

NSF CC* Planning: Designing a Regional Science DMZ for Small Colleges and Universities in Pennsylvania

NSF Proposal Award Number: 2201269



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- Appendix A = Appendix-A-NSF-Planning-Grant-Science-Education-Drivers.pdf
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Goal # 1 – Identification and Support of Science and Education Drivers

Identify the process to identify, understand, and quantify existing science and education drivers; understand the corresponding cyberinfrastructure. Provide both the technical and application support associated with the implementation of required cyberinfrastructure in support of the initial and then subsequent research and education applications. The goal includes Identifying overlapping interest areas and commonly used cyberinfrastructure resources.

The project team was established with staff from Lafayette College, Indiana University at Pennsylvania (IUP), Lehigh Carbon Community College (LCCC) and KINBER. A biweekly project meeting cadence was established to work on planning efforts. The team began updating science and educational drivers for their own institutions. The team also conducted video calls with external regional organizations to better understand and develop mechanisms to identify cyberinfrastructure-based applications and to also understand the required cyberinfrastructure-based resources required. The project team held investigative collaboration video calls with the following organizations: SOX / SLR, TheQuilt.Net, Duke/NCShare/Davidson College, ESNet, OneNet, Front Range GigaPop/UCR/NCAR, Utah Education Network, Sun Corridor Network, Franklin and Marshall, University of Massachusetts, Villanova, FirstLight, Pennsylvania State University, and the Massachusetts Green High Performance Computing Center.

The combined table in Appendix A (as of 4/18/23) illustrates the diverse set of science and education drivers identified under the planning grant activity.

Identified Science and Education Drivers				
Institution	Educator/Researcher	Research & Education Topic	Application	CI Requirements
Lehigh Carbon Community College	Susan Miner, Dr. Sami Jo Eckhart, Robert J. Ritter	GenCyber Middle and High School Teacher Program	Canvas LMS	Robust WAN Connection
Lehigh Carbon Community College	Susan Miner, Kristen Gower	C++ Virtual Lab	Research Computer Lab Coursework	Robust WAN Connection, Solid Virtual Desktop Provider
Lehigh Carbon Community College		Early College Program	Apply information literacy skills	Robust WAN Connection, Stable Computer Lab environment
Lehigh Carbon Community College		Improving Undergraduate STEM Education (IUSE): Hispanic Serving Institutions (HSI) Program		
Indiana University at Pennsylvania	Dr. Frederick Adkins	Data Analytics, Geospatial Intelligence, AI, Robotics, STEAMSHOP Initiatives:		Big Data, GIS resources, Remote Visualization
Indiana University at Pennsylvania	Dr. Frederick Adkins and Dr. Soundarajan Ezekiel	IUP Data Analytics/Computer Science AI platforms and resources	Expand research capacity in AI and data analytical research through improvements to high-performance computing capabilities	Big Data, Remote Visualization
Indiana University at Pennsylvania	Dr. Frederick Adkins and Dr. Tracey Cekada	IUP Safety Science AI and Robotic Research	Short-term and long-term AI and robotic research with necessary computing infrastructure.	Big Data, Remote Visualization
Indiana University at Pennsylvania	Dr. Frederick Adkins and Dr. John Bernhard	IUP Geological-Geospatial Intelligence	Remote sensing and mapping using unmanned aerial systems. Identifying and defining key security and geographical parameters with AI applications	Big Data, Remote Visualization
Indiana University at Pennsylvania	Dr. Frederick Adkins and Mr. Sean Dery	IUP STEAMSHOP	High-impact practices in design thinking and science, technology, engineering, art, and mathematics (STEAM) education	Big Data, Digital Design, Remote Visualization
Indiana University at Pennsylvania	Dr. Waleed Farag	Enhance Cybersecurity and STEM education in Pennsylvania: Institute for Cyber Security	A set of innovative initiatives and activities focusing on student recruitment, retention, and completion of STEM and cybersecurity programs	https://www.iup.edu/cybersecurity/index.html
Indiana University at Pennsylvania	Dr. Waleed Farag	GenCyber Program	Desire to Learn (D2L) LMS	Robust WAN Connection, Stable Computer Lab environment
Indiana University at Pennsylvania	Nicholas Deardorff	Scanning Electron Microscope	A training platform for undergraduate and graduate students to learn modern, state-of-the-art analytical techniques used in a large variety of science and technology disciplines	
Lafayette College	Jason Alley, Peter Goode	Federated HPC Access Research Project	Secure Shared HPC Resource Access Mechanisms	Federated Identity Framework
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Lafayette College	Jim Dearworth	Confocal and Scanning Electron Microscopy		
Lafayette College	Chip Nataro, Markus Dubischar	EVO/SEM Microscope & XtaLAB mini II single crystal X-ray diffractometer	Research from biology, chemical and biomechanical engineering, civil engineering, environmental science, geology, neuroscience, and physics	Federated Identity Framework
Lafayette College	Heidi Hendrickson	Molecular Dynamics	HPC Cluster Applications	
Lafayette College	John O'Keefe, Jason Alley	Science DMZ	Science DMZ Build-out	Robust WAN Connection
Penn State University	Dr. Joe Chuffi, Vincent Petrelli, Shemi McCleary, Stephen B. Leonard	Digital Foundry at New Kensington	Workforce Education Programs, EMETS Program	Robust Networking, Secure Remote IoT Access

Lafayette College

The project team collaborated with several of Lafayette College's IT staff and faculty members. Lafayette College is a highly selective, undergraduate liberal arts college located in Easton, Pennsylvania with an enrollment of approximately 2,700 undergraduate students, half of whom major in STEM related fields. Lafayette has developed a campus-wide High Performance Computing strategy to address the increasing demand for enhanced research enabled by high-performance computing and other technology capabilities. ITS staff have surveyed Lafayette STEM faculty for current or anticipated needs for HPC resources and applications. Examples identified in the survey included: creating neural networks to research how to improve computer vision and automated image identification; molecular dynamics simulations of proteins and enzymes; simulations of the ecological impact of extreme climate events and the movement and replication of bacteria; and using datasets with millions of observations to generate complex economic models. While the past survey results have provided a good foundation for identifying science drivers within their campus environment, additional work is underway to identify required infrastructure enhancements as well as to identify possible external collaborations. These requirements will be incorporated into a campus-wide network refresh, planned for the fall of 2023.

Lafayette College has made significant improvements to support researchers in recent years, reflecting its reputation as a premier STEM-focused liberal arts college. These improvements were driven by the College's strategy. Examples include establishing a centrally supported high-performance computing cluster, creating the Hanson Center for Inclusive STEM Education, and forming an interdisciplinary Data Science minor, concurrent with the creation of a cadre of student Data Associates to assist researchers in several ways. Lafayette has also installed a new, shared confocal microscope for research. Despite these achievements, increased demand from both existing and incoming faculty and researchers for enhanced research instrumentation and connectivity has revealed gaps in their cyberinfrastructure.

To address the gaps, a plan has been drafted to address key goals to ensure that the College's Cyberinfrastructure is secure, robust, and meets the needs of their research community and collaborators. As mentioned previously, Lafayette is currently upgrading its network infrastructure, with a goal to implement a 40/100GB backbone, as well as replacing and upgrading all routers and switches across the network. The node connecting Hugel Science Center, Acopian Engineering Center, and Rockwell Integrated Sciences Center will be expanded to create a high-speed science research connection. In addition, the College is hoping to create a new Science DMZ, complete with frictionless scientific data flow from edge to core, as well as a data transfer node (DTN). In addition, the College plans to leverage improved federation controls via a Federated HPC Access Research Project.

Lafayette is a member of the Ecosystem for Research Networking (ERN) and a collaborator on the Northeast Cyberteam. Lafayette identified the Resource Sharing Project as a possible methodology to facilitate connecting federated identity trusted HPC resources, so that faculty researchers at Lafayette could submit batch jobs to any available distributed resource. External pools can support jobs that require more or different resources than may be available locally as a no-cost "bursting" option. Despite the strength of Lafayette's HPC environment, use cases have arisen that require a prohibitive amount of time or resources that can be run locally. Therefore, having a no-cost option to submit those types of use cases to a growing cloud of resources is attractive to their teams. Other regional participants such as Rutgers, offer a deep pool of resources to meet use cases Lafayette cannot currently support, such as

high-throughput computing (HTC). During the in-person event held at Lafayette, the team noted that The Massachusetts Green High Performance Computing Center (MGHPCC) offered a promising methodology and model to follow for Lafayette and its other regional collaborators.

The planning team also noted that Lafayette has deployed a scanning electron microscope (SEM). It provides a high-tech, industry-standard, long-awaited tool to the community of Lafayette researchers that has since opened numerous opportunities with other regional institutions. Regional High Schools such as Phillipsburg High School and Moravian Academy have been able to make use of the microscope as a collaborative tool, a rare acquisition for an undergraduate college. Not only has it aided in research and hands-on teaching and learning for Lafayette's biology, chemical and biomechanical engineering, civil engineering, environmental science, geology, neuroscience, and physics faculty and students, but external collaborators are encouraged to utilize the SEM for research and educational opportunities as well.

Indiana University at Pennsylvania (IUP)

The project team collaborated with Indiana University of Pennsylvania (IUP) faculty and staff to identify current and future science and education drivers. IUP faculty have made significant progress in areas that necessitate additional investments in cyberinfrastructure (CI).

Indiana University of Pennsylvania (IUP) is one of fourteen colleges that comprise the Pennsylvania State System of Higher Education (PASSHE). PASSHE's mission is to increase educational attainment in the Commonwealth, prepare students at the undergraduate and graduate levels for professional and personal success in their lives, and to contribute to the economic, social, and cultural development of Pennsylvania's communities. With over 6,000 undergraduates and 1,600 graduate students, IUP combines the academic opportunities of a large university with the highly personalized and intimate learning centered environment of a small college. The Carnegie Foundation ranks IUP as an R2 Doctoral University with High Research Activity. IUP has been a frequent participant in KINBER's cyberinfrastructure seminars and workshops. While some IUP faculty are content with the current level of connectivity, many are not fully aware of opportunities to access external CI resources. The project team has identified several science research and education drivers within the campus environment that would benefit from additional cyberinfrastructure investment.

IUP recently received \$4.98 million from the Department of Defense for the first three years of a novel project to enhance Cybersecurity and STEM education in Pennsylvania. This funding advances activities of the IUP Institute for Cyber Security which is an interdisciplinary initiative that promotes and encourages cybersecurity awareness and practice, both on campus and off, through teaching, research, and service activities. The Institute is affiliated with faculty and students at other institutions, such as community and other four-year colleges, sharing resources and promoting information security and data integrity training and practice. The recent grant partners with Bucks County Community College, Butler County Community College, Montgomery County Community College, Northampton Community College, Pennsylvania Highlands Community College, and Westmoreland County Community College. IUP has agreements with these colleges and dual admission agreements with Penn Highlands and with Westmoreland. The grant initiative and its goals are aligned with IUP's Strategic Plan, which includes a commitment to diversity, equity, and inclusion and towards providing the resources and services that students need to achieve their educational goals. This grant funding develops innovative initiatives and activities focused on student recruitment, retention, and completion of STEM and cybersecurity

programs. The project also engages with the local secondary schools and regional industries related to cyber defense and cybersecurity.

In conjunction with a group of national universities, IUP's Professor Waleed Farag has been awarded funding for the eighth time to run the GenCyber program in summer 2023. This year, the camp is open to middle and high school students. By Increasing student diversity in cybersecurity college and career readiness pathways, IUP is at the forefront of workforce development. The camp will address essential security concepts with an interesting, novel approach to strengthen interest in cybersecurity among middle and high school students in western Pennsylvania and beyond. The project team identified that IUP's consistent investments in CI infrastructure to date have facilitated educational projects like GenCyber, enabling them to provide engaging instruction, group activities, structured discovery, hands-on laboratory experiences, and informal instruction to both individual and combined groups of middle and high school students in western Pennsylvania and beyond.

The project team identified another key project at IUP with science drivers and specific CI requirements, the Build Back Better Regional Challenge Grant (BBBRC). This IUP award is part of a larger Southwestern Pennsylvania New Economy Collaborative \$62.7-million federal grant awarded by the US Economic Development Administration. This academic and science driven initiative builds on IUP's strengths in STEAM (science, technology, engineering, arts, and mathematics), including expertise in connecting data analytics and applied research in worker safety, robotics, and geospatial data. The goal is to create more pathways and opportunities for regional workforce training. The BBBRC award was announced on September 2 by the Collaborative, which includes a Pittsburgh regional "pipeline" spanning the 11-county region of Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Washington, and Westmoreland counties.

There are four sub-projects at IUP receiving funding under BBBRC with a common focus on technology adoption, upskilling infrastructure, and commercialization in the robotics sector. It is a university-wide collaboration, involving faculty from several departments in IUP's Kopchick College of Natural Sciences and Mathematics, the College of Arts and Humanities, the Division of University Advancement, the School of Graduate Studies and Research, and members of the IUP Research Institute. The grant activities leverage the strong research and student training programs in computer sciences, safety sciences, environmental health, and geospatial/geological sciences from IUP's Kopchick College of Natural Sciences and Mathematics in combination with IUP's new university-wide STEAMSHOP makerspace. The overall goal is to create an integrated research program in AI (artificial intelligence) and robotics that capitalizes on these strengths and develops key partnerships across campus and the region.

This science driver has new CI requirements surrounding the underlying Big Data, the need to provide distributed access to it, and to move it around. The project also has remote visualization requirements that IUP currently does not have on campus and requires CI collaborations to deliver. The BBBRC award spans four key project areas needing CI support:

IUP Computer Science and Data Analytics AI platforms and resources: IUP will expand research capacity in AI and data analytical research through improvements to high-performance computing capabilities. This infrastructure will serve the computing needs of current faculty conducting AI research and training as well as expansion into computer vision. It will serve as a backbone resource to connect with and empower several other applied research programs across campus.

IUP Safety Science AI and Robotic Research: The Department of Safety Sciences offers an interdisciplinary research program that leverages AI computing infrastructure and robotics resources to investigate workplace functions such as material handling, employee health and safety, severe injury and fatality prevention, data collection, and workplace productivity measurements.

IUP Geological-Geospatial Intelligence: The Department of Geography, Geology, Environment, and Planning provides robust training opportunities with remote sensing and mapping using unmanned aerial systems and expertise identifying and defining key security and geographical parameters with AI applications. These programs provide critical training, research and development, data collection, dissemination of findings, and workforce training.

IUP STEAMSHOP: A campus-wide initiative, STEAMSHOP transforms learning at IUP by empowering students from all backgrounds and preparations to actively engage with an interdisciplinary digital fabrication lab (makerspace) that applies high-impact practices in design thinking and science, technology, engineering, art, and mathematics (STEAM) education to attract a more diverse population and improve undergraduate persistence, retention, and career preparedness. The primary goal of STEAMSHOP is to enhance economic development and foster entrepreneurial interest in the region through the design and prototyping of solutions for real-world challenges and the creation of new small businesses. The technological, entrepreneurial, and leadership skills gained through participation in STEAMSHOP programming better prepares students for the rapidly evolving workforce.

An additional science driver impacting CI at IUP is the scanning electron microscope (SEM) funded by a recent \$425,829 NSF Major Research Instrumentation grant to Dr. Nicholas Dearthoff ([Award #1827176](#)). This SEM images objects at nanometer scale and, when combined with the Energy Dispersive Spectroscopy (EDS) device, can determine chemical compositions. The SEM-EDS combination creates very large datasets and is used for both scientific research and as a training tool by faculty and students across many regional universities and businesses. The award supports the investigators and their students using the SEM-EDS in a wide range of research topics, including: 1) quantifying crystallization within volcanic deposits (tephra, lava, and diabase sills) and lab crystallization experiments, 2) characterizing solid-state mineral chemistry and crystallography in semiconductor materials, 3) identifying diatom taxonomy to determine temporal variability of the silica and carbon cycles in both freshwater and marine systems, 4) analyzing Roman ceramics to investigate (pre)historic trade connections, 5) analyzing tooth-tooth interaction and tooth-food interaction in extinct (fossils) and living vertebrates, 6) characterizing ash morphologies from tree wood and nuts found at archaeological sites to correlate vegetation response to changing climate, 7) analysis of fine-grained aerosols to examine air-quality, and 8) studying rapid tectonic exhumation. Sharing data produced by the SEM-EDS to partners across campuses and with industry and non-profit partners requires state-of-the-art CI resources.

Lehigh Carbon Community College (LCCC)

The project team worked with Lehigh Carbon Community College (LCCC) staff and educators to identify and update current and upcoming science and education application drivers. Since 1966, LCCC has served the greater Lehigh Valley and eastern Pennsylvania area by providing a high-quality, affordable education. Five campus locations make up a comprehensive, two-year, publicly supported college whose mission is to provide high quality learning experiences that are affordable and accessible. LCCC serves more than 9,700 credit and 4,100 noncredit students each year offering more than 90 programs of study in business, education, communication, computer science, technology, humanities, health care, science, engineering, and math. LCCC is designated by the U.S. Department of Education as a Hispanic-Serving Institution, with a student population approximately 27 percent Hispanic/Latino, with 67 percent of the students at the LCCC Allentown site identifying as Hispanic. LCCC has transfer agreements with over 50 colleges and universities in place for continuing education. LCCC is also a participating college in the Minority Service Cyberinfrastructure Consortium (MS-CC).

It was identified that LCCC would like to better integrate cyberinfrastructure-based services into its curriculum, such as a modern shared, cloud-based virtualized environment in support of its STEM initiatives. LCCC experimented with Microsoft Azure Cloud/Virtual Labs for the 2022-2023 academic year for some of their academic lab environments. The Virtual Lab pilot identified that not enough CI resources were being given to the virtual cloud-based environment, leading to unstable performance issues as well as impacting student learning. Virtual Labs appeared as a common requirement for CI investments and maturity by this planning grant team amongst many institutions. Sustaining consistent stable robust lab environments has been a challenge for LCCC as for many smaller institutions.

Another area of CI planning identified as an opportunity at LCCC is their dual enrollment curriculum known as Early College Program. This is a deeply rooted community focused program offered at eleven area school districts. Early College is a program for 11th and 12th grade students who enroll full-time at LCCC for two years, earning their General Studies A.A. degree while simultaneously earning their high school diploma. Using methodologies combined with technology, students learn how to demonstrate critical thinking and problem-solving skills by analyzing intricate problems involving unclear possibilities, and employ effective methods of research. The program also teaches students how to apply information literacy skills, effectively use written and oral communication skills, and discuss the differences in human cultures. Reliable CI infrastructure is a fundamental requirement for this program to be a success for students. Often K12 resources are limited and must rely on LCCC's CI resources. Future CI planning opportunities to better engage and support this program were identified by the team.

LCCC has been a participant in the GenCyber Teacher Camp program. This week-long camp provides opportunities for teachers in Carbon, Lehigh, Northampton, and Berks Counties to collaborate and explore cybersecurity topics that are appropriate for all secondary age groups. The NSF sponsored camps have helped to improve teaching methods for delivering cybersecurity content in secondary curricula. This is accomplished by creating a network of teachers who acknowledge the need for cyber safety and strive to create better digital citizens among today's students. The camp also increases interest in cybersecurity careers and promotes diversity in the cybersecurity workforce that trickles down to K-12 aged students. Another goal for the camp is to empower students with the essential skills for safe online behavior.

The National Security Agency and the Department of Homeland Security have designated Lehigh Carbon Community College as a National Center of Academic Excellence in Cyber Defense Two-Year Education (CAE2Y). The designation is through the academic year 2023. This designation means that LCCC now has a position on the cyber defense educational landscape. LCCC is one of 10 higher-education institutions in Pennsylvania with this designation and the only community college. These criteria are common to all four-year institutions that have earned this designation and should allow LCCC students increased transfer opportunities to some of the nation's top universities

The project team identified to remain competitive, key investments and sustainability methodologies must be applied. The recent Missing Millions Report* identified findings and paths forward; this area of focused cyber education illustrates LCCC's commitment to several of the paths forward found in the report - including but not limited to Ensuring Inclusive Access as well as experimenting with cross-institutional partnerships to support underrepresented, next-generation scholars along professional development pathways.

Pennsylvania State University:

The grant team collaborated with Penn State University research staff on several occasions in several areas. The in-person workshop held at Lafayette College, gave the project team an opportunity to learn more in depth about an innovative science and education driver located at the PennState New Kensington called the Digital Foundry. The program's mission aims to exchange ideas, explore technologies, and create opportunities to prepare students for the current and future workforce development. The focus is on education and training, hosting events and industry projects to provide students with access and exposure to possibilities with partners in local manufacturing. Established in 2022, this new regional PA focused facility illustrates an investment in the latest digital manufacturing technologies for teaching and learning. The new facility presented a unique set of regional CI requirements that are being addressed with innovative approaches today and more are planned for the future of the operation. This program is part of a larger initiative at PennState called the Regional Digital Innovation program.

The PennState campus EMET research curriculum and Digital Foundry Workforce Development Levels 1-3 curriculum require several key functions and digital automation components. These include Sensing and Data Generation, PLC Development, Production Process Monitoring, Data Visualization and Dashboarding, Production Process Monitoring, SMART Manufacturing Concepts, Data Integration and Storage, Production Data Preparation, Production Data Statistical Analysis, Production Data Contextualization, Production Data Collection and Analytics, Supervisory Control and Data Acquisition. As well as Data Visualization, Machine Sequencing, Unified Name Space.

In developing the workflows with the components with the PSU network staff, the team identified that network performance as well as network security needed to be both addressed in ways to provide secure access to the manufacturing floor IoT equipment without compromising the PSU network itself. It is understood that modern day manufacturing floor equipment requires networking for the operation of sometimes hundreds of sensors. Placing these devices on the PennState Administrative Network was not an option, thus creating a need for a DMZ approach. The staff has investigated Private and Public 5G options as well as creating isolated networks to solve the needs. Providing access to these networks can be challenging without a properly scaled Identity Management approach for the student and educator accounts. The need for high-speed connectivity to the network was improved with a

recent upgrade to the WAN connection to 10Gbit. It has been identified that regional computing resources may be required for the curriculum soon as the program is being scaled out to additional regional PA partners. This unique driver example can be seen as a possible cookbook for similar regional facilities that may be similar in nature with heavy remote IoT requirements.

Digital Foundry is looking to open opportunities for remote collaboration for students, our technology partners and small to medium sized manufacturers. These partners are leading and developing what is known as the Fourth Industrial Revolution AKA “Industry 4.0” or “i4.0”. The ability to access the target manufacturing hardware in the Digital Learning and Demonstration Lab (DLDL) from these audiences enables research and education possibilities for accelerated development of the solutions that are being provided to the next generation of Students and Researchers. The systems in the DLDL directly support the curriculum for all levels of Workforce Training. These systems are designed to supplement and enhance the learning experience for our students; therefore, it was identified that a friction free DMZ remote access model directly supports and is seen as critical for future remote education and training. Digital Foundry project builds and envisions systems for manufacturers that are intended to span locations in different parts of Pennsylvania, the US, and the world. By providing a modern CI infrastructure that demonstrates cybersecurity concepts on this scale would lead in supporting how systems would function and can provide a de-risking opportunity for the Digital Foundry for systems of this type.

Some of the Identified overlapping interest areas amongst the institutions included: Access to High Performance Computing Resources, Large Data Transfers of Research Data, Virtual Computer Labs, Remote access to on-campus scientific instrumentation, GenCyber camps and training programs, Federated Identity challenges, and overall IT CI resource constraints.

Goal #2 – Identification of Science and Education Drivers and bridging to the Technical Aspects

Develop mechanisms for a campus to identify cyberinfrastructure-based applications and understand the required cyberinfrastructure-based resources and appropriate campus science DMZ architectures including its relationship to the existing campus network.

While collaborating with NCShare project representatives (Duke, Davidson College, MCNC, and North Carolina Central) and the OneNet project representatives, several key planning takeaways were acknowledged in developing successful mechanisms for institutions to better understand and identify application and CI requirements. These included:

- Development of a shareable Toolkit for listening sessions. This including invitation letters, Survey examples, session slides, post meeting letter examples
 - <https://sites.duke.edu/ssdmz/researcher-use-cases/listening-session-toolkit/>
- Building Communities of Practice which involves both faculty and IT personnel. This allows individuals to learn from one another and build knowledge as a team. Communities can also help to build trust within a campus.
- Identification of Campus Champions in pursuit of research and education mission and goals.
- Conduct facilitated faculty conversations by having candid open discussions on what technical barriers they faced in pursuing their research. Conducting post conversation surveys was

important to document these conversations. Holding follow-up sessions to capture items was also a key takeaway.

- Development of Survey and Post Survey tools to better identify key topics and common CI needs
 - <https://sites.duke.edu/ssdmz/files/2021/05/ssDMZ-listening-session-survey.pdf>

By utilizing some of these various methodology techniques a campus can better develop and update their Cyberinfrastructure (CI) plans. Smaller organizations can then help to better prioritize limited resources based on outcomes of the mechanisms.

The project team identified examples of both campus and regional cyberinfrastructure (AKA “CI”) plans from facilities around the U.S. These plans were submitted as part of a proposal to the National Science Foundation’s Campus Cyberinfrastructure programs (CC-IIE, CC-NIE, CC-DNI, and CC*). The materials are examples for universities and institutions looking to develop their own campus CI plans, strategies, and architectures to support research, education, and discovery. These materials are located at this link: <https://fasterdata.es.net/nsf-docs/campusCIplanning/>

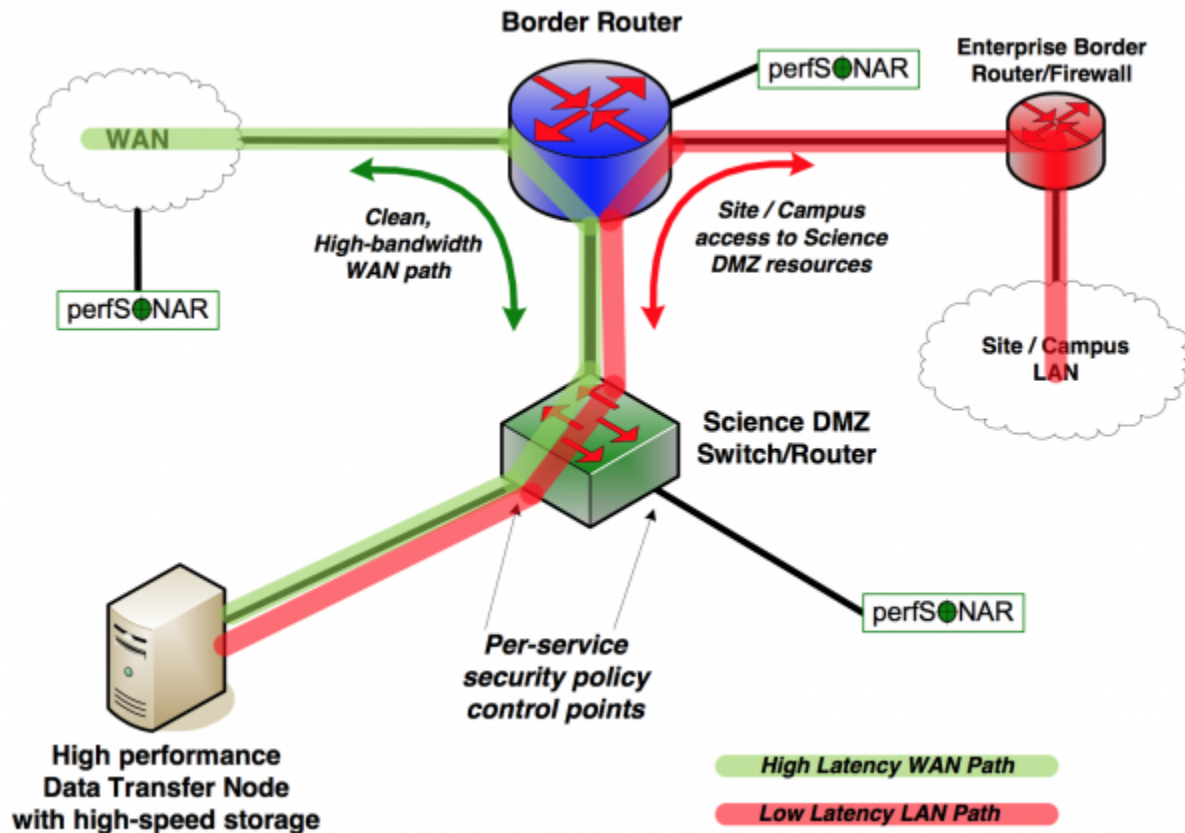
Goal #3- Technical Aspects

Investigate the feasibility of various campus and regional Science DMZ designs through outreach to existing funded projects. Utilizing the outcomes from these investigations, models for campus Science DMZs as well as a design for a statewide regional science DMZ aimed at easing access to cyberinfrastructure resources will be developed.

The project team explored several campus and regional Science DMZ designs. The four Key Components of the Science DMZ model remain constant in our exploration activity, even for the smaller under-resourced institutions. The four Key Components include:

1. A network architecture explicitly designed for high-performance applications, where the science network is distinct from the general-purpose network.
2. The use of dedicated systems for data transfer. Data Transfer Nodes (DTNs) are high-end purpose built Linux servers that facilitate high speed data transfer between remote systems.
3. Performance measurement and network testing systems that are regularly used to characterize the network and are available for troubleshooting. PerfSONAR (performance Service-Oriented Network monitoring ARchitecture) nodes are essential for the performance testing and characterization of the science DMZ network.
4. Security policies and enforcement mechanisms that are tailored for high performance science environments.

The architecture comes together as a whole in this simplified diagram See Appendix D



The project team has examined supporting materials and investigated efforts that support advancements in the four Key Components which have matured over the past few years. Since 2012, The NSF's Trusted CI Center of Excellence has provided leadership in this area. The mission of Trusted CI Center is to lead in the development of an NSF Cybersecurity Ecosystem with the workforce, knowledge, processes, and cyberinfrastructure that enables trustworthy science and NSF's vision of a nation that is a global leader in research and innovation. The updated Ecosystem includes integration of the Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21).

The project team identified that a Pennsylvania Regional Science DMZ "Interchange" model would be beneficial to a wide variety of diverse use cases including the under-resourced institutions. Collaborative partner research validates that such a regional network can serve a critical role in the Science DMZ ecosystem by connecting independent Campus networks to each other. Models examined included traditional Science DMZs, specialized (e.g. VRF) network routing infrastructure, provider offered Science DMZ services (e.g. managed Switches, DTNs, security infrastructure, or different classes of service). Regional interchanges help to coordinate access to national and international destinations through limited announcements and routing.

Goal #4 - Sustainability

Critical to the long-term success of both campus and regional Science DMZ infrastructure is identifying viable sustainability models for long term support. Identify the various models.

The project team examined and collaborated with others on various models of various CI sustainability approaches. Often, campus network hardware, circuit upgrades, computing and storage projects are the stimulus activities required to advance sustainable hardware and associated service CI plans. Upgraded equipment often offers improvements in energy efficient operations. The newer equipment can also reduce operating costs due to less expensive maintenance contract costs. Efforts in regional collaboration pooling of hardware contracts for equipment maintenance and data circuits are components of sustainable cost saving approaches. Critical takeaways in this team's discovery are that Campus IT strategy must be aligned with Science and Education drivers which inherently rely on understanding the needs of the institutional scientific and educational community.

Sustainability also includes staffing to properly support various campus CI plans. The in-person workshop held at Lafayette College educated the project team on a number of novel approaches happening in the region to help address staffing. Under the CAREERS Cyberteam Program, a regional pool of Research Computing Facilitators to support researchers at small and mid-sized institutions in Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island, leveraging the work of the [Northeast Cyberteam](#) and national programs including Extreme Science and Engineering Discovery Environment (XSEDE), Campus Champions, CaRCC and others are made available to the R&E community. The project team uncovered over 100 individuals from the PA region alone who are associated with the NSF funded program. The introduction of a campus or regional "Research Computing Facilitator" (RCF) is a concept that helps to combine technical knowledge, strong interpersonal skills, and a service mindset to support Research Computing CI. RCF focused individuals advise and assist researchers at the crossroads of transitioning work beyond their laptop, as well as enable computation-experienced researchers to maximize the limited on or off campus HPC. By building a RFP pipeline, a Distributed Experts Network of resources can be realized by the larger campus as well as smaller under-resourced institutions. Any student, undergraduate or graduate, can apply to be a Student RCF to feed the pipeline of support assets.

The project team discovered that Franklin and Marshall's CI strategy attempts to address sustainability with a two-part model that leverages federal research funding opportunities to enhance infrastructure and services available to their community as well as implementing key institutional policies. Researchers who receive grants or startup funds that require computing resources are required to contribute resources to a centralized campus compute cluster and not attempt to fund and/or manage their own. This approach was established in 2015. However, Franklin and Marshall leadership recognizes that external funding opportunities can be highly competitive programs, especially for non R1 institutions, and the institution itself has a responsibility to maintain these assets and use institutional resources to do so as necessary, particularly as they are often also utilized in teaching students. Franklin and Marshall consistently allocate \$700,000 annually as capital for cyberinfrastructure renewals. Research computing-related infrastructure is accounted for in this amount in addition to the College's network infrastructure, servers, etc. By allocating to capital a regularized amount each year, this provides flexibility for years when the expenditures may be less (extra funds carried forward) or more than that annual allocation.

The IUP approaches to sustainability are outlined in their Presidential Goals. CI projects fall under the key areas including the reduction of the use of one-time funds for budget balancing. A key goal is to develop and apply shared procedures for investing in academic, research, and support programs for ROI. IUP utilizes a multi-faceted approach to ensuring cyberinfrastructure (CI) sustainability. First, it leverages dedicated funds and funding sources to continuously invest in state-of-the-art servers, storage (1.1PB of raw storage), disaster recovery, business continuity and networking gear (including 15,400 active network jacks and 2,400 wireless access points) all backed by high quality maintenance contracts. This special Central Computing Reserve funding has been in place for more than 30 years to address both capital and operational CI needs over both the short and long term. These systems and hardware are each protected by two data centers that received more than \$1 million in renovations alone since the mid-2010s in areas like new redundant power sources, new enterprise-grade HVAC and new UPSs to go along with existing independent generators as yet another power source. Added capital budget is made available from the university, as needed, to ensure these components are replaced or upgraded in alignment with industry standards. The data centers and systems are governed by highly trained and experienced IT staff with dedicated responsibility for administration in networking, systems, and databases. The staff are supported by dedicated cybersecurity staff and numerous major investments in cybersecurity-related tools - such as an enterprise-class border firewall with sustainable, dedicated funding established in 2016. Finally, IUP became a 'cloud first, but not cloud only' institution in 2015, providing flexibility to house systems and data in the best manner to meet specific needs.

The project team heard from several institutional leaders at the NSF PI workshop in Minneapolis, MN surrounding CI sustainability. Jorge Crichigno from University of South Carolina contributed to some key takeaways surrounding sustainability including: Strengthen the relationships among faculty, Research Computing (RC), and IT leadership and Research Computing. Communicate continuously with faculty and researchers. Attend webinars, trainings, implement work study and undergraduate research positions, promote positions and recruit students early—freshman and sophomores. Share ideas with the community, receive feedback, learn best practices as proactively seek funding opportunities, donations, common projects with industry and agencies.

Tracy Futhey also provided some lessons learned from her experiences at Duke University. She advised that pre-award, be strategic and choose projects wisely. Select key projects that accelerate what your campus needs to do to help to justify future institutional dollars spent to sustain. Treat CI projects as building blocks and leverage one project's outcomes to the next and add in any operating expenses. Establish faculty relationships, consider funds for graduate students on projects. Gain the support of your leadership. Post awards are strategic and nurture the faculty relationships. Consult with them often and sincerely as they benefit from the scale of production CI environments, and benefit from their scientific domain expertise. Build your team, aim for any senior personnel from one grant as they can become co-PIs on the next and eventually PIs. Update leadership often and forecast any future costs. Tactically produce annual reports, get them in, and make them good. Participate in and learn from the PI community. Volunteer for panel reviews as you and your team will learn a lot about the review process.

The Project team identified a common sustainability theme among collaborating participants. Both fiscal and staffing support for CI projects was at times difficult to secure, especially at under-resourced institutions. Sustaining knowledge and expertise was identified as important for long term success in the science and educational driven CI supported initiatives. The concepts of shared

resources amongst Minority Serving Historically Black College and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), Tribally Controlled Colleges and Universities (TCCUs), Native American-Serving Nontribal Institutions (NASNTIs) and Minority serving institutions (MSIs) is popular and gaining community support. The team learned about the efforts being made by the Minority Serving-Cyberinfrastructure Consortium (MS-CC), and the efforts in the Community and Capacity Building, Workforce Development and Research Support areas. Specifically, the goals of creating a single unified DMZ for Collaborative Research for MS-CC Membership were of interest to the project team as well as the developmental evaluation, feedback surveys, and building internal facilitation capability energies.

KINBER maintains relationships with other not for profit RENS, ESNNet, EPOC as well as with for-profit entities. The organization is attentive to identifying negotiated services and pricing consortia to bring to KINBER members for cost relief and sustainability. The willingness to make capital investments as required in key areas to benefit statewide CI projects is in line with the board of directors vision. For example, KINBER is currently in the process of installing new next generation routers in the research and education metropolitan anchor points of presence in Pittsburgh and Philadelphia.

Goal #5 – Regional Workshops

Convene a regional workshop that codifies and disseminates the information collected during the planning process and identifies next steps, including submission of Regional Connectivity for Small Institutions of Higher Education.

A regional in-person and virtual workshop was hosted by Lafayette College in Easton, PA on February 22, 2023. Twenty-eight participants attended either in-person or virtually from twelve separate collaborating institutions or organizations: KINBER, Lafayette College, Swarthmore College, Indiana University at Pennsylvania, University of Texas / EPOC, Duke, Davidson College, Penn State University, Villanova, University of Massachusetts, and the Massachusetts Green High Performance Computing Center.

Six relevant subject matter presentations were presented to the group over the course of the day by nine speakers. Each presentation contained subject area knowledge and learned experiences focused on the planning process that institutions must engage in when developing research and educational cyber infrastructure projects. Best practice overviews for small campuses drawing from past experiences was a common presentation theme. Improvement of cyber infrastructure (CI) for science and education was a common theme.

The full meeting agenda for the event can be found <https://www.kinber.org/nsf-grant/>

The presentations and session video recordings are hyperlinked inside the agenda document.

The attendee roster is linked here:

<https://www.kinber.org/wp-content/uploads/2023/06/NSF-Grant-In-Person-Event-Agenda.docx.pdf>.

As a direct result of the workshop, several follow-up discussions and collaborative calls have continued. Collaboration video calls with staff from Penn State University, Digital Foundry at New Kensington and KINBER have been held to explore the possibility of better connecting the Digital Foundry with other institutions across the commonwealth of Pennsylvania. Identifying the mission and goals of the Digital foundry alongside the infrastructure challenges has provided valuable insight on what is needed for a successful IT based workforce development program. The Digital Foundry is an excellent example of an innovative program that is trying to bridge the divide of IT skills and workforce development with the community college system in PA. As a team we are exploring and examining the possibilities of a novel collaborative NSF CC* area two grant amongst several regional partners because as a result of the planning workshop.

The workshop has resulted in continued discussions with The Pennsylvania State University, Lafayette College, Swarthmore College, Indiana University of Pennsylvania and KINBER. Our planning grant activities have highlighted and reinforced the need for regional collaborations. Some institutions have resources and expertise in areas that others do not.

These regular virtual interactions with this project team as well as in-person meetings at Easton, PA and KINBERCON 2023 have led into deeper discussions surrounding a future NSF 23-526 CC* Area 2 grant application. The goal of such an activity would be the introduction of a Pennsylvania based regional science DMZ design building upon the findings of this planning grant. The next generation PA-DMZ would leverage 100G and 10G connection speeds over leased line circuits from various service providers, and would employ next generation servers for Data Transfer Nodes and PerfSonar Nodes.

What was Accomplished under these goals? *You must provide from at least one of the four categories below:*

Major Activities:

- Established Bi-monthly project team meetings to inform science driver activity, research and education cyber planning process, information exchange:
 - KINBER
 - Indiana University at Pennsylvania
 - Lafayette College
 - Lehigh Carbon Community College
 - Swarthmore College
- Travel to Annual NSF PI / Quilt.Net workshop, Minneapolis, MN 9/20–22/23
 - <https://www.thequilt.net/public-event/2022-nsf-campus-cyberinfrastructure-pi-workshop/>
- Developed a NSF Project Quad Chart
 - See Appendix C - Appendix-C-NSF-Planning-Grant-QUAD_Chart.pdf
- Organized and held a regional in-person/virtual workshop:

- <https://www.kinber.org/wp-content/uploads/2023/06/NSF-Grant-In-Person-Event-Agenda.docx.pdf>
 - Workshop Attendees are embedded in the link above
- Identification of updated Science and Education Drivers @ Partner Institutions
 - Attached as Appendix A
- Held several External Partner and Collaborator virtual meetings
 - Villanova
 - FirstLight
 - NC Share (Davidson College, Duke, MCNC, NC State Central)
 - MGHPCC (Massachusetts Green High Performance Computing Center)
 - Pennsylvania State University
 - SOX / SLR
 - TheQuilt.Net
 - ESNet
 - OneNet
 - Front Range GigaPoP/UCR/NCAR
 - Utah Education Network
 - Sun Corridor Network
 - Franklin and Marshall
- Developed a Key Resource CI Planning Web Resources Document
 - Attached as Appendix B
 - Also linked here - <https://www.kinber.org/nsf-grant/>
- Organized attended KINBERCON 2023
 - A Pennsylvania based IT conference for the research and education advanced networking community.
 - <https://kinbercon.org/>
- Developed project and team inertia towards a CC* Area 2 Regional Grant

Specific Objectives:

- This project worked with the initial set of pilot schools, Indiana University of Pennsylvania, Lafayette College and Lehigh Carbon Community College to develop mechanisms for a campus to identify cyberinfrastructure-based applications, understand the required cyberinfrastructure-based resources and identify appropriate campus science DMZ architectures. Through further engagement with Penn State University, the project team had an opportunity to learn more about an innovative science and education driver located at Penn State New Kensington called the Digital Foundry and included those findings as part of the overall outcomes. The project investigated the feasibility of various campus and regional Science DMZ designs through outreach to existing funded projects and developed a design for a statewide regional science DMZ

aimed at easing access to cyberinfrastructure resources in a cost-effective manner for small and mid-sized campuses in the region.

Significant Results:

- Increased collaboration amongst project team members as well as outreach organization staff. Improved relations amongst individuals from within Pennsylvania as well as regional and national levels which paved the way for future collaborative CI project initiatives and potential endeavors. The collaboration further advanced a methodology for identifying science drivers and requirements for small college campuses. It was through regular active engagement with campus researchers and IT staff, that the project team was able to derive the information found in [Appendix-A-NSF-Planning-Grant-Science-Education-Drivers.pdf](#).
- Through investigations, collection of materials and sharing of knowledge surrounding the architecture and CI requirements for improved capabilities at smaller under-resourced institutions, the project team identified that a Pennsylvania Regional Science DMZ "Interchange" model would be beneficial to a wide variety of diverse use cases including the under-resourced institutions. Collaborative partner research validates that such a regional network can serve a critical role in the Science DMZ ecosystem by connecting independent campus networks to each other. Regional interchanges help to coordinate access to national and international destinations through limited announcements and routing. The design model can be found in [Appendix-D-NSF-Planning-Grant-Science-DMX-.pdf](#)
- The Project team identified a common sustainability theme among collaborating participants. Both fiscal and staffing support for CI projects was at times difficult to secure, especially at under-resourced institutions. Sustaining knowledge and expertise was identified as important for long term success in the science and educational driven CI supported initiatives. The concepts of shared resources amongst Minority Server Historically Black College and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), Tribally Controlled Colleges and Universities (TCCUs), Native American-Serving Nontribal Institutions (NASNTIs) and Minority serving institutions (MSIs) is popular and gaining community support. The team learned about the efforts being made by the Minority Serving-Cyberinfrastructure Consortium (MS-CC), and the efforts in the Community and Capacity Building, Workforce Development and Research Support areas. Specifically, the goals of creating a single unified DMZ for Collaborative Research for MS-CC Membership were of interest to the project team as well as the developmental evaluation, feedback surveys, and building internal facilitation capability energies.

KINBER maintains relationships with other not for profit RENs, ESNet, EPOC as well as with for-profit entities. The organization is attentive to identifying negotiated services and pricing consortia to bring to KINBER members for cost relief and sustainability. The willingness to make capital investments as required in key areas to benefit statewide CI projects is in line with the board of directors vision. For

example, KINBER is currently in the process of installing new next generation routers in the research and education metropolitan anchor points of presence in Pittsburgh and Philadelphia

Key Outcomes or Other achievements:

- Identification of resources for cyber professionals in the research and education communities of interest and communities.
- In person and virtual participants are better equipped to identify Science and Educational drivers and tie to Cyber Infrastructure architectures, operational norms as well as sustainability approaches.
- Participant exposure to NSF sponsored trainings, knowledge transfer opportunities and cyber infrastructure plan development fundamentals.
- Better understanding of a number of novel approaches happening in the region to help address staffing.
- Identification of common challenges facing under resources institutions: Access to High Performance Computing Resources, Large Data Transfers of Research Data, Virtual Computer Labs, Remote access to on-campus scientific instrumentation, GenCyber camps and training programs, Federated Identity challenges, and overall IT Cyber Infrastructure resource constraints.
- Example CI Plans were identified and shared.

What opportunities for training and professional development has the project provided

- In-Person & Virtual Regional Workshop – Lafayette College, Easton, PA 2/22/23
- In-Person collaboration event: KINBERCON2023, held in Pittsburgh, PA, 4/25/23 & 4/26/23
- Cyberinfrastructure for Research Data Management Workshop held Princeton NJ 5/23 & 5/24
- Virtual programs and Presentations by Engagement and Performance Operations Center (EPOC), University of Texas
- Multiple Virtual NSF Trainings announcements
- NSF Spring 2023 NSF Virtual Grants Conference
- NSF Research Infrastructure Outreach Workshop announcements, Washington, DC, June 27-30 2023
- NSF Policy Outreach Center Videos: <https://nspolicyoutreach.com/resource-center/>

How have the results been disseminated to communities of interest?

- E-mailed distributions
- KINBER Website: <https://www.kinber.org/nsf-grant/>

Products

- Books
 - None

- Book Chapters
 - None
- Inventions
 - None
- Journals or Juried Conference Papers
 - None
- Licenses
 - None
- Other Conference Presentations / Papers
 - None
- Other Products
 - None
- Other Publications
 - NSF-Planning-Grant-Final-Report.pdf
- Patents
 - None
- Technologies or Techniques
 - None
- Websites
 - <https://www.kinber.org/nsf-grant/>

Participants / Organizations

- What individuals have worked on the project?
 - Nathan Flood
 - Most Senior Project Role: PD/PI
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Manages the Project with staff from KINBER and external outreach/partners
 - Funding Support: NSF
 - International Collaboration: No
 - International Travel: No
 - Susan Miner
 - Email: sminer@lccc.edu
 - Most Senior Project Role: co-PD/PI
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Assists PI with staff from LCCC

- Funding Support: Lehigh Carbon Community College
- International Collaboration: No
- International Travel: No
- John O'Keefe
 - Email: okeefej@lafayette.edu
 - Most Senior Project Role: co-PD/PI
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Assists PI with staff from Lafayette College
 - Funding Support: Lafayette College
 - International Collaboration: No
 - International Travel: No
- Chad Burnham
 - Email: cburnham@kinber.org
 - Most Senior Project Role: PM
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Manages the Project with staff from KINBER and external outreach/partners
 - Funding Support: KINBER Budget
 - International Collaboration: No
 - International Travel: No
- Ben Miller
 - Email: bmiller@kinber.org
 - Most Senior Project Role:
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Technical Resource
 - Funding Support: KINBER Budget
 - International Collaboration: No
 - International Travel: No

- Alexis LaPointe
 - Email: alapointe@kinber.org
 - Most Senior Project Role: Other Professional
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Technical resource and administrative support
 - Funding Support: KINBER Budget
 - International Collaboration: No
 - International Travel: No
- Deborah Bonawitz
 - Email: dbonawitz@kinber.org
 - Most Senior Project Role: Other Professional
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Technical resource and administrative support Funding Support: KINBER Budget
 - International Collaboration: No
 - International Travel: No
- Jason Simms
 - Email: simmsj@lafayette.edu
 - Most Senior Project Role: Other Professional
 - Nearest Person Month Worked: 1
 - Contribution to the Project: Technical Resource
 - Funding Support: Lafayette College
 - International Collaboration: No
 - International Travel: No

Has there been a change in the active other support of the PI/PD(s) since the last reporting?

- No

What other organizations have been involved as partners?

- Lehigh Carbon Community College – Susan Miner, Carly Klimash, Dr. Kelly Trahan

- Indiana University Pennsylvania - Bill Balint, Dr. Rick Adkins
- Lafayette College - John O'Keefe, Jason Simms, Jason Ally, Peter Goode
- Penn State University - Wayne Figurelle, Todd Allen Price, Gretta Kellogg, Kathy Hill, Wolf Hey, Sherri McCleary, Vincent Petrelli, Stephen B. Leonard, Dr Joe Chuffi

What other collaborations or contacts have been involved?

- SOX / SLR - Samuel (Cas) A'Angelo,
- TheQuilt.Net - Jennifer Leasure, Jennifer Griffin
- Duke - Tracy Futhey, Charley Kneifel, Will Brockelsby, Katie Kilroy, Laura Webb
- ESNNet - Jennifer Schopf, Jason Zurawski, Kenneth Miller
- OneNet - April Good, Brian Burkhardt, John Hennessey, Sky Pettett
- Front Range GigaPoP/UCR/NCAR – Marla Meehl, John Hernandez, Fabian Guerrero
- Utah Education Network - Jim Stewart
- Sun Corridor Network - Derek Masseth
- UMass - Michael Zink
- Davidson College – Kevin Davis
- MGHPCC - John GoodhueFranklin and Marshall - Carrie Rampp, Jason Brooks
- Villanova – Dr. Aaron P. Wemhoff, Jonathan Hardy, Leo Nelson
- Swarthmore College - Jason Simms, Andrew Ruether
- FirstLight – Grant Dull, Patrick Coughlin
- Franklin and Marshall College - Carrie Rampp, Jason Brooks

Impacts

- What is the impact on the development of the principal disciplines(s) of the project?
 - The grant process facilitated various collaborations allowing individual institutional IT practitioners and researchers to examine sets of science and education drivers along with corresponding CI requirements. Grant participants recognized constraints beyond campus bandwidth levels to include compute and storage capacity cyberinfrastructure elements. In addition these under-resourced institutions identified IT staffing level shortcomings to support campus infrastructure initiatives to further research and education drivers.
- What is the impact on other disciplines?
 - The discipline of CI systems planning can be seen by some as part business, part art and part craft. Aligning CI planning with the wide breadth of the research and education community highlights a broader impact on each institution's strategic plan. The two-way conversations that must occur between researchers and CI practitioners can be hard work yet must occur for successful and meaningful broader research results. The various faculty engagement approaches as well as sustainability approaches are sometimes novel yet deliver similar effective results in CI planning. By driving the eternal engagement iterative process, campuses can closely examine beyond their current and into their future CI needs. This activity of shining a light on impactful research project areas is critical for the successful mission and goals statements of institutions of learning into the future.

- What is the impact on the development of human resources?
 - The outputs of the planning grant have exposed a few approaches to the challenges of staffing levels and staff support models that keep research and education moving ahead. By pooling staff resources, CI projects can further have a significant impact on the planning, completion and performance improvement contained within campus and regional CI projects. The planning grant does continue to highlight the need for skilled professionals within the under-resourced campuses and the regional network environment. It also identified the continued need for professional development with the existing workforce to retain the professional staff and to expose them to best practices and new solutions to improve their organizations.

- What is the impact on physical resources that form infrastructure?
 - The planning grant strengthened the idea that a shared regional CI infrastructure can and does improve the workflows of larger research communities. Allowing for faster network speeds to move data greatly reduces dwell time with various research data activities. By enabling and implementing the friction free Science DMZ fundamentals, research data sets can now move quicker for necessary processing and collaboration work. In planning for newer and faster routers, switches and larger data communications pathways, the research can move forward in consequential ways. By promoting and sustaining CI enhancements, the information resources can potentially be opened to an expanded set of researchers. This activity in turn and by nature advances science and education to all.

- What is the impact on institutional resources that form infrastructure?
 - Nothing to report
- What is the impact on information resources that form infrastructure?
 - Nothing to report
- What is the impact on technology transfer?
 - Nothing to report
- What is the impact on society beyond science and technology?
 - The planning grant strengthened and improved the collaborative relationships between various campuses, including improved collaborations between under-resourced universities and those with better resources. It is expected that the constant exchange of information, best practices and knowledge will improve research and education collaboration in the commonwealth moving forward, improving cyberinfrastructure and identifying further areas of need and opportunities to collaborate.

Changes / Problems

- 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 case 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.