as follows:

- Refine model fusion for merging controlled and passive source experiments;
- Expand the joint inversion optimization approach to include potential field and delay travel times;

The overarching goal of the third subproject, **Advancing Understanding of Ecosystem Processes Using Cyberinfrastructure**, is to enhance understanding of ecosystem properties and processes by applying new CI-science approaches that identify factors affecting ecosystem structure and function in desert and arctic ecosystems over multiple spatiotemporal scales. The are as follows: assess how multi-scale and multi-method approaches to environmental observation enhance understanding and extrapolation of ecosystem structural and functional properties and processes; examine how uncertainty (especially systematic-error uncertainty) propagates in data from eddy covariance towers that measure land-atmosphere carbon, water and energy exchange, and determine how to optimally decrease this uncertainty; and explore Semantic Web approaches for enhancing environmental data discovery, retrieval, integration, and visualization in Web mapping applications.

The Semantic Web activities have been described earlier. Other activities are as follows:

- Examine how uncertainty (especially systematic-error uncertainty) propagates in data from eddy covariance towers that measure land-atmosphere carbon, water and energy exchange, and determine how to optimally decrease this uncertainty;
- During 2012-13, with the help of colleagues from different sites, we have calibrated the data collecting and data processing algorithms from our eddy covariance tower -- by simultaneously processing our data with our algorithms and with the algorithms provided by other sites. As a result, after finding and eliminating minor discrepancies, we have a perfect agreement, showing that our results are accurate -- as accurate as other well-established eddy covariance towers.
- We are currently working on techniques that would allow us to go beyond the current accuracy estimates, and to use our experience in processing uncertainty and our knowledge of the environmental situations to get more accurate estimates. As of now, based on the known empirical fact that some of the eddy-covariance measurement errors are not normally distributed, we have developed preliminary algorithms for gauging this non-normality. The correctness of these algorithms have been theoretically proven, we are currently testing them on simulated (simplified) data, and we plan to eventually apply them to the real data.
- We also plan to use the knowledge of temporal and spatial dynamics of meteorological processes as a prior knowledge capable of decreasing the resulting uncertainty. Again, we have some preliminary algorithms, and the results of applying these algorithms to samples taken from real data are encouraging.

Significant Results: Dr. Francesca Samsel in collaboration with Dr. Craig Tweedie created a visualization of his environmental research for Cyber-ShARE's visualization wall called *Turbulence and Topography.* The visualization was presented at the International Symposium on Electronic Arts (ISEA), and she presented a workshop at the IEEE Visualization 2012. *Turbulence and Topography* melds the data, graphs, photographs and drawings, to create a visual exploration for the viewer; the researchers monitor, map and evaluate the ongoing physical changes in the arctic environment of Barrow, Alaska and the Chihuahuan Desert of New Mexico.

Dr. Deana Pennington, leveraging funding from an NSF CI-Team grant, used a case study of a highly successful, long term, transdisciplinary research effort on hantavirus combined with findings from studies of team science to generate a hypothesized model that links cross-disciplinary collaboration with transformative scientific outcomes. She showed that potentially transformative research depends on existence of an interesting, worthwhile problem to which participants can contribute in salient ways, human and material foundations within disciplines, collaborative mutualism across disciplines, and a transformative learning process that enables knowledge integration across diverse perspectives. Transformative learning theory suggests that new, integrated conceptual understanding is initiated by disorienting dilemmas. She argued that engagement in cross-disciplinary collaboration constitutes disorienting dilemmas that initiate transformative learning. The hypothesized model provides a generalized framework for understanding how transformative

learning occurs in cross-disciplinary collaboration, and how that can lead to transformative science.

Aida Gándara, under the supervision of Dr. Villanueva Rosales and Dr. Gates created the CARP methodology to collect, annotate, refine, and publish scientific collections over the Semantic Web and for increasing accessibility of scientific research results. The methodology allows heterogeneous information that is distributed over the Web to be uniformly structured and linked. The descriptions of machine-processible information facilitates searches and integration with other Semantic Web information, increasing understanding of scientific research results for collaboration and reuse. Her research discusses the interaction of existing Semantic Web tools and techniques that are used together to create scientific collections. By using generic Semantic Web techniques, collections can be used to describe almost any topic, not just scientific resources, facilitating access and understandability of many topics from information currently shared on the Web. These results are the first step towards the creation of ontologies needed to facilitate the knowledge negotiation of IDR teams through ontology alignment and visualization, one of the main objectives of the Knowledge subproject.

Key outcomes or Other achievements:

This section describes the results of the external evaluation that examined the following questions: (Q1) To what extent, and in what ways, is the Center enabling synergistic, interdisciplinary research? (Q2) How well prepared are students as CI-knowledgeable professionals? (Q3) How well developed is the network of Cyber-ShARE collaborations? (Q4) What is the value added by Cyber-ShARE? (Q5) What are the challenges faced by the Cyber-ShARE Center?

To answer these questions, the external evaluation employs the following measures:

- Faculty and student social network surveys focused on the nature and extent of the interactions and relationships developed through the Cyber-ShARE Center. Surveys will be distributed in fall, 2013.This method addresses questions 1 and 3.
- Faculty, student, and organizational partner interviews to explore the interdisciplinary interactions, communications, and learning facilitated by the Cyber-ShARE Center. Interviews will also assess interdisciplinary research challenges, benefits, and knowledge gained about facilitating interdisciplinary and communication. *This method addresses questions 1-5.*

To date, 12 faculty and student interviews have been conducted. In the fall of the coming academic year, the social network analysis survey will be implemented to all Cyber-ShARE participants and organizational partners. Organizational partners who have joined the Cyber-ShARE Center within the past year will also be interviewed in the fall of 2013. The analysis of these additional interviews will be added to the already completed analysis of student and faculty interview from spring, 2013 and integrated into the 2014 external evaluation report.

Key evaluation findings organized by the research questions are as follows:

Q1. To what extent, and in what ways, is the Center enabling synergistic, interdisciplinary research?

In interviews, 8 out of 12 Cyber-ShARE participants (67%) reported that the communication tools and ontologies created by the Center have greatly enabled collaborative, cross-disciplinary research. Participants also reported that the tools developed by the Cyber-ShARE foster innovation and provide the means for researchers to develop novel ideas and approaches. The few interviewees who did not discuss Cyber-ShARE's ontologies or semantic web were new to the Center and did not discuss cyberinfrastructure in depth during the interview. On the other hand, all faculty and most doctoral student interviewees described the ways in which the cyber- and human infrastructure in the Center facilitates data management and communication among teams with diverse disciplinary backgrounds and skill sets.

Q2. How well prepared are students as CI-knowledgeable professionals?

A full 100% of interviewees, including both students and faculty, reported that students increase their skills and abilities as CI-knowledgeable professionals from their work in the Cyber-ShARE Center. Interviewees reported that students gained technical and intellectual skills by working on innovative and important research problems with interdisciplinary research teams. Students, especially those in environmental sciences, reported that they are more aware of cyberinfrastructure and data management strategies. Weekly meetings with cross-disciplinary teams also helped students to gain knowledge and technical understanding. Most importantly, faculty report that team meetings helped students and faculty to understand the language, terminology, concepts, and ways of thinking across disciplines. Interviewees also reported that students gained presentation and communication skills in a variety of venues, including presenting at group meetings, professional conferences, and public outreach settings.

Q3. How well developed is the network of Cyber-ShARE collaborations?

This question will primarily be answered by the social network analysis to be administered in the fall, yet students and faculty did comment in interviews on the extent of their networks and collaborations through the Cyber-ShARE Center. In interviews, 11 out of 12 Cyber-ShARE participants (92%) reported the benefits of the interdisciplinary research networks they access through the Center. These networks provide "cross-fertilization" for innovative research ideas as well as mentoring for students. In fact, the Cyber-ShARE Center is an effective recruitment tool for talented faculty and graduate students interested in the collaborations and challenges of interdisciplinary research. Specifically, two faculty members and two graduate students (25% of the interview sample) reported that they came to UTEP because of the research and the people in the Cyber-ShARE Center. However, participants' networks were largely limited to collaborations within UTEP, although a few interviewees noted partnerships with external organizations, such as the University of Southern California.

Q4. What is the value added by the Cyber-ShARE Center?

Faculty members were asked to discuss the value added to the institution by housing the Cyber-ShARE Center as well as the value added to the research projects themselves. Faculty reported three main benefits of the Cyber-ShARE Center: 1) The Center provides greater institutional support and cohesion to research efforts, 2) The Center improves interdisciplinary communication, 3) The Center provides deliberate student training and development through

mentoring and workshops. Students reported that the mentoring that they received from faculty and more advanced peers in the Cyber-ShARE Center added value to their education. One doctoral student noted that she received better mentoring and career preparation from the Cyber-ShARE Center than she did from her home department.

Q5. What are the challenges faced by the Cyber-ShARE Center?

Faculty cited several challenges faced by the Cyber-ShARE Center: financial sustainability, particularly for student research funding, but also for the other important support and infrastructure provided by the Center; maintenance or expansion of the infrastructure and functions of the Center; and future planning, particularly for the possibility of pursuing higher-level funding to maintain the Center.

All faculty were supportive of the renewal goal of expanding the center through a higher-level NSF grant, but acknowledged the challenges of preparing for this endeavor. Additionally, all faculty noted that the upper administration at UTEP supports interdisciplinary research and the center itself, yet departmental promotion and reward systems are still essentially oriented toward research occurring within discrete disciplinary boundaries.

*** What opportunities for training and professional development has the project provided?**

- Cyber-ShARE hosted a talk for female STEM students and faculty with Romelia Flores, Distinguished Engineer and Master Inventor, IBM, and the Centennial Lecturer for the University of Texas at El Paso on Feb. 19, 2013

Cyber-ShARE hosted a distinguished lecture from Dr. Michel Dumontier, Associate Professof of Bioinformatics in the Department of Biology, the Institute of Biochemistry and School of Computer Science at Carleton University in Ottawa, Canada, Scientific Director or the open-source Bio2RDF linked data for life sciences project and currently serves as a chair for the World Wide Web Consortium Semantic Web in Health Care and Life Sciences Interest Group (W3C HCLSIG).

Cyber-ShARE Center is an XSEDE campus champion and worked with Dr. Patricia Teller, Director of Research Computing at UTEP, to promote workshops on UTEP campus. XSEDE conducts workshops to assist scientists in collaborating and sharing computing resources, data and expertise.

Cyber-ShARE invited Greg Abram (gda@tacc.utexas.edu), Scalable Visualization Research Specialist, and Brandt Westin (bwesting@tacc.utexas.edu), Visualization Manager, from the University of Texas Austin's Texas Advanced Computing Center (TACC) to conduct a training session, Introduction to Scientific Visualization. Faculty and students were invited. The topics included the use of remote visualization software to visualize data sets generated on a Linux cluster. A review of the scientific visualization process along with an overview of the visualization software available to TACC users, including the Longhorn visualization portal, the parallel visualization software Paraview, and the trending visualization software Processing. In addition, they covered software and techniques for using tiled displays with an interactive example using the Cyber-ShARE tiled display system.

Cyber-ShARE held workshops throughout the year that focused on the development of team, professional, and research skills:

- Affinity Research Group Workshops - target development of skills for undergraduate and master's student workshops.
- Jumpstart Workshops - target PhD student development focused on proposal writing

Selected student enrichment programs are as follows:

- GK12 Teachers/Students Field Trip to Cyber-Share Viz-Wall (Jun. 28, 2013) Transmountain Early College High School; Showed teachers and students the use of the cluster/building/resources in the different projects and the importance of Cyber-Share for multi-disciplinary work.
- High School Visit - Transmountain Early College High School (Jun. 24, 2013); Dr. Villanueva introduced 24 high school students to research and education activities performed by the center, subproject and interdisciplinary collaboration.
- Database Course Final Presentations - Reporting System (May 8, 2013); Dr. Villanueva-Rosales offered a Database course for Spring 2013 at UTEP. One of the final projects was to design a database for an online Cyber-ShARE reporting system, which was used as a prototype for the design of the current Reporting System
- Sharing Scientific Research over the Semantic Web (Feb. 1, 2013)Presented work to group that led to dissemination of knowledge
  Impact of activity on faculty, students, and/or scientific community: Dissemination of Knowledge
- Field Trip - GK 12 (Nov. 15, 2012) The purpose of this activity was to show high school students the research taking place in the Cyber-Share Center. Anibal Sosa, part of the Geosciences project, showed students some of his work and talked about the relevance of the 3D structure models developed in the project for the RGR region and desertic areas in general. The presenter used the Cyber-Share viz-wall to show students the 3D graphics developed by Mr. Sosa and described the importance of having a cluster of high performance computers available to perform computations that would otherwise require a lot of time and resources to complete.
- TMECHS Field Trip (Oct. 17, 2012); Presented to students the research being done in Computational Science, Environmental Science, Geological Science, and other STEM areas to encourage their career choices and have them interested in work being done in the center.
- Excites Presentation (Sep. 7, 2012); Presenters introduced 45 students from Morehead Middle School to research and education activities performed by the Center and subprojects, multidisciplinary collaboration, and CI tools.

*** How have the results been disseminated to communities of interest?**

Results have been disseminated broadly through workshops; engagement with NASA and EarthCube working groups; webinars to LTER; presentation at conferences; presentations to faculty and center directors on campus; and on-line courses. Cyber-ShARE has been disseminating tools that support the NSF I3 project through a series of presentations on campus. Presentations are detailed in the Products section of this report.

Selected dissemination efforts are highlighted:

- Cyber-ShARE presented a talk at the NSF Research Data Management Implementation Workshop (RDMI) that brought together research computing communities and leading experts in data management to discuss actual implementation architectures. The workshop was a collaboration with the Coalition for Academic Scientific Computation (CASC) and provided an opportunity to share Cyber-ShARE results in data management.
- The visualization effort, *Turbulance and Topography,* has been disseminated through an on-line article, “Artist in the Lab, Scientist in the Studio,” by the Texas Advanced Computing Center (TACC) that describes the digital murals of Francesca Samsel, and how art can engage viewers and inspire interest in larger scientific issues (http://www.tacc.utexas.edu/news/feature-stories/2012/artist-in-the-lab). It was also disseminated in another on-line magazine called International Science Grid This Week that provides an interactive communication platform to discuss digital technologies and culture, and to give visibility to innovative projects of digital art (http://www.digitalmeetsculture.net/article/visualizing-data-as-if-under-a-microscope/). In addition, the work was disseminated at the International Conference on Electronic Art; Texas Art, Science, and Information Technology meeting at the University of Texas at San Antonio; a workshop at the IEEE Visualization 2012; HCI+ISE Conference; SEAD Network Conference; ISEA 2012; invited lecture at Texas A & M; and a workshop at the College Art Association Conference. Samsel has informally disseminated information about this effort to the National Academy of Sciences.

- Field demonstrations of the Ecosystem Processes phenocams and kite aerial photography systems have been delivered to colleagues from Los Alamos National Lab, University of Arizona, Arizona State University, the University of New Mexico, the US Department of Agriculture's Agricultural Research Service at the New Mexico State University, and the University of Malawaran in East Kalimantan. Software demonstrations for the Phenocam analyzer software have also been delivered to these colleagues.
- An overview of newly developed technologies field tested at the Jornada Experimental Range (JER) and in the Arctic, and new approaches to data and information management have been delivered through working groups for the Long Term Ecological Research program – Earth Science Information Partners working group on envirosensing (http://wiki.esipfed.org/index.php/EnviroSensing_Cluster), the National Snow and Ice Data Center' Advanced Cooperative Arctic Data Information Service advisory board, the advisory board to the Polar Geospatial Center, and the National Science Foundations' Information Assurance Working Group for the Arctic.
- CyberShARE was promoted through the prototype VizWall on loan to the Insights Science Center, the regional science museum, from June 2012-Dec. 2012.

*** What do you plan to do during the next reporting period to accomplish the goals?**

With respect to Center Objective 1, the Center will continue to refine MetaShARE tool, the Reporting System, and other collaboration tools. The Reporting System is being designed to generate reports automatically for the annual report and CREST Web report. The goal is to generalize its use for other projects and centers. MetaShare needs additional infrastructure to automate data collection and interact with iRods for data management policies. The Center will conduct rigorous V&V on products and pilot their use. We also plan to integrate WDO It into MetaShARE and the use of Visko in Virtual Learning Commons;

For Center Objective 2, the Center will begin working with Teacher Education researchers and the Smithsonian on a new grant. CyberShARE has recruited Dr. Karen Villaverde to work on a multi-touch screen that will be used to K-12 outreach and to develop outreach components that incorporate CyberShARE tools. We will also organize professional training, e.g., MetaShare tool and 3-D modeling using the visualization wall through XSEDE (TACC) when applicable.

For Center Objective 3, the Center will develop a strategic plan for regional engagement with the business and technical industries.

Members of the Knowledge Subproject group will start investigating the ability of ontologies to represent mental models in IDR teams. The previous results of the Subproject's research will provide the building-blocks needed to facilitate knowledge negotiation through ontology alignment and visualization. The focus of the research in the next reporting period will be investigating the role of ontology mappings techniques being developed in the group for knowledge negotiation. The group will also leverage the Visko framework, created by a Cyber-ShARE PhD alumni, for the knowledge negotiation process. The knowledge subproject group will continue educating students with knowledge in Semantic Web and the dissemination of previous results.

In the next period, the 3-D modeling of Earth group will be expanding its effort to collect new data in Colombia as we build new partnerships with Colombian institutes. We will continue to analyze data form field experiments in Kenya that focus on volcanic centers. This work is partially supported by the Geothermal Development Company. We expect GDC employees to visit the Center to finalize analysis of the newly collected data. We are expanding our joint inversion approach to include 4 datasets, including receiver functions, surface waves, gravity, and body wave travel times. We will be further developing a new approach for the joint inversion problem: multiple objective optimization. Finally, we expect to have new 3-D models in the continent U.S., using multiple data sets, as we expand the southern Rio Grande Rift work to the east throughout the state of Texas.

The Ecosystem Processes subproject has the following plans:

- Maintain time series observations at the JER.
- Continue to analyze field data from the JER.

- Collaborate on an ecological scaling study with colleagues at UNM who are investigating the implications of the 2011 freeze event on ecosystem processes.
- Continue to develop the prototype JER data and information system. See http://irpsrvgis25.utep.edu/Jornada/ and http://irpsrvgis25.utep.edu/Jornada_JS/
- Continue to test and develop semantic technologies for webGIS
- Refine new control and measurement systems for the JER tramline that measures surface spectral reflectanc
- examine how uncertainty (especially systematic-error uncertainty) propagates in data from eddy covariance towers that measureland-atmosphere carbon, water and energy exchange, and determine how to optimally decrease this uncertainty;
- Conduct student training, publications and presentations, dissemination of research products and technologies.

Products

Journals

Kreinovich, Vladik. (2013). Cheking Monotonicity Is NP-Hard Even for Cubic Polynomials. *Reliable Computing*. 18 90-96.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). A New Analog Optical Processing Scheme for Solving NP-Hard Problems. *Journal of Uncertain Systems*. 7 238-240.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). Estimating Correlation under Interval Uncertainty. *Mechanical Systems and Signal Processing*. 37 43-53.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). Orders on Intervals Over Partially Ordered Sets: Extending Allen's Algebra and Interval Graph Results. *Soft Computing*. 17 1379-1391.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). Brans-Dicke Scalar-Tensor Theory of Gravitation May Explain Time Asymmetry of Physical Processes. *Mathematical Structures and Modeling*. 27 28-37.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). For Describing Uncertainty, Ellipsoids Are Better than Generic Polyhedra and Probably Better than Boxes: A Remark. *Mathematical Structures and Modeling*. 27 38-41.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). Interval or Moments: Which Carry More Information?. *Soft Computing*. 17 1319-1327.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kreinovich, Vladik (2013). Is It Possible to Have a Feasible Enclosure-Computing Method Which Is Independent of the Equivalent Form?. *Reliable Computing*. 18 1-8.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = No

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = No

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = No

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Acknowledgment of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = AWAITING_PUBLICATION; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

Del Rio , Nicholas R (2012). *VisKo Demonstration.*. Earth Science Information Partners (ESIP) Visualization Cluster Demo.. El Paso, Texas.

Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

Del Rio , N. R., Pennington, D. (2013). *Querying for big data visualization*. SIGGraph 2013. El Paso, Texas.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Esparza, P., Villanueva Rosales, N., Gates, A. Q. (2012). *Searching, Sharing, and Connecting Researchers through Semantic Web Technologies*. New Mexico Celebration of Women in Computing (NMCWiC). Las Cruces, New Mexico.

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Status = ACCEPTED; Acknowledgement of Federal Support = Yes

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Publications

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Kreinovich, Vladik (2013). *A review of "Partial metric spaces" by M. Bukatin, R. Koppeman, S.*. Cyber-ShARE participant(s) funded by CREST Program..

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Kreinovich, Vladik (2013). *Special issue on ``uncertainty modeling and analysis with intervals: foundations, tools, applications" - Editorial*. Cyber-ShARE participant(s) funded by CREST Program..

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Technologies or Techniques

Algorithms for multi-objective optimization: To properly take uncertainty into account, we used multi-objective decision making, an approach in which, instead of optimizing a single objective function, we produce the set of results corresponding to several possible objective functions -- in our case, objective functions corresponding to different possible values of relative uncertainties. For this, we expanded our previously developed optimization algorithms to the multi-objective optimization case.

Accuracy-Estimating Technique: The new accuracy-estimating techniques have been developed that lead to geophysically reasonable estimates and thus, to more accurate model fusion results.

The “GrantOpportunities” ontology used to automate the matching of grants with potential applicants. It is used for the mash-up of grant opportunities published by Grants.gov and UTEP researchers’ areas of expertise. **Grant opportunities,** available at: http://ontology.cybershare.utep.edu/Expertise/GrantOpportunities.owl.

The EON ontology is used to describe areas of expertise of researchers by means of a hierarchy of disciplines covered in the Catalog of Federal Domestic Assistance (CFDA). **EON,** available at: http://ontology.cybershare.utep.edu/Expertise/eon.owl

The Geocache ontology integrates the definition of services that provide data consumed by the Geocaching game, these services currently include VIIRS true color images and ArcGIS Rest Services. **Geocache**, available at: http://ontology.cybershare.utep.edu/Geocaching/Geocache.owl

The MicroMeasurements ontology describes Micrometeorological measurements, based on the database used to store sensor measurements and observations of the Ecosystems Processes subproject. **MicroMeasurements**, available at: http://ontology.cybershare.utep.edu/Geocaching/MicroMeasurements.owl

The Edac ontology describes OGC-WCS data to be used by ELSeWeb SADI service descriptions. **Edac,** ver 3.0, available at: https://ontology.cybershare.utep.edu/ELSeWeb/master/documents/semantic-web/rdf/ontology/edac-v3.owl

The Lifemapper ontology describes Lifemapper experiments and is used for ELSeWeb SADI service descriptions. **Lifemapper**, available at: https://ontology.cybershare.utep.edu/ELSeWeb/master/documents/semantic-web/rdf/ontology/lifemapper-v3.owl

The RIM ontology uses the Research Influence Model (RIM) to describe the components of a research project and contains properties for asserting relationships between different projects. Also contains rules to infer "influencedBy" relationships based on evidences captured by the VLC. **RIM,** available at: https:// ontology.cybershare.utep.edu/VLC/master/ontology/RIM.owl

The VisKo ontology describes different visualizations such as isosurfaces, volumes, and raster maps. **VisKo-View**, available at: http://openvisko.org/rdf/ontology/visko-view.owl

VisKo-Operator ontology describes different kinds of abstract visualization operations, such as converting, filtering, mapping and transforming to be used by Visko. **VisKo-Operator**, available at: http://openvisko.org/rdf/ontology/visko-operator.owl

VisKo-Service ontology associates an abstract visualization operation with an executable OWL-S service. **VisKo-Service,** available at : http://openvisko.org/rdf/ontology/visko-service.owl

The CARP core ontology provides common characteristics, i.e., properties and classes, across scientific collections. By default, scientific collections can be queried about the basic structure provided by this ontology. **CARP ontology ,** available at http:// ontology.cybershare.utep.edu/CARP/carp-ns.rdf

Patents
Nothing to report.

Inventions
Nothing to report.

Licenses
Nothing to report.

Websites

Title:	CyberShARE Center
URL:	http://cybershare.utep.edu
Description:	General Website for the Center.
Title:	I3 Website
URL:	http://i3.cybershare.utep.edu/
Description:	CyberShARE Center serves as the anchor for the I3 project thatis focused on creating the cyberinfrastructure to support knowledge and resource sharing across broadening participation efforts on campus and supporting interdisciplinary research at UTEP.

Other Products

Product Type:	Audio or Video Products
Description:	VisKo: Enabling Visualization Generation Over the Web. A short demo that illustrates the use of the Visko framework.
Other:	Audio or Video Products
Product Type:	Virtual Geocache Game Demo. Knowledge subproject. A short demo that
Description:	illustrates the basic components of the Virtual Geocache game.

Other: Models

Product Type: Web-Probe. Knowledge subproject. A short demo that illustrates the basic components and use of the Web-Probe tool.
Description:

Other: Audio or Video Products

Product Type: Visualization of 3D seismic tomography models:
Description: http://www.youtube.com/watch?v=5ZI9RG7x2lE

Other: Databases

Product Type: Spectral library (www.spectrallibrary.utep.edu): allows reflectance in the visual and near infra-red spectra to be queried and plotted in an online environment (production). Sharing Information: several conference presentations have featured this site, and it has also been referenced in literature. It is also discoverable via Web searches.
Description:

Other: Software or Netware

Product Type: JOGGLER - a data handling GUI-driven software that harvests, manages, queries and exports data and web services. Sharing Information: This is being used in an ARMAP production-level web mapping application and is the backbone of the Jornada FLEX application and information system, and will also be used in the new BAID grant. Demonstrations have been given to the national snow and ice data center.
Description:

Other: Software or Netware

Product Type: Site choice tool - a Geographic Information System processing routine that uses a series of parameterized decision and optimization algorithms to identify and prioritize site selection for ecological and environmental research and instrument placement (prototype). The tool has been used for situating sensors in Indonesia for a USAID project and will also be heavily used for situating the new sensor network in Barrow as part of a BAID project. Sharing Information: Dispersed through publications, posters, and presentations
Description:

Other: Software or Netware

Product Type: Arctic Research Mapping Application:
Description:

- ARMAP-Internet Map Server - allows GIS-interactivity with more than 750 data and information layers, including more than 10,000 locations associated where US Federally funded research has taken place since the late 1990?s (Production).
- ARMAP for Google Earth (production) - allows ARMAP data to be viewed in Google Earth (production)
- ARMAP for ArcGIS Explorer - allows globe visualization and interactivity with ARMAP data (production).
- ARMAP-Flex application - allows querying and visualization of the ARMAP dataset to show, for example, trends in US federal research expenditure for different fields of arctic research (beta).

Sharing Information: The software is discoverable through the website: www.armap.org, and it is widely disseminated through the community.

Other: Databases

Product Type:
Description: BAID-Internet Map Server (production) allows GIS-interactivity with more than 646 data and information layers, including more than 9000 research sites dating back to the 1940's.

- BAID for Google Earth (production) - allows BAID research site data to be viewed in Google Earth.
- BAID Instrument Browser (production) - allows map visualization and interactivity with informational and other data associated with more than 350 instruments in the Barrow area in northern Alaska.
- Barrow SAR viewer (production) - allows map visualization and interactivity with near real time space-borne synthetic aperture radar acquired for the Barrow area.

Sharing Information: Available through www.baidims.org

Other: Software or Netware

Product Type:
Description: WDOIt! workflow editor development: Tool for creating work-related ontologies including terminology and workflows. Development, help with design of general features and fixes and specifically implemented concept renaming, bookmarking, some drag-n-drop features and workspace support. We are in the process of preparing for first release including development of test cases and software web deployment. Sharing Information: Website (open source access) and presentations at national and international meetings

Other: Software or Netware

Product Type:
Description: Probe-It!: A browser suited to graphically rendering Proof Markup Language (PML) based provenance associated with results derived from inference engines and workflows. Probe-It! consists of three primary views to accommodate the different kinds of provenance information: results, justifications, and provenance, which refer to final and intermediate data, descriptions of the generation process (i.e., execution traces) and information about the sources respectively. Sharing Information: The software will be shared through the portal at http://cybershare.utep.edu/. It currently can be found at: http://trust.cs.utep.edu/probeit/.

Other: Software or Netware

Product Type:
Description: Prospec: A tool for automated development of formal specifications including patterns and scopes. Ordered sequences, non-deterministic sequences, and concurrency can be specified through composite propositions. Sharing Information: The software is being shared through the portal at http://cybershare.utep.edu/.

Other: Software or Netware

Product Type:
Description: Talwani: A 2.5-D gravity modeling tool which is based on the Talwani technique and allows forward modeling of gravity profiles. Subsurface models created with the Talwani software tool can match the pattern of a specific gravity anomaly. Sharing Information: The software is being shared through the portal at http://cybershare.utep.edu/.

Other:

Participants

Research Experience for Undergraduates (REU) funding

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Maria C Barraza	Undergraduate Student	2
Edith Betancourt Marrufo	Undergraduate Student	1
Sergio H Celis	Graduate Student (research assistant)	3
Nicholas R Del Rio	Graduate Student (research assistant)	6
Candice Christine Fierro	Other Professional	6
Guillermo Flores	Graduate Student (research assistant)	2
Diana Franco Gutierrez	Undergraduate Student	2
Matthew Giandoni	Graduate Student (research assistant)	3
Ashley N Grijalva	Undergraduate Student	3
Ivan Gris	Other Professional	3
Madhulatha Hari	Graduate Student (research assistant)	2
Joshua B Hicks	Undergraduate Student	4
Musa J Hussein	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Ari Kassin	Other Professional	6
Jennifer L Keck	Undergraduate Student	1
Elizabeth Ann Lopez	Undergraduate Student	4
Karla Elizabeth Lujan	Undergraduate Student	6
Loren Ochoa	Undergraduate Student	3
Erika S Ollivier	Graduate Student (research assistant)	4

Name	Most Senior Project Role	Nearest Person Month Worked
Francisco Osuna	Other Professional	12
Edgar Padilla	Graduate Student (research assistant)	3
Marianna Pena	Undergraduate Student	4
Oscar Remirez	Undergraduate Student	2
Norma Rivera	Graduate Student (research assistant)	2
Juan R Rodriguez	Undergraduate Student	4
Francesca Samsel	Consultant	1
Uram A Sosa Aguirre	Postdoctoral (scholar, fellow or other postdoctoral position)	7
Lennox E Thompson	Graduate Student (research assistant)	3
Karina Valtierra	Undergraduate Student	3
Sandra Villarreal	Graduate Student (research assistant)	3
Bertha S Villegas	Undergraduate Student	6
Aaron Velasco	Co PD/PI	1
Craig E Tweedie	Co PD/PI	1
Leonardo Salayandia	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Rodrigo A Romero	Staff Scientist (doctoral level)	10
Deana Pennington	Co PD/PI	12
Azucena Zamora	Graduate Student (research assistant)	6
Sergio Armando Vargas	Graduate Student (research assistant)	6
Christian Teran Lopez	Undergraduate Student	6
Jesus Manuel Tabares	Undergraduate Student	2

Name	Most Senior Project Role	Nearest Person Month Worked
Hector Adrian Saenz	Graduate Student (research assistant)	5
Geovany A Ramirez Garcia	Graduate Student (research assistant)	6
Hugo D Porras	Graduate Student (research assistant)	5
Julio C Olaya	Graduate Student (research assistant)	5
Geoffrey I Owen	Graduate Student (research assistant)	4
Ezer Patlan	Graduate Student (research assistant)	6
Omar Ochoa	Graduate Student (research assistant)	6
Carlos A Nieto	Undergraduate Student	2
Elba M Nieto	Graduate Student (research assistant)	1
Jesus Roberto Nevarez	Graduate Student (research assistant)	2
Roberto Munoz	Undergraduate Student	2
Mayra Melendez	Undergraduate Student	6
Naomi R Luna	Undergraduate Student	6
Abdiel F Lopez	Graduate Student (research assistant)	6
Leonardo O Lerma	Graduate Student (research assistant)	4
Christine Marie Laney	Graduate Student (research assistant)	6
Young-An Kim	Graduate Student (research assistant)	6
Aline Jaimes	Graduate Student (research assistant)	5
Ann Q Gates	PD/PI	1
Antonio Garza	Graduate Student (research assistant)	5
Julian Cesar Lopez	Undergraduate Student	5

Name	Most Senior Project Role	Nearest Person Month Worked
Angel Fernando Garcia Contreras	Graduate Student (research assistant)	5
Javier Eduardo Garza	Graduate Student (research assistant)	4
Ariel Garcia	Graduate Student (research assistant)	6
Aida Gandara	Graduate Student (research assistant)	6
Patricia Esparza	Other Professional	12
Joseph R Aguirre	Undergraduate Student	2
Diego Aguirre	Graduate Student (research assistant)	6
Jitin Arora	Graduate Student (research assistant)	2
Carmen E Avila	Graduate Student (research assistant)	2
Jorge Berumen	Undergraduate Student	5
Cesar R Chacon	Graduate Student (research assistant)	3
Ryan P Cody	Graduate Student (research assistant)	6
Alla K Dove	Undergraduate Student	2
Vladik Kreinovich	Co PD/PI	1
Miguel Argaez	Co PD/PI	1
Natalia Villanueva Rosales	Co PD/PI	12

What other organizations have been involved as partners?

Name	Location
Ameriflux	LBNL
Computing Alliance of Hispanic-Serving Institutions	UTEP
GEON	San Diego Supercomputing Center
Los Alamos National Lab	New Mexico

Name	Location
National Ecological Observatory Network, Inc	Boulder, CO
New Mexico State University	Las Cruces, NM
Raytheon	Los Angeles, California
Smithsonian Latino Center	Washington DC
USDA Jornada Long-Term Ecological Network	Las Cruces, NM
UT Austin Texas Advanced Computing Center	Austin, Texas

Have other collaborators or contacts been involved? N

Impacts

What is the impact on the development of the principal discipline(s) of the project?

As part of Cyber-ShARE's efforts of building communities in computer science, Dr. Villanueva Rosales is a co-chair of the AAAI Fall Symposium on Discovery Informatics which will be held on November, 15-17 in Arlington Virginia. During this symposium, members of the Knowledge Subproject will present their work for dissemination and extending the network of collaborators. The current results of the Knowledge Subproject research have informed the Computer Science community about methodologies for sharing, reusing and integrating scientific data. Previous results of this project have provided methods, tools and best practices on creation, use and visualization of provenance, in particular using the recently recommended (April 2013) provenance language PROV-O. Current efforts include the investigation of the role of provenance in ontology mapping, an important task in the semantic-based integration of data. Results in the semantic-based choreography of web services for the integration and visualization of scientific data has informed the Computer Science community about the limitations of current techniques as well as proposed extensions. Based on the experience in the training of the next generation of cyberinfrastructure-savvy professionals, an on-line course and a series of workshops have been developed and are offered as part of the Center's training program.

The 3-D Modeling of Earth subproject is developing novel and robust approaches to better determine Earth structure. We expect that these approaches will have board applications, from academic to industry applications.

The impacts of the Ecosystems subproject are as follows:

- New methods for measuring environmental variables using low-cost off the shelf technologies have been developed and new software for analyzing data from these systems has been developed. Dissemination of prototype systems has been positive and suggests there is broad support and need for such technologies in the environmental sciences.
- New approaches to data and information management have been developed and tested. Dissemination of preliminary results suggest there is widespread interest in the use of these tools in the environmental sciences.

What is the impact on other disciplines?

As described earlier, Cyber-ShARE has had an impact in Visual Arts through it efforts to visualize the research in environmental science on the Cyber-ShARE visualization wall. Cyber-ShARE's efforts on data quality monitoring

is being transferred to the Regional Center on Cyber-Security and Energy Systems for use on electric grid applcations. Cyber-ShARE is working with Dr. Steve Stafford (Metallurgical & Materials Engineering) and Dr. John D. Olivas (past Astronaut and recently hired to coordinate projects through Cyber-ShARE) on the creation of an ERC Center of Research for Extreme Environment Advanced Material Systems. Cyber-ShARE's is providing support and infrastructure for building high functioning interdisciplinary teams, visualizing data and materials, analyzing and integrating data/knowledge.

Cyber-ShARE's Visualization Cluster resources have been extended to various on-going projects with the Geology and Electrical and Computer Engineering Departments as noted below:

- Jose M. Hurtado, an associate professor for the Geology Department is currently working with Remote Sensing Image Analysis through the use of different Software Applications such as: ENVI, MATLAB, ArcGIS and Google Earth.
- Dr. Richard Langford, also from the Geology Department is working with PetroMod petroleum systems modeling software, which combines seismic, well, and geological information to model the evolution of sedimentary basins.
- Ricardo von Borries, an associate professor from the Electrical and Computer Engineering Department is utilizing the Visualization Cluster in signal processing to predict and quantify the development of muscle fatigue using surface electromiographic (emg) signals.

What is the impact on the development of human resources?

The collaboration among members of the three Cyber-ShARE projects results in integration of knowledge from geosciences, computer science, mathematics, environmental science, and engineering. Through these highly interdisciplinary projects, the Cyber-ShARE Center actively prepares the next-generation scientist and engineer who can work on diverse teams with knowledge of using cyberinfrastructure (CI). The professional development workshops provide training in CI middleware, visualization, as well as professional, research, collaboration, and team skills. The outreach components involve students in activities that include technology and science, and the courses that reach future teachers are critical to human resource development. In addition, students are exposed to cutting-edge technologies and concepts that are not typically introduced in the curriculum, and students are able to practice and hone their skills in a real application.

Cyber-ShARE promotes the involvement of students in development workshops, preparation for graduate studies, scientific symposia, and mentoring through experiences at the university and through conferences, e.g., AGU, Computing Alliance of Hispanic-Serving Institutions, and SACNAS.

The impact of the Cyber-ShARE Center on expertise development in data analytics and integration at UTEP is reflected in the 2012-2013 strategic hire position that resulted in the hiring of Dr. Natalia Villanueva-Rosales who has expertise in data integration, ontologies and other Semantic Web technologies. Dr. Villanueva-Rosales will have an assistant professor position in the Computer Science Department. In addition, the Computer Science Department hired Dr. Mohamed Hossain who has expertise in big data and visual analytics.

As described earlier, UTEP sponsored workshops provided by the Texas Advanced Computing Center and promoted workshops by XSEDE (eXtreme Science and Engineering Discovery Environment).

What is the impact on physical resources that form infrastructure?

The Cyber-ShARE Center houses a core facility for visualization. The Cyber-ShARE Collaborative Visualization System (C2ViS) Laboratory supports multidisciplinary scientific collaboration and visualization of scientific datasets for exploratory, monitoring, educational, and outreach purposes. What is the impact on institutional resources that form infrastructure?

The Cyber-ShARE Center also provides a Testing and Production level development environment through a IBM 3650 M4 server system powered by twelve 2.0GHz Intel Xeon processors, 32GB DDR3 RAM and 12TB of operational storage space. The system infrastructure is laid out into 6 separate virtual Linux servers composed of a Network File System, Network Information System, Web Server, Database Server, Versioning Control System and an Application Server for in-house development. In addition, the center equips a supplementary 12TB of storage space by means of a Dell EqualLogic storage solution.

Other infrastructure includes the following:

- 2009-Present. Eddy tower, robotic tram system, sensor network, phenocam network, remote power supply and wireless communications at the USDA Jornada Experimental Range, New Mexico. This infrastructure has been supported by the NSF funded Cyber-ShARE Center of Excellence at UTEP.
- 2009-Present. Network of seven automatic weather stations at UTEP's Indio Mountains Research Station.
- 2009-Present. A Green roof and sensor testing facility on the roof of the Biology Building at UTEP. This facility was catalyzed by the NSF-funded Cyber-ShARE Center of Excellence and was developed with the support of UTEP Facilities.
- 2009-Present. A growth cabinet with a series of 11 microcosms for experimenting with plant and soil monoliths to understand controls of ecosystem processes. This system includes a range of wireless and wired micrometeorological sensors and an open path trace gas analysis system with programmable solenoid valves to control airflow to each microcosm. This infrastructure was built for the IPY-BTF project with support from the Cyber-ShARE Center of Excellence.
- 2009-Present. A paraglider unmanned aerial vehicle (UAV). This remote control UAV is low and slow flying and controlled by line-of site remote control. The aircraft allows for an hour of flight time and a payload of approximately 15 kilograms. This infrastructure was developed through UTEP's Cyber-ShARE Center of Excellence and in collaboration with Industry (Atair Aerospace, http://www.atair.com/).
- 2007-Present. A lab for the design, prototyping, testing and manufacture of sensors, field equipment and other hardware for ecological and environmental research (700 sq ft). This lab includes a walk-in double cold room and a large workshop that houses a range of power and machining tools, systems for the development and testing of electrical circuitry, and a range of building materials and spare parts.

What is the impact on institutional resources that form infrastructure?

Cyber-ShARE provides core facilities and capabilites for research on campus. For example, through its Meta-Share framework, it has been working with faculty on data management plans and data retrieval. Dr. Pennington provides guidance on and contributes to a number of interdisciplinary projects.

The Center serves as the anchor for the NSF-funded I3 initiative to build cyber-infrastructure, communication, and connections to broaden STEM participation. The initiative challenges faculty, administrators, and stakeholders to think strategically about the creative integration of NSF-funded awards. UTEP’s project fosters interdisciplinary collaborations on campus that promote student success, integrate research and education, and result in effective education for a diverse student body with particular emphasis in Science, Technology, Engineering, and Mathematics (STEM) areas. Cyber-ShARE has expertise on building interdisciplinary collaborations. Working with the Office of Research and Sponsored projects, Cyber-ShARE has taken the lead in transferring its Semantic Web technologies to establish an Expertise system that connects faculty through personal profiles, Center profiles, communities, and research stories. This effort connects existing university resources, i.e., Digital Measures, to maintain updated information. The effort has been supported through I3, Cyber-ShARE, and institutional resources.

What is the impact on information resources that form infrastructure?

Cyber-ShARE is having an impact on information resources through its Expertise project.

The university's Information Resources and Planning (IR&P) Strategic Plan includes the collaborative efforts with the University's Center for Institutional Evaluation, Research, and Planning and Cyber-ShARE to collect, manage, and disseminate data on Student Success projects.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?

Cyber-ShARE is developing cohorts of students with 21st century demographics and skills. These students are well prepared to address the scientific challenges facing society through global change, through deep expertise in their selected discipline and cross-cutting capabilities in the design and use of cyberinfrastructure; teamwork and collaboration; and interdisciplinary research integration.

The tools developed by the Cyber-ShARE Center can be used by researchers and educators beyond science and technology. For example, MetaShare, a knowledge-based system that supports the creation of data management plans, can be used to annotate data with metadata and support discovery and retrieval of data and knowledge.

Cyber-ShARE's work with artist Francesca Samsel illustrates how visualization can help scientists analyze and communicate their research findings.

Changes

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.