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Maine EPSCoR End-to-End Connectivity for Sustainability Science Collaboration

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Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1108153
Project Title:	Maine EPSCoR End-to-End Connectivity for Sustainability Science Collaboration
PD/PI Name:	Michael Eckardt, Principal Investigator Jeffrey Letourneau, Co-Principal Investigator Vicki Nemeth, Co-Principal Investigator Bruce E Segee, Co-Principal Investigator
Recipient Organization:	University of Maine
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Submitting Official (if other than PD\PI):	Michael Eckardt Principal Investigator
Submission Date:	11/29/2013
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Michael Eckardt

Accomplishments

* What are the major goals of the project?

This NSF EPSCoR C2 project allowed Maine EPSCoR to continue the state's momentum to enhance the connectivity

of the state's research, higher education, and K-12 institutions through Maine's Research and Education Network (MaineREN). Over the last few years, multi-million dollar investments have built networking and computing power at the state level, including: 1) the installation of 1,100 miles of middle-mile fiber optic cable; 2) investments in shared computing resources for high performance computing and cloud computing; 3) the Maine School and Library Network; 4) the Maine Learning Technology Initiative (grade 6-12 laptops); and 5) investments in high-performance visualization and videoconferencing.

This C2 project allowed Maine EPSCoR to address the cyberinfrastructure gaps at the seven campuses of the University of Maine System that had still been preventing the delivery of true end-to-end connectivity between Maine's researchers and the new advanced networking services provided over MaineREN.

The research and education focus that was enabled by this C2 project is the Maine EPSCoR Sustainability Science Initiative (SSI) RII Track 1, with the goal of providing SSI researchers and students at the seven campuses of the University of Maine System true end-to-end connectivity. Cyberinfrastructure is an important key to helping SSI to advance their sustainability science objectives to: 1) examine interactions between social and ecological systems (SES) as landscapes change in response to urbanization, forest management, and climate variability; 2) investigate how such SES knowledge affects, and is influenced by, the actions and decisions of diverse stakeholders, with a goal of strengthening connections between knowledge and action; 3) evaluate the factors that facilitate and impede interdisciplinary collaboration, with a goal of identifying and implementing individual and institutional best practices that are needed to support successful interdisciplinary research programs in sustainability science.

In particular, the C2 connectivity improvements that are now in place will support the Track1 SSI research agenda by addressing various data management, visualization, and virtual proximity challenges that were present.

Except for a small amount of support towards the AAAS review, all of the C2 budget was allocated for the capital cyberinfrastructure improvements, with the goal of enabling the effectiveness of the research and education activities of the SSI Track 1 project. This then means that there is a high degree of leveraging and synergy between the two projects, and that the personnel participation, research, diversity, and workforce development activities were supported from a variety of other sources including SSI Track 1, state funds, university funds, and UMaine System funds (and therefore are not a direct part of this award). While somewhat confusing for reporting purposes, this high degree of leveraging resulted in a tightly integrated and effective manner of furthering Maine's research and education capacity in Sustainability Science. The implementation and administration of all three NSF EPSCoR projects (Track 1, 2, C2) has been through the Maine EPSCoR office at the University of Maine, which allowed for effective coordination and leveraging of resources and investments for the maximum benefit to Maine researchers.

Intellectual Merit:

By extending the reach of the enhanced MaineREN fiber backbone directly to the individual SSI researchers, the high speed connectivity required to conduct cyber-enabled research and integrated education will now allow for increased: 1) capacity for advances in discovery and innovation; 2) interdisciplinary and inter-institutional collaboration and communication; 3) expanded opportunities for workforce development and broadened participation; 4) and an integrated approach for data management, modeling, and visualization.

This C2 project leveraged and enabled the research and education focus of our Maine EPSCoR Sustainability Science Initiative (SSI), which is our NSF EPSCoR RII Track 1 project. Based at the University of Maine (UMaine), which is the state's flagship research and education institution, SSI also includes participation by five of the other six primarily undergraduate campuses of the University of Maine System (as well as five private colleges). The other UMaine System campus partners are: UMaine Augusta (UMA), Farmington (UMF), Fort Kent (UMFK), Presque Isle (UMPI), and the University of Southern Maine (USM). The sixth campus, UMaine Machias (UMM), has been engaged as part of a pending NSF proposal involving sustainability science.

This C2 addressed the primary bottleneck that was still remaining in Maine's cyberinfrastructure landscape, which was the final connection between the fiber backbone and the researchers and students on the university and college campuses. Although the potential bandwidth between sites is virtually unlimited, researchers were hampered by a choke point literally within the last few meters of the communication. By being able to address these relatively small

gaps under this C2, Maine will be able to make very large gains in the effectiveness of the state's cyberinfrastructure that will allow researchers to fully utilize investments to improve research effectiveness, promote collaboration, improve K-12 interaction, and develop the future workforce of the state.

This C2 project was also fully integrated with the Maine EPSCoR RII Track 2 award that expanded the reach of MaineREN into the most rural parts of the state, reaching additional research and education facilities and adding redundancy.

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

Major Activities:

Although, with the state's recent investments, the potential for bandwidth between sites is now virtually unlimited in Maine, researchers were still being hampered by a "choke point" on their campuses literally within the last few meters of the communication. Therefore the activities of this C2 project revolved around implementing enhanced broadband connectivity directly for the buildings of SSI researchers and students on the seven UMaine campuses.

As outlined in the proposal, the YR2 concentration was on the planning, design, engineering, and installation of the cyberinfrastructure improvements in the remaining three buildings on the UMaine campus where SSI researchers and students are working, and at SSI partner institutions UMA, UMM, and UMFK.

In addition, as cyberinfrastructure improvements were completed, training activities for SSI researchers and students began in order to assist in the usage of the new capacities being provided.

As part of the SSI RII Track 1 project, the American Association for the Advancement of Science (AAAS) Research Competitiveness Service provided a scientific peer review in the spring of 2013. While the panel primarily examined focal questions on the SSI RII Track 1 project objectives, the scope of their assessment was expanded to also consider the potential impact of the C2 cyber-enabled research and education activities leveraging effect.

During YR2, this project continued to be on track to meet all of its strategic milestones for installation of the cyberinfrastructure as described below.

Specific Objectives:

YR2 objectives focused on the deployment of broadband connectivity in the remaining buildings and campuses that house researchers and students in the Maine EPSCoR Sustainability Science Initiative (Track 1).

YR2 University of Maine (UMaine):

UMaine's fiber plant is configured as a ring of fiber hubs with spokes off to multiple buildings. In the past few years, the UMaine campus had invested in augmenting its core fiber optic ring with single mode fiber to upgrade its core network to a 10 Gigabit Ethernet backbone. However, most buildings at UMaine did not have the single mode entrances necessary to deliver 10 Gbps connectivity to the buildings. Additionally, the internal building wiring was last upgraded in the early 1990's to Category 3 cable which is unable to support gigabit Ethernet connections to the desktop.

The challenge at UMaine that was addressed in this C2 project was to rewire eight buildings at UMaine (5 in YR1, 3 in YR2) with Cat-6 cable and install single mode fiber building uplinks back to the closest core fiber hub. The buildings housing SSI researchers and students required upgraded connectivity in order to enable higher levels of research, data management, visualization, communication, and

collaboration. The objectives for these buildings' existing multi-mode fiber entrances (uplinks), would be to augment with single mode fiber, and to replace the internal Category 3 cabling with Category 6 cabling. As the existing cable plant was not always installed to even Category 3 specification (cable runs exceeding 100 meters), new Intermediate Distribution Frames (IDFs) were also required to be built and outfitted as part of the new cable plant designs.

YR2 University of Southern Maine (USM):

USM has two primary campuses, one in Portland and one in Gorham, located approximately 12 miles apart. The two campuses are connected together with dark fiber leased from the local cable TV company. The Science Building on USM's Portland campus serves as the southernmost in-state Point of Presence of MaineREN's DWDM infrastructure and is the layer-3 termination point for Maine's Internet 2 connection. USM's connectivity to MaineREN is currently a 10 gigabit Ethernet connection. The challenge of extending this level of connectivity onto the USM campuses was in its current fiber plant - on both of USM's campuses the inter-building fiber plants consisted of a mixture of 50 and 62.5 micron multi-mode fiber. In order to extend high bandwidth connectivity, 10 Gbps and beyond, across the campuses, the intra-campus fiber plant needed to be augmented with single mode fiber.

YR2 University of Maine Augusta (UMA), Fort Kent (UMFK), and Machias (UMM):

For the five remaining Sustainability Science Initiative partner institutions involved in this project, the connectivity gap existed at the edge of their campuses. The campuses themselves had relatively robust campus networks to distribute the connectivity between buildings and to the end users, and had made the necessary investments to keep their Inside and Outside Plants (ISP/OSPs) relatively modern. Their buildings have either Category 5e or Category 6 based ISPs and their OSPs are made up of a mixture of multi-mode and single mode fiber.

The new high-speed advanced network connectivity was scheduled to be delivered to the campuses across the upgraded MaineREN network. All five campuses either directly connected to MaineREN (UMA) or leased connections back to the MaineREN network running at either 1 Gbps (UMF) or 100 Mbps (UMFK, UMM, UMPI).

What all five campuses lacked was a high performance edge router to connect the campus networks to the MaineREN backbone (each campus had a Cisco 7200 Router of various vintages). This challenge would be met by installing new Cisco ASR 1002 routers with dual 10 Gb/sec Ethernet interfaces and four 1 gigabit Ethernet interfaces at each campus to facilitate connecting the campus networks to MaineREN. Most buildings on these campuses had network switches capable of delivering 100Mbps Ethernet to the desktop with their major buildings being migrated to new switches to be able to deliver gigabit Ethernet so that extended high performance connectivity to the desktop would be possible once it was delivered to the campus edge.

Additional objectives and accomplishments regarding broadening participation, diversity, and workforce development are outlined in section 1.3C.

Significant Results: During YR2, the following actions were implemented to meet the above objectives:

YR2 University of Maine (UMaine):

Planning began in fall 2012 for upgrading the fiber cyberinfrastructure at the remaining three buildings at UMaine, which were Dunn, Sawyer, and Stevens. SSI researchers and students are located in these buildings and have key needs that require upgraded connectivity in order to enable higher levels of research, data management, visualization, communication, and collaboration. The installation phases began on schedule in late fall 2012 and were completed by spring 2013.

Maine EPSCoR worked with UMaine's Information Technology and Facilities staff to implement these upgrades, which included:

- 1) The buildings' existing multi-mode fiber entrances (uplinks) were augmented with single mode fiber uplinks back to the closest core fiber hub.
- 2) The internal Category 3 cabling in these buildings was replaced with Category 6 cabling.
- 3) As the existing cable plant in each building was not always installed to even Category 3 specification (cable runs exceeding 100 meters), new Intermediate Distribution Frames (IDFs) were built and outfitted as part of the new cable plant designs.
- 4) The project was overseen by BICSI RCDD certified professionals to ensure current University and EIA/TIA standards were followed.

By June 2013, we had completed all but one of the proposal objectives, with cyberinfrastructure improvements finished at the planned eight buildings at UMaine, as well as at five of the other UMaine System campuses. While the project at USM was still being completed at that time, it had become apparent that we had managed to generate some cost savings over the life of this project due to economies of scale and pricing in this fast-changing field, which resulted in actual costs less than the estimates we had been given.

We therefore requested that the scope of our proposal be expanded to allow us to take advantage of this opportunity, and to gain greater advantages by being able to provide advanced connectivity capability to SSI researchers and students at one additional building at UMaine (Merrill Hall). This expansion was still very much within our proposal goal of closing the gaps in CI for the Maine EPSCoR RII Sustainability Science Initiative researchers at UMaine campuses. It just allowed for the unexpected addition of one additional SSI building that was not able to be included in the original proposal due to budget constraints. Its addition to the project then resulted in end-to-end connectivity for almost all of our remaining SSI researchers and faculty at UMaine. (This expanded scope was approved.)

The cost savings that we were able to generate therefore allowed us to do cyberinfrastructure improvements at Merrill Hall on the UMaine campus. The need for the fiber improvements in this building, and the planned upgrades, was exactly the same as that for the other eight buildings at UMaine. Therefore, CI upgrades to this building included new single mode fiber uplinks, Category 6 cabling, and Intermediate Distribution Frames. We worked with our UMaine Facilities office to immediately begin this additional project, and it was completed by the August 31st end date for the grant.

YR2 University of Southern Maine (USM):

During the end of YR1, planning meetings were held with key technical personnel at USM and the University of Maine System MaineREN Director prior to the YR2 installation phase. The result was that bids went out during Spring 2013, and installation began June 2013.

The end-to-end connectivity gap for SSI researchers at USM that was addressed was the fiber backbone of the University's two primary campuses, with the fiber plants on both campuses augmented by installing 24 strand single mode fiber cables to buildings key to SSI researchers there, including the Law Building, the Library, Bailey Hall and buildings that make up the fiber core for the Portland campus. The fiber terminated in each building using industry standard SC/UPC connectors with the plant design and installation overseen by BICSI RCDD certified professionals following current University and EIA/TIA standards. This allowed for the new 10 Gbps connectivity over MaineREN to now be available to researchers.

The final cost of installing the fiber cables came in slightly lower than projected. Therefore, we were also able to install a sixteen port 10Gig ethernet module for the core switch at USM's Portland campus. The module was used to light the single mode fiber installed, and to increase the bandwidth between the two campuses, Portland and Gorham, from 1Gbps to 10 Gbps.

YR2 University of Maine Augusta (UMA), Fort Kent (UMFK), and Machias (UMM):

Planning began in fall 2012 for the three remaining SSI campus partners (UMA, UMFK, and UMM). The installation of their high performance edge routers was completed by summer 2013.

This will allow the SSI research and education teams at each of these five campuses to have end-to-end access to the highest connectivity possible at this time, including access to UMaine's Supercomputer. The timelines for each of the campuses were chosen so that the installation of the routers coincided with the deployment of the new MaineREN network upgrades.

Key outcomes or
Other achievements:

In addition to the above cyberinfrastructure investments, one of the key outcomes of this C2 project has been the ability to leverage other statewide cyberinfrastructure investments and activities that happened concurrently.

In July 2012, the Advanced Computing Group (ACG) was created as a formalization of the UMaine group that had been serving the supercomputing and cloud needs for UMaine, the State of Maine, and the Northeast region over the years. While the group is located at the University of Maine campus in Orono (where the supercomputer is located), it is a part of the University of Maine System, which allows it to serve all seven campuses. This partnership between the UMaine flagship campus and the other campuses was directly modeled on the Maine EPSCoR office's Track 1 system-wide collaborations, and was spurred by the growth and potential of the cyberinfrastructure investments made under this NSF EPSCoR C2, plus the Track 1 and Track 2 projects being leveraged. Having this formal group to enable and support statewide cyber activities is a crucial piece to Maine's success in this area. C2 Co-PI Bruce Seegee serves as the ACG Director.

In addition, with state bond support, ACG installed a new high-performance supercomputer in mid-2012, and from June 2012 to February 2013 the facility

served over 2 million core hours of CPU time (the equivalent of approximately 228 years of computer time on a single processor). The new C2 cyberinfrastructure will all SSI researchers and students throughout the state to now have full access to this capacity.

In order to fully take advantage of the potential of the new statewide cyberinfrastructure capacity and capabilities, ACG hired a new Data Specialist plus a Data Outreach Specialist in spring 2013. Both positions are now dedicated half-time to assist SSI researchers and students in addressing various data management, visualization, and virtual proximity challenges. This has proven to be a key to being able to take full advantage of the state's new cyberinfrastructure capacity, and while their work with the SSI researchers has just begun, it will continue far beyond the scope and timeframe of this grant.

Given all of the above, the ability to document the research impact and outcomes from these C2 improvements will necessarily span beyond the grant timeframe. We will continue to monitor and evaluate the following:

1) SSI Data Management and Modeling: Under the SSI Track 1 project, a dedicated SSI server (messi.target.maine.edu) was created on the ACG supercomputer. This includes a centralized database, an authentication system for SSI users that transcends campus boundaries, and an automatic data backup process. One of the SSI research goals is to produce data models that can be of value to all SSI researchers and stakeholders, which is now possible with the completion of this C2 project. By providing SSI researchers with the enhanced ability to have data and compute resources centrally located and available to all researchers, plus administered, maintained, and backed up, a much more effective research agenda can be implemented.

2) Cloud Computing: The primary impediment to researchers utilizing centralized cloud computing more fully has not been the lack of hardware resources, but rather the connectivity of the end users acting as a choke point. The C2 cyberinfrastructure improvements now allow all SSI researchers at the seven UMaine System campuses to take advantage of UMaine's newly upgraded high-performance computer and cloud resources.

3) Visualization: SSI researchers have begun utilizing visualization walls to provide a means for high-resolution imagery to be displayed, examined, and shared. They also can be a valuable tool for collaborating across distance. The C2 cyberinfrastructure installations will help remove the connectivity barriers to greater utilization of this technology throughout the state.

4) SSI Partner Communication and Virtual Proximity: Maine EPSCoR recently completed a new SSI Communications Center under its SSI Track 1 project, which features high-performance videoconferencing and visualization systems. This Center requires end-to-end high bandwidth in order to be effective in eliminating the barriers to collaboration imposed by distance, and that has been made possible by the connectivity installations under this C2. This Center is used to virtually bring together all of the SSI participants throughout the state for All-Team meetings, workshops, seminars, and sharing of research and results.

With this C2 project leveraging the other investments and closing one of the last cyberinfrastructure gaps for the state, ACG began focusing on grant submissions to support further statewide collaboration for the creation of data building blocks, infrastructure upon which to build them, and training programs for

the next generation of sustainability scientists. These included:

- 1) NSF Data Infrastructure Building Blocks (DIBBS) proposal (UM, USM, UMF, UMM, UMFK): to sponsor a series of meetings across the State (and in neighboring New Brunswick, Canada) to assess data needs and tools necessary to promote growth in research across the region.
- 2) NSF "SYNERGY IGERT-CIF21: Synergistic Data Integration, Modeling, and Knowledge Discovery to Foster Sustainability": to promote the training of graduate students in Sustainability Science by focusing on the use of data, modeling, and cyberinfrastructure techniques to promote multidisciplinary research in sustainability.
- 3) NSF CRI proposal and NSF MRI proposal: significantly increase the diversity and magnitude of the ACG computing, data storage, and visualization resources for statewide use.

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

As noted above, the first two employees were hired into the Advanced Computing Group in spring 2013. Traditionally, UMaine supercomputer users have been more highly technical and cyber self-sufficient than the average researcher or student. Therefore, the efforts of the new ACG Data Outreach Specialist and the Data Specialist will be instrumental in providing the support necessary to significantly increase the usage of the ACG resources by less cyber-focused individuals. These include the majority in SSI.

To that end, Maine EPSCoR and UMaine's Advanced Computing Group (ACG) collaborated to hold four training workshops during spring 2013 to begin to engage and inform SSI researchers and students. Workshops focused on introductions to ACG data management policies and procedures, and the new cyber technology available including cloud computing with virtual machines, data storage, high resolution visualization technology, and high performance computing (39 participants, 28 male/11 female). In addition to these workshops, Maine EPSCoR and UMaine's Advanced Computing Group also held other demonstrations/presentations at four meetings of SSI researchers and students (26 participants, 11 males/8 females). Additional training workshops were scheduled for late fall 2013, and will continue again in the spring 2014.

Broadening Participation:

This C2 project centered around leveraging cyber capacity for institutional partners in the Maine EPSCoR SSI Track 1 network, which spans nearly the entire populated range of the state of Maine. The over 12 institutional partners of higher education in this initiative span nearly the entire populated range of the state of Maine, from Fort Kent in the far north to Portland in the south, and from Machias in the east to Farmington in the west.

The cyber-enabled research and education focus of sustainability science brings together over 300 researchers, students, and stakeholders from throughout the state and encompasses over 17 different disciplinary fields. Their collaborative work includes data gathering and analysis, modeling, and deriving understanding through cross-disciplinary collaboration, all of which provides a rich basis for the C2 cyber-enabled opportunities to broaden participation and provide training.

SSI is a fully integrated research and education program that advances discovery and understanding while promoting teaching, training, and learning. All aspects seek to broaden the participation of women and underrepresented groups, and includes a geographically and institutionally-diverse portfolio of projects. The broader impacts of the SSI project that is being enabled by the C2 cyberinfrastructure improvements include:

- 1) supporting a research portfolio that includes teams with remarkably diverse inter-disciplinarity;
- 2) engaging with over 200 stakeholder groups from across the state (including Maine's tribal communities) to identify pressing problems for the state, define research needs, and develop effective solutions;

- 3) involving students in a culture of interdisciplinary research and practice;
- 4) utilizing a statewide collaboration of colleges and universities focused on the theory and practice of sustainability science;
- 5) initiating new curriculum and partnerships designed to advance workforce and economic development and help grow Maine's green innovation economy.

Collectively, these SSI activities are helping to increase Maine's research capacity and competitiveness at the same time as they enhance our ability to link scientific knowledge with improved actions and decision.

As SSI researchers and students begin to take advantage of the new cyber capacity and tools available to them, integrated SSI diversity and workforce development activities and partnerships can also be enhanced. This includes fostering new aspects to ME EPSCoR SSI's existing programs and collaborations with:

- 1) Maine Girls Collaborative Project: Maine EPSCoR mini-grants will now encourage the inclusion of cyber-enabled activities related to SSI for girls of all ages.
- 2) Expanding Your Horizons: ACG staff will be recruited to offer cyber-enabled activities at this annual program for middle school girls.
- 3) Native STEM Scholarship Development Program: research internships, programs, and activities will encompass cyber-enabled research activities whenever possible.
- 4) NSF ADVANCE: ME EPSCoR has worked with this project, through the UMaine Provost's office, to help women faculty from the other UMaine System campuses who directly participate in SSI. New cyber-enabled capacity can assist in this effort.
- 5) SSI Student Research Internships: over 150 undergraduate and graduate students involved in SSI internships will be able to take advantage (through their SSI research teams) of the new cyber capacity, potentially enabling new research abilities.
- 6) ME EPSCoR High School Research Internships: one high school student (from Old Town High School) was successfully placed with the ACG team in a year-round internship during YR2, and continues during this year.
- 7) SSI Courses: SSI continues to explore how to utilize distance learning for teaching undergraduate sustainability science courses throughout the state; this effort will be more feasible with the new statewide cyber capacity.
- 8) Maine STEM Collaborative: ME EPSCoR presenters at the Maine STEM Summit in March 2014 will provide information on the potential for K-12 connections with cyber-enabled research and education at the state's universities.

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

Four training workshop presentations were given by ACG staff during spring 2013, and repeated in fall 2013. Presentations focused on introductions to ACG data management policies and procedures, and the new cyber technology available including cloud computing with virtual machines, data storage, high resolution visualization technology, and high performance computing. Presentations were also made at an additional four SSI meetings. (See above.)

Additional general information about the C2 project was distributed via press releases, articles in the Maine EPSCoR newsletter, and on the Maine EPSCoR website.

Specific presentations on the new cyber technology now available were also made at the 2013 Maine EPSCoR State Conference in September, and ACG staff also had a hands-on exhibit to demonstrate activities for conference participants.

Co-PI Jeff Letourneau, Executive Director of NetworkMaine at the University of Maine System, worked directly to communicate with the IT directors from each of the UMaine campuses, as well as the statewide NetworkMaine Council.

Products

Books

Nothing to report.

Book Chapters

Nothing to report.

Conference Papers and Presentations

Nothing to report.

Inventions

Nothing to report.

Journals

Nothing to report.

Licenses

Nothing to report.

Other Products

Instruments or Equipment.

Cyberinfrastructure upgrades to the seven campuses of the University of Maine System included: new single mode fiber uplinks, Category 6 cabling, Intermediate Distribution Frames, and high-performance edge routers.

Other Publications

Nothing to report.

Patents

Nothing to report.

Technologies or Techniques

Nothing to report.

Thesis/Dissertations

Nothing to report.

Websites

Nothing to report.

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Eckardt, Michael	PD/PI	1

Letourneau, Jeffrey	Co PD/PI	1
Nemeth, Vicki	Co PD/PI	1
Segee, Bruce	Co PD/PI	1
Gaspar, Ami	Other Professional	1
Wilson, Christian	Technician	1

Full details of individuals who have worked on the project:

Michael Eckardt

Email: michael.eckardt@umit.maine.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Overall program oversight.

Funding Support: Position not supported with grant funds - supported through institutional role as UMaine Vice President for Research.

International Collaboration: No

International Travel: No

Jeffrey Letourneau

Email: jeffl@maine.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Oversight of the cyberinfrastructure installations at UMaine System campuses.

Funding Support: Position not supported with grant funds - supported through institutional role as UMaine System Executive Director Networkmaine.

International Collaboration: No

International Travel: No

Vicki Nemeth

Email: vicki.nemeth@umit.maine.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Responsible for the day-to-day project administration and implementation oversight, and all financial activity.

Funding Support: Position not supported with grant funds - supported through institutional role as Maine EPSCoR Director.

International Collaboration: No

International Travel: No

Bruce E Segee**Email:** segee@maine.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 1**Contribution to the Project:** Implementation of data management and training elements.**Funding Support:** Position not supported with grant funds - supported through institutional role as UMaine Professor of Electrical and Computer Engineering.**International Collaboration:** No**International Travel:** No**Ami Gaspar****Email:** ami.gaspar@maine.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 1**Contribution to the Project:** Maine EPSCoR technical staff at the University of Maine System**Funding Support:** None**International Collaboration:** No**International Travel:** No**Christian Wilson****Email:** chris.wilson@maine.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 1**Contribution to the Project:** Maine EPSCoR technical staff at the University of Maine System**Funding Support:** None**International Collaboration:** No**International Travel:** No**What other organizations have been involved as partners?**

Name	Type of Partner Organization	Location
University of Maine at Augusta	Academic Institution	Augusta, ME
University of Maine at Farmington	Academic Institution	Farmington, ME
University of Maine at Fort Kent	Academic Institution	Fort Kent, ME
University of Maine at Machias	Academic Institution	Machias, ME
University of Maine at Presque Isle	Academic Institution	Presque Isle, ME
Universitv of Southern Maine	Academic Institution	Portland. ME

Full details of organizations that have been involved as partners:

University of Maine at Augusta**Organization Type:** Academic Institution**Organization Location:** Augusta, ME**Partner's Contribution to the Project:**

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

University of Maine at Farmington**Organization Type:** Academic Institution**Organization Location:** Farmington, ME**Partner's Contribution to the Project:**

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

University of Maine at Fort Kent**Organization Type:** Academic Institution**Organization Location:** Fort Kent, ME**Partner's Contribution to the Project:**

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

University of Maine at Machias**Organization Type:** Academic Institution**Organization Location:** Machias, ME**Partner's Contribution to the Project:**

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

University of Maine at Presque Isle**Organization Type:** Academic Institution**Organization Location:** Presque Isle, ME

Partner's Contribution to the Project:

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

University of Southern Maine**Organization Type:** Academic Institution**Organization Location:** Portland, ME**Partner's Contribution to the Project:**

Collaborative Research

Other: Cyberinfrastructure improvements

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?NO

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

The research and education focus that is being enabled by this C2 project is the Maine EPSCoR Sustainability Science Initiative (SSI) RII Track 1, with a goal of providing SSI researchers and students at the seven campuses of the University of Maine System true end-to-end connectivity. SSI is advancing the emerging field of sustainability science in three important and integrative ways: 1) examining interactions between social and ecological systems (SES) as landscapes change in response to urbanization, forest management, and climate variability; 2) investigating how such SES knowledge affects, and is influenced by, the actions and decisions of diverse stakeholders, with a goal of strengthening connections between knowledge and action; 3) evaluating the factors that facilitate and impede interdisciplinary collaboration, with a goal of identifying and implementing individual and institutional best practices that are needed to support successful interdisciplinary research programs in sustainability science.

The C2 connectivity improvements that are now in place will support the Track1 SSI research agenda by addressing various data management, visualization, and virtual proximity challenges that were present. This project allowed Maine EPSCoR to address the cyberinfrastructure gaps at the seven campuses of the University of Maine System that had still been preventing the delivery of true end-to-end connectivity between Maine's SSI researchers and the new advanced networking services provided over MaineREN.

By extending the reach of the enhanced MaineREN fiber backbone directly to the individual SSI researchers, the high speed connectivity required to conduct cyber-enabled research and integrated education will now allow for increased: 1) capacity for advances in discovery and innovation; 2) interdisciplinary and inter-institutional collaboration and communication; 3) expanded opportunities for workforce development and broadened participation; 4) and an integrated approach for data management, modeling, and visualization.

What is the impact on other disciplines?

See above - SSI is multi-disciplinary.

What is the impact on the development of human resources?

New training opportunities by ACG staff are providing increased professional development for SSI researchers and students.

What is the impact on physical resources that form infrastructure?

This C2 addressed the primary bottleneck that was still remaining in Maine's cyberinfrastructure landscape, which was the final connection between the fiber backbone and the researchers and students on the campuses of the UMaine System. Although the potential bandwidth between sites is virtually unlimited, researchers were hampered by a choke point literally within the last few meters of the communication. By being able to address these relatively small gaps under this C2, Maine will be able to make very large gains in the effectiveness of the state's cyberinfrastructure that will allow researchers to fully utilize investments to improve research effectiveness, promote collaboration, improve K-12 interaction, and develop the future workforce of the state.

What is the impact on institutional resources that form infrastructure?

The new cyber resources add important value to the cyberinfrastructure for each campus participating in this project.

What is the impact on information resources that form infrastructure?

An enhanced capacity to transition to centralized cloud computing can allow for greater statewide access to data, resources, and high-performance computing.

What is the impact on technology transfer?

The increased cyber capacity of SSI researchers can allow for greater cyber-enabled interactions with stakeholders throughout the state and beyond, potentially increasing opportunities for economic development collaborations.

What is the impact on society beyond science and technology?

See all of the above.

Changes/Problems

Changes in approach and reason for change

In June 2013, Maine EPSCoR filed the following request for a change in the scope of work for this project, which was approved by our NSF Program Officer:

"At this time, we have completed all but one of our proposal objectives, with cyberinfrastructure improvements finished at the planned 8 buildings at UMaine, as well as at 5 of the other UMaine System campuses. The final proposal objective is still on-going for the project at the University of Southern Maine, which is currently underway and will be completed shortly. It has now become apparent that we have managed to generate some cost savings over the life of this project due to economies of scale and pricing in this fast-changing field, which resulted in actual costs less than the estimates we had been given. Therefore we anticipate having approximately an \$80,000 balance that was budgeted but not needed to accomplish the construction projects that were part of our original proposal. We would therefore like to request that the scope of our proposal be expanded to allow us to take advantage of this opportunity, and to gain greater advantages by being able to provide advanced connectivity capability to SSI researchers and students at one additional building at UMaine (Merrill Hall). This proposed expansion of scope is still very much within our proposal goal of closing the gaps in CI for the Maine EPSCoR RII Sustainability Science Initiative researchers at UMaine campuses. It just allows for the unexpected addition of one additional SSI building that was not able to be included in the original proposal, and is still consistent with the proposal objective to upgrade SSI researcher buildings at UMaine (it just represents an expansion of the number of buildings that could be upgraded).

We had been unable to include this building in the original proposal due to budget constraints, but its addition to the project would then result in end-to-end connectivity for almost all of our remaining SSI researchers and faculty at UMaine. This request to expand the scope does not change the overall goals and objectives of this project-which were to achieve end-to-end connectivity for SSI researchers. The cost savings that we were able to generate would simply allow us to do additional

infrastructure improvements that would connect more of our SSI researchers on the UMaine campus. The additional building that we are asking to add to this project is Merrill Hall on the UMaine campus. CI upgrades to this building have just been officially estimated at \$79,974, with \$17,798 of that in materials (optical fiber, interior distribution and cabling, power & grounding, etc.) and \$62,176 in labor and services (fiber, cable, & raceway installation, build BDF & IDF rooms, install cable rack, etc.) The need for the fiber improvements in this building, and the planned upgrades, is exactly the same as that for the other eight buildings at UMaine that were discussed in our proposal (page 7), with current conditions severely limiting connectivity for SSI researchers. If approved by NSF, our UMaine Facilities office is prepared to begin this additional project as soon as possible, and to complete it by the August 31st end date for the grant."

Actual or Anticipated problems or delays and actions or plans to resolve them

None - all components implemented on or ahead of schedule.

Changes that have a significant impact on expenditures

As described above, an approved change of scope allowed us to add cyberinfrastructure improvements to one additional building on the UMaine campus. All NSF funds have now been fully expended.

Significant changes in use or care of human subjects

Not applicable.

Significant changes in use or care of vertebrate animals

Not applicable.

Significant changes in use or care of biohazards

Not applicable.