Engagement and Performance Operations Center (EPOC)

Summary

The goal of the EPOC project is to provide researchers and network engineers with a holistic set of tools and services needed to debug performance issues and enable reliable and robust data transfers. It supports six main activities: Roadside Assistance and Consulting, Application Deep Dives, Network Analysis using NetSage, Data Mobility Exhibition, the provision of Managed Services, and Training. Year 4 Quarter 1 highlights include starting several virtual Deep Dives, an extensive training workshop with University of South Carolina, we worked with NSF large scale facilities, including the Event Horizon Telescope (EHT), the Vera Ruben Observatory (VRO), the Arecibo observatory, and the Large Hadron Collider (LHC), and also completed four Roadside Assistance and seventeen Consultation cases.

1. EPOC Overview

The Engagement and Performance Operations Center (EPOC) is a production platform for operations, applied training, monitoring, and research and education support. EPOC is a collaborative focal point for operational expertise and analysis and is jointly led by Indiana University (IU) and the Energy Sciences Network (ESnet). EPOC provides researchers and network engineers with a holistic set of tools and services needed to debug performance issues and enable reliable and robust data transfers. By considering the full end-to-end data movement pipeline, EPOC is uniquely able to support collaborative science, allowing researchers to make the most effective use of shared data, computing, and storage resources to accelerate the discovery process.

EPOC supports six main activities:
- Roadside Assistance and Consulting via a coordinated Operations Center to resolve network performance problems with end-to-end data transfers reactively;
- Application Deep Dives to work more closely with application communities to proactively understand full workflows for diverse research teams in order to evaluate bottlenecks and potential capacity issues;
- Network Analysis enabled by the NetSage monitoring suite to proactively discover and resolve performance issues;

- The Data Mobility Exhibition/Baseline Performance Testing to test transfer times against known "good" end points, with the goal of transferring a TeraByte in an Hour;
- Provision of Managed Services via support through the IU GlobalNOC and our Regional Network Partners;
- Training to ensure effective use of network tools and science support.

This report details the staffing, collaboration, and focused work in each of the six activities during Year 4 Quarter 1. Note that at the time of this report, COVID-19 and its associated travel restrictions were in a state of high fluctuation. This report has been restructured based on suggestions from our External Advisory Committee, including putting the lists of meetings and talks at the end of the report.

2. Staffing and Internal Coordination

At the beginning of Year 4, funded project staff included:
- Jennifer Schopf, IU, PI - overall project director
- Jason Zurawski, LBNL, co-PI, Deep Dives and Managed Services Lead
- Hans Addleman, IU, Roadside Assistance and Consulting Lead
- Dan Doyle, IU, system architect - Measurement and Monitoring co-Lead
- Heather Hubbard, IU, Project coordination
- Ken Miller, LBNL, Science Engagement and DME support
- Ed Moynihan, IU, Science Engagement
- George Robb, LBNL, Managed Services support
- Doug Southworth, IU, Partner coordination and Deep Dive support

Dave Jent is a co-PI, but due to his position at IU is unable to formally charge the project. The IU Global NOC Software team provides 0.5 FTE of developer support for the NetSage deployments.

IU hired Brenna Meade as a network engineer and she started in June, 2021. She will be focusing on Roadside Assistance and some of the broader outcomes for that activity.

3. Project Partners

EPOC has three types of partners: *Networking Partners*, who are deploying the infrastructure EPOC supports and use their members for outreach for EPOC, *Infrastructure Partners*, who are themselves collaborations that support a variety of cyberinfrastructure (CI) services, and *Science Community Partners*.

3.A Networking Partners

The current Networking Partners include:
- **Front Range GigaPop (FRGP),** the regional collaboration of networks that cover the western states, including Colorado, Wyoming, Arizona, Idaho, Utah, and New Mexico.
- **iLight,** the regional network for Indiana.
- **The Great Plains Network (GPN)**, the regional network that serves North Dakota, South Dakota, Nebraska, Iowa, Minnesota, Kansas, Missouri, Oklahoma, and Arkansas.
- **The Keystone Initiative for Network Based Education and Research (KINBER),** the regional network for Pennsylvania.
- **The Lonestar Education and Research Network (LEARN),** the regional network for Texas.
- **National Oceanic and Atmospheric Administration (NOAA) N-wave,** the R&E network for NOAA.
- **The Ohio Academic Resources Network (OARnet)**, the regional network for Ohio.
- **Pacific Northwest GigaPop (PNWGP)**, which provides access to next generation internet services and technologies throughout the Pacific Rim, but in the US primarily in California, Oregon, and Washington State.
- **Southern Crossroads (SoX),** the regional network for much of the southeastern part of the US, including parts of Alabama, Georgia, South Carolina, and Tennessee.
- **Sun Corridor Network (SCN),** the regional network for the state of Arizona.
- **Texas Advanced Computing Center (TACC)** at the University of Texas at Austin, United States, an advanced computing research center

A complete listing of our activities with these partners is given in Section 12.

As we are formalizing our Network Partners program, discussions with several groups continued during Quarter 1. These include both NYSERNet, the R&E network for the state of New York, and the University of Hawaii's Pacific Islands Research and Education Network (PIREN). In addition, NOAA's N-Wave network agreed to become a formal partner in June, highlighting the increasing level of collaboration between the teams.

3.B Infrastructure Partners

EPOC's Infrastructure Partners are used to leverage the different kinds of support offered by each group to expand the set of services available to the broader community. The current set of Infrastructure Partner organizations includes:
- **The Campus Research Computing Consortium (CaRCC)** is a consortium of over 30 campuses that facilitates access to cyberinfrastructure. Schopf is the main contact for this group. She is currently following many of their mailing lists and regularly attends several of the Track meetings, including the Emerging Centers Track.

- **Trusted CI: The NSF Cybersecurity Center of Excellence** supports cybersecurity for NSF funded projects. Addleman is the main contact for Trusted CI. EPOC and Trusted CI staff are discussing the creation of documents that give best security practices and recommendations for Science DMZ architectures. EPOC staff will also be joining the upcoming Trusted CI engagement with the University of Arkansas in Quarter 2 to share Science DMZ architecture expertise.
- **Internet2** supports solving common technology challenges for their over 200 educational, research, and community members. Schopf is the main contact for this organization. We are still working with Internet2 to understand interactions in lieu of the regular in person meetings.
- **The Quilt** provides a central organization for networks to share the best practices to support end user science. Zurawski is the primary contact for the Quilt and has regular meetings with their organization. EPOC participates with the Quilt in a number of ways, and has continued to do so virtually during the pandemic:
  - Publication of EPOC materials for the Quilt Circle Magazine in 2021 [Publication #28]
  - Zurawski is serving on the advisor committee for the Quilt-sponsored virtual 2021 CC* PIs meeting.
- **The Science Gateway Community Institute (SGCI)** provides best practice recommendations and support for scientists building and using data portals. EPOC is a formal partner of SGCI and recommends SGCI services when appropriate. There were no formal meetings or interactions with SGCI during Quarter 1.
- **The Extreme Science and Engineering Discovery Environment (XSEDE)** supports a single virtual system and CI expertise through the Campus Champions. Schopf is the primary contact for this group and is updating XSEDE liaisons during the quarter.

We are working closely with the Globus team on the test sites for the DME (Section 7) and participated in Globus World 2021 [Meeting #12, Presentation #27]. We also collaborated with them on several Roadside Assistance and Consultation Cases (107, 147, 159).

Another project we are in discussions with to see if they would like to formally become an Infrastructure Partner is with the FABRIC testbed, and its international component, FAB. We will be supporting several of the experiments and making sure the end-to-end paths for the testbed are running smoothly. FABRIC plans to start bringing experiments between institutions online later this calendar year, and EPOC engineers will work to make sure performance is as expected. EPOC staff attended the FABRIC experimenter workshop in April [Meeting #3]. FABRIC staff demonstrated how experimenters can set up on the FABRIC infrastructure and a number of experimenters gave presentations showing their planned work. In June, EPOC engineers began working with FAB and University of Bristol engineers to prepare for installation of a FABRIC rack on their campus. This work includes defining, configuring, and working with our international networking partners to connect the FABRIC equipment back to the main FABRIC network in the US.

3.C Science Community Partners

EPOC Science Community Partners each consist of a collaboration of scientists which we envisioned would enable us to scale our reach to larger community groups. The current Science Community Partners include:

- **The Earth Science Information Partners (ESIP)** is a consortium of over 180 members that provides a forum for the Earth science data and technology community. We monitored several mailing lists and are looking for collaboration opportunities.
- **The University of Hawai'i System Astronomy Community** supports 15 facilities with hundreds of researchers and experiments every year. We are also coordinating on Consultation #121.
- **The Midwest Big Data Hub (MBDH)** supports the use of data for a variety of applications and end users across twelve states. Southworth was planning to attend the All Hubs Meeting, a conference which includes all of the regional hubs, in June 2020, but this meeting was cancelled due to COVID related travel restrictions and no updated meeting date has been set at this time.

3.D Large Scale Facility Work

While EPOC focuses primarily on work with small and medium sized institutions, we also work with several of the NSF Large Scale Facilities. In this quarter, that work included:

- **Arecibo Observatory:** We continued our work with staff at the Arecibo Observatory, University of Central Florida (UCF), the Texas Advanced Computing Center (TACC), the University of Puerto Rico, Globus, and the CICoE Pilot to transfer data from the Arecibo data store to TACC. The team expects the bulk of the data transfers to be complete by Quarter 2. This is being tracked as Roadside Assistance Case #107. In addition, Robb gave an invited keynote presentation on our work with Arecibo [Presentation #27], and there were several press releases on the topic as well [#23, 24, 25]
- **Event Horizon Telescope (EHT):** In October, 2020, a conversation started between various NSF IRNC network operators and the researchers who are part of the international Event Horizon Telescope (EHT) project. In Quarter 1, EPOC engineers also reached out staff at the Submillimeter Array (SMA) and James Clerk Maxwell Telescope (JCMT) the two instruments in Hawaii to start work baselining their network. This is being tracked as Roadside Assistance Case #121.
- **Vera Rubin Observatory (VRO)**: Moynihan attended the VRO Networking Meeting [Meeting #7], and is tracking their needs for data movement and ways that EPOC can help them as they begin their data challenges shortly.
- **Large Hadron Collider:** Moynihan and Southworth attended the High Luminosity LHC Data Challenge meeting [Meeting #11], where Southworth presented NetSage as a possible solution to their cross-site monitoring needs going forward [Presentation #26] .

3.E External Partners

In addition to the previously mentioned partners, the EPOC team is coordinating with a number of additional groups.

The "Toward the National Research Platform" (TNRP) project (NSF #1826967), led by Larry Smarr and Tom Defanti, is tasked by NSF to stay in coordination with EPOC as both teams support the other CC* awardees. Current coordination is primarily taking place during the bi-weekly PRP/I2 Engagement calls, or when we jointly attend meetings. Moynihan attended the PRP Capstone Event [Meeting #17].

We are working closely with members of the University of South Carolina Cyber Training team (MNSF#1829698), as detailed in Section 9.

EPOC is working with the CI Engineering Community (https://www.es.net/science-engagement/ci-engineering-brownbag-series/) to catalog the presented webinars from the Lunch and Learn series held from 2017 to present. To date, 109 webinars have been held, and are available on the EPOC YouTube channel as of June 31, 2021: https://www.youtube.com/channel/UChIaulc1bccif1Dz4cfZl0w.

Our work with BGP is complimented by the newly formed GNA-G / APAN Routing Working Group (RWG) (https://www.gna-g.net/join-working-group/gna-g-routing-wg/), which Schopf and Addleman co-lead, along with Warrick Mitchell, AARNet. We envision using that platform to increase the message of the work that EPOC is doing. The RWG was ratified by the GNA-G Leadership team in April, 2021. The first meeting of the RWG was held in June, 2021, and focused on an overview of what the group hopes to accomplish and a presentation from engineers at the University of Oregon on the Route Views project. Several presentations about the working group were also given [Presentations #32, 34]

3.F Support for Grant Submissions

A BoF was held as part of the Great Plains Network Annual Meeting [Meeting #13] describing how EPOC can support submissions to the NSF CC* Solicitation [Presentation #29]. We expect to be supporting additional work for the next submission deadline later in the year.

4. Roadside Assistance and Consulting

A key aspect of the EPOC project is the operations center and process pipeline for immediate help, referred to as Roadside Assistance and Consulting, which helps collaborators when data sharing failures occur. EPOC coordinates with the multiple domains and organizations involved to achieve a resolution. More information about the Roadside Assistance and Consulting process is available at: https://epoc.global/wp-content/uploads/Roadside-Assistance.pdf. Hans Addleman is the lead for this effort.

4.A Roadside Assistance Cases

In Year 4 Quarter 1, we had four completed Roadside Assistance Case:

- **76 - National Center for Atmospheric Research (NCAR):** NCAR distributes scientific weather data from instruments and simulations to 250 consortium member institutions using the Local Data Manager (LDM). LDM is testing a new version of the file transfer protocol, based on UDP multicast, on a 5-site testbed that includes NCAR, University of Virginia (UVA), University of Wisconsin Madison (UW-M), University of Washington (UW) in Seattle, and University of California San Diego (UCSD). In the test setup, UCSD and NCAR had issues with packet loss when sending and receiving from the other three sites. UW-M, UVA, and UW are able to transmit and receive data as expected from each other. EPOC staff worked with engineers for each institution as well as a suite of regional network engineers associated with the end points and narrowed the issue down to a single switch in the FRGP network in Denver, Colorado. Delays in procurement and installation pushed this installation to June, 2021, and now multicast testing is working as expected with no packet loss. The writeup for the RA case is Publication #36.

- **107 - Arecibo:** University of Central Florida (UCF) requested EPOC staff to consult with the staff at the Arecibo Observatory about moving 2 petabytes of data off site to a Microsoft Azure Cloud storage instance and a subset of that data to UCF's Advanced Research Computing Center (ARCC) cluster for data processing. It was discovered during these discussions that the data at Arecibo was the only copy of over 20 years of observations, emphasizing the need to have a backup copy. On November 6, 2020, one of the main cables supporting the radio telescope failed, causing major damage to the dish, and endangering the data center at Arecibo. This work became prioritized and it was evaluated that making a copy to Azure would take almost 3 years. In late November, the Texas Advanced Computing Center (TACC) offered to store the data indefinitely. On December 1, 2020, a second cable failed causing a collapse and destruction of the telescope. The data center was not damaged during the collapse but the data movement was seen as even more critical.

  In December, 2020, a larger plan to move the data from Arecibo to TACC was created with input from TACC, University of Puerto Rico (UPR), Arecibo, UCF, Globus, the CI CCOE Pilot at ISI, and EPOC staff. Arecibo staff purchased several portable network attached storage appliances (NAS) and began a cycle of loading them at the Arecibo data center, transporting the appliances to the UPR campus, and then transferring the data to TACC using Globus. Baseline performance testing with perfSONAR showed a clean path between the UPR campus and TACC.

  Since that time, over 1PB of data has been moved from Arecibo to TACC while a team monitored the performance via NetSage and logs provided by TACC and Arecibo. Data will continue to be moved and Arecibo staff have started moving data off of tape backup to spinning disk for transfer to TACC. TACC engineers continue to work with Arecibo staff to make the data available via a portal for access by researchers. The writeup for the RA case is Publication #37.

- **164 - Kyungpook National University (KNU):** During routine NetSage traffic analysis of the TransPAC-PacWave 100G circuit, EPOC engineers noticed a significant amount

of traffic from Kyungpook University in South Korea to CERN in Geneva, Switzerland. Data transfer performance was slow, averaging 30Mbps over the course of several weeks. EPOC engineers reached out to engineers at KOREN to inform them of their findings, as well as offer assistance with improving transfer speeds or finding a more efficient route. KOREN engineers investigated the problem, and as a result moved the traffic from KOREN to KREONET, which reduced the number of network hops and increased the transfer performance. The writeup for the RA case is Publication #38.

- **165 - National Institute of Informatics (NII):** EPOC staff, utilizing NetSage for routine traffic analysis on the TransPAC-PacWave 100G circuit, noticed the erroneous routing of traffic from the National Institute of Informatics (NII), in Japan, to Pohang University, in South Korea, which was being detected on the TransPAC NetSage Sensor in Seattle. This traffic was being routed over TransPAC to Chicago, where it then picked up Internet2's peering with KREONet and returned back across the Pacific to South Korea. Traffic going in the other direction, however, was routed correctly across available links in the region. EPOC staff worked with KOREN engineers to adjust the BGP advertisements to the APAN-JP router in Hong Kong, resulting in traffic taking a much more efficient route within Asia. The writeup for the RA case is Publication #39.

In Year 4 Quarter 1, we had one ongoing Roadside Assistance Cases:

- **121 - Event Horizon Telescope (EHT)**: EPOC staff are part of an ongoing conversation between the astronomy researchers that are part of the Event Horizon Telescope (EHT) and the researchers supporting the NSF-funded International Research Network Connections (IRNC). The EHT science use cases involve transporting terabytes of data from eleven telescopes in different locations to the MIT Haystack Observatory for consolidation and analysis. The telescopes each stream data at a rate of at a rate of 64 Gbps. The NOEMA telescope in France and the 30mm telescope in Spain were chosen as the first two facilities to work with, and we set up baseline testing to MIT Haystack from both telescopes using iPerf, scp, and the EHT data transfer tool, m5copy. EPOC staff also reached out to the staff at the two EHT telescope participants in Hawaii to start baselining their networks as well. This project has been slowed by issues with physical access to sites, disk space, and user access to the control computers. EPOC staff continue to work with the staff at Haystack and hope to complete testing in Quarter 2.

4.B Consultation Cases

In Year 4 Quarter 1, we had seventeen completed and seven ongoing Consultations. The most common Consultation topics this quarter were transfer performance issues, Science DMZ Architecture, and questions about EPOC's virtual Deep Dive process.

Completed Consultations included:

- **63 - National Oceanic and Atmospheric Administration (NOAA):** NOAA staff reached out to EPOC to request help and materials to run their own Deep Dive. EPOC staff provided materials and guidance. EPOC staff presented virtually on the process during a NOAA meeting and the ticket was closed.

- **105 - Lafayette College (LC):** The manager of research and high performance computing at Lafayette College requested information about Science DMZs, DTN design, and data architecture best practices. The discussion encompassed data transfer testing, network performance testing and Science DMZ design for a potential NSF CC* grant proposal.
- **113 - Texas A&M University (TAMU):** As part of release testing, NetSage staff found a seven-day transfer between Texas Advanced Computing Center (TACC) and TAMU that moved over 24 TB of data at a rate under 500Mbps. TAMU engineers reported that they made some software upgrades to their switches and firewalls in Quarter 3. NetSage shows that the transfer rate is variable between 500Mbps and 1.3Gbps after the changes. Early in Year 3 Quarter 4 during a routine check of NetSage, it was found that the transfer rates had again fallen under 500Mbps. EPOC and TAMU Engineers discussed the performance drop at that time and TAMU engineers found no apparent changes in the network configuration. TAMU engineers installed perfSONAR nodes to help troubleshoot the issue and then considered this issue resolved.
- **135 - Texas Advanced Computing Center (TACC):** TACC was in the process of a network refresh and the manager of Network Operations asked for EPOC assistance during the planning stage. The discussion centered around switching and firewall hardware architecture.
- **152 - Brown University:** A senior network engineer at Brown University asked questions about adding a firewall to the path of an established Science DMZ. EPOC staff answered questions and shared best security practices. The Brown engineer reported they were able to change the design of their Science DMZ based on the discussion and remove the proposed firewall from the path.
- **153 - Saint Louis University (SLU):** EPOC staff met with the Director of Network Services at SLU to describe support and services that the EPOC project could provide.
- **154 - NYSERNet:** A network engineer at NYSERNet reached out to EPOC for an overview of NetSage. EPOC and NetSage staff demonstrated NetSage for NYSERNet staff and discussed a NetSage deployment in NYSERNet and the possibility of becoming an EPOC partner.
- **155 - Texas A&M University San Antonio (TAMUSA):** A researcher at TAMUSA contacted EPOC for assistance in designing a Science DMZ network. Initial discussions indicated that the proposed network was being designed without identifying specific scientific use cases. This further revealed several questions regarding specific access policies, usage patterns, and technical requirements that could not be answered without a deeper understanding of the research landscape. EPOC, working with LEARN, encouraged TAMUSA to adopt some tactics from the Deep Dive approach to understanding research use cases, to better address the concerns regarding how to design, implement, and operate a Science DMZ for the campus. TAMUSA is currently gathering this information and will use the outcomes to develop a strategic plan for design and implementation of the infrastructure.
- **157 - Syracuse University:** Syracuse University runs a DDoS scrubbing service at the border of their campus network that requires special configurations for packet size manipulation and redirection of traffic to the scrubbing services network. The Chief

Network Architect at NYSERNet reached out to EPOC for help investigating the performance impact this has on traffic on the campus network, as many of their connector universities are also signing up for this type of scrubbing service. EPOC engineers worked with the NYSERNet staff to test the effect this service may have on data transfers using perfSONAR. The investigation found that modern DTN and perfSONAR servers could handle the packet size manipulation with little to no impact at 10Gb/s speeds.

- **158 - New York University Langone Health (NYULH):** Staff at NYULH are investigating the Science DMZ model and how it might fit their network. A meeting was held to discuss best Science DMZ architecture and security practices.
- **159 - Yale:** The program director for the next generation network project at Yale reached out to discuss some performance abnormalities they experienced with Globus file transfers. EPOC engineers discussed their network configurations and provided a number of suggestions based on security and NAT devices present in the path of the transfer.
- **161 - Rensselaer Polytechnic Institute (RPI):** The Chief Network Architect at NYSERNet contacted EPOC to discuss and investigate the performance impacts of configuring smaller than standard MTU settings on campus border routers at RPI to support the use of a commodity network protection service. The network hardware manipulates packet sizes independently of end devices to conform to a specified MTU configuration of an external service. The concern was this might impact the performance of data transfers by inducing packet fragmentation or MTU blackholes. Investigation into these concerns were not conclusive due to the lack of testing resources available on the RPI campus. Results from the prior work with NYSERNet and Syracuse University (Case #157), along with limited testing to a perfSONAR node on the RPI campus, indicated that modern network hardware and servers were able to handle the MTU changes with limited impact to overall data transfer speeds.
- **162 - LEARN:** LEARN was awarded an NSF CC* grant (https://www.tx-learn.org/Grants/CC_Grant1925553.php) to work with their membership to create a regional infrastructure to support scientific research. LEARN staff requested time from EPOC to understand how the Deep Dive process could be integrated into their initial meetings with participants in this grant. EPOC gave a briefing to LEARN staff and some of the regional members, and provided materials that could be used virtually to conduct requirements analysis.
- **163 - Yale:** EPOC and Yale staff discussed the design best practices and tuning a Data Transfer Node (DTN), including feed back on processor selection, network architecture for a multi-10G-link setup, and RAM channel optimizations based on processor selection.
- **166 - National Oceanic and Atmospheric Administration (NOAA):** NOAA and EPOC staff met early in Quarter 1 to discuss the Deep Dive process and the potential for one to be done virtually. NOAA identified a use case in acoustics as the basis for a Virtual Deep Dive and presentation with NOAA members. More information on the Virtual Deep Dives can be found in Section 5.

- **167 - LEARN:** LEARN staff procured several Ciena 3926 switches for use at various customer sites in the LEARN network. These switches are capable of running a virtualized instance of perfSONAR and engineers were using this platform to do bandwidth tests from the LEARN core to the customers border router. Engineers noticed that at MTU 9000 they could achieve ~9Gbps speeds, while at MTU 1500 only ~3Gbps speeds were achievable. After consulting with EPOC engineers, it was suggested that LEARN engineers use the Linux-based tool mpstat to understand the load on the host processor during a bandwidth test at each MTU setting. This testing revealed that the host processor was running at 100% during bandwidth tests at MTU 1500 and was unable to keep up with the number of packets generated during a 10Gbps test. When the MTU was set to 9000, fewer packets were generated which meant that the CPU could handle the load and therefore better performance. LEARN engineers, armed with a better understanding of the capabilities of the hardware, have now configured their test specifications to make the best available use of these resources.
- **168** - **Southern Crossroads (SOX):** The President of SOX reached out to EPOC engineers for help troubleshooting a newly installed DTN that was experiencing poor data transfer performance. EPOC engineers worked with him to perform perfSONAR tests to a number of remote nodes in the SOX regional network. The performance problem was isolated to the newly installed DTN. Specifically, the Packetbeat software was identified via log analysis as causing the issue. Testing with the program disabled showed that the DTN was able to perform as expected.

Ongoing consultations included:
- **117 - Allen Institute (AI):** EPOC staff are consulting with staff at the Allen Institute regarding CI resources in the community and funding opportunities. The end result is expected to be a report that can guide non-profit institutions that are looking to build CI capabilities.
- **142 - University of Alaska Fairbanks (UAF):** EPOC staff consulted with engineers from the International Arctic Research Center at UAF on applying for a CC* grant. Emphasis was placed on science use cases, which area of the solicitation to apply to, Science DMZ best practices, data transfer nodes, and the need for deep buffered switches to support long distance data transfers. UAF has challenges in establishing connectivity to the lower 48 states and is weighing connectivity options for their WAN connection versus the local needs on the LAN. The engagement continues as UAF engineers prepare their proposal for the October 2021 deadline or another solicitation in 2022.
- **143 - Arizona State University (ASU):** ASU staff asked for assistance in designing the data architecture for an experimental facility for the Compact X-Ray Free Electron Laser (CXFEL). The instrument is similar to the Department of Energy Light Sources and will support researchers in fields such as material science. The facility is still waiting on funding decisions, but is currently evaluating the proper setup of a data architecture, including the network infrastructure, storage, computational power to calibrate and analyze samples, and the workflow tools to be used to control the components. This consultation is ongoing to review future plans.

- **147 - South African Radio Astronomy Observatory (SARAO):** The SARAO, in collaboration with the South African National Research Network (SANReN), approached EPOC for assistance on a multi-continent performance problem when downloading data from the National Radio Astronomy Observatory (NRAO) in Charlottesville, VA. After several weeks of debugging, a number of problems were identified and corrected, including:
    - Network routing abnormalities were found and addressed in SANReN's network.
    - Firmware updates were performed on SANReN's routing hardware.
    - An MTU configuration problem was discovered and corrected on the campus network for the University of Virginia, which provides the network connection to NRAO.

  EPOC staff are also helping the group evaluate data transfer tools, such as Globus, that may speed up the overall data transfer. This consultation is ongoing while NRAO explores installing a Globus endpoint.
- **160 - American Museum of Natural History (AMNH):** EPOC staff did a NetSage demonstration for AMNH and found example transfers with very poor performance including a 2.6TB transfer to the University of Arizona that took over a week with average performance of 4.6 Mbps. EPOC engineers will start troubleshooting this performance issue in Quarter 2.
- **169 - National Institute of Standards and Technology (NIST):** The supervisor of the NIST Boulder Network Operations Team reached out for EPOC recommendations related to Science DMZs and DTNs. They have a use case with data sets from 1-200TB and are about to make investments in their infrastructure. The EPOC team provided examples and answered questions and is awaiting feedback from NIST before completing this interaction.
- **170 - Lonestar Education And Research Network (LEARN):** LEARN has several recently installed perfSONAR Docker instances that are not performing as expected. A LEARN engineer reached out to EPOC engineers for troubleshooting assistance, and an initial investigation into the performance problems was launched.

4.C Additional Outcomes

Based on the broad set of Roadside Assistance and Consultation Cases addressed during Quarter 1, we have created or are working on following Best Practice documents:
- It's all about the MTU's: https://epoc.global/wp-content/uploads/About-MTUs.pdf
- A Science DMZ starter pack, which will consist of several documents giving the background, how to find and evaluate DMZ use cases, how to select a 10G DTN, and what the security aspects are.
- A guide to understanding why a 100G connected perfSONAR or DTN node may not always achieve 100G transfer rates.

4.D Metrics

Table 2: A summary of Quarter 1 Roadside Assistance and Consultation Cases. Green rows are completed cases

ID	Main Site	EPOC Partner	Type	Start Date	End Date	Area of request	Asked by: Eng, Scientist, other	Science Domain	Primarily R(ch), E(du), O(ther)	Size: S, M, L
63	NOAA	FRGP, NOAA	Cons	12/16/19	4/21/21	DD	Eng	Infra	O	-
76	NCAR	FRGP	RA	3/6/20	6/17/21	Trans Perf	Eng	Climate	R	L
105	LC	KINBER	Cons	8/13/20	6/30/21	DMZ, DTN	Eng	Infra	E	S
107	Arecibo	TACC, Globus	RA	8/21/20	6/1/21	Trans Perf, DMZ	Eng	Astro	R	L
113	TAMU	TACC, LEARN	Cons	9/10/20	6/30/21	Trans Perf	Eng	Infra	R	L/M
117	AI	PNWGP	Cons	10/21/20		Arch	Eng	Infra	R	L
121	EHT	NEAAR/ TP/UH Astro	RA	10/28/20		Trans Perf	Sci	Astro	R	L
135	TACC	TACC	Cons	1/5/21	6/20/21	Arch	Other	Infra	E	L
142	UAF	PNWGP	Cons	1/28/21		Grant	Eng	Infra	R / E	M
143	ASU	SCN	Cons	2/9/21		Arch	Eng	Infra / Bio	R / E	L
147	SARAO	Globus	Cons	2/16/21		Transfer Perf, Globus	Eng	Infra	R	L
152	Brown	-	Cons	2/24/21	5/3/21	DMZ, Firewall	Eng	Infra	R / E	M
153	SLU	GPN	Cons	2/24/21	5/26/21	Arch	Other	Infra	E	M
154	NYSERNet	-	Cons	3/4/21	4/5/21	NS	Eng	Infra	R	-

155	TAMUSA	LEARN, TACC	Cons	3/8/21	6/15/21	DMZ, Science	Eng	Infra	E	S
157	Syracuse	-	Cons	3/25/21	5/11/21	Perf, Security	Eng	Infra	E	M
158	NYULH	-	Cons	3/26/21	5/14/21	DMZ	Eng	Medical	R	M / L
159	Yale	Globus	Cons	3/31/21	6/10/21	Trans Perf	Eng	Infra	R / E	L
160	AMNH	SCN	Cons	3/31/21		Trans Perf	Eng	infra	O/E	-
161	RPI	-	Cons	3/31/21	5/11/21	Trans Perf	Eng	infra	R / E	M
162	LEARN	LEARN	Cons	4/7/21	5/3/21	DD	Eng	infra	R / E	L
163	Yale	-	Cons	4/13/21	5/12/21	DTN	Eng	infra	R / E	L
164	KNU	TP	RA	4/15/21	5/16/21	Trans Perf	Eng	infra	R	S
165	NII	TP	RA	4/15/21	5/16/21	Routing	Eng	infra	R / E	S
166	NOAA	FRGP, NOAA	Cons	4/23/21	6/16/21	DD	Eng	environmental	R	L
167	LEARN	LEARN	Cons	5/13/21	6/30/21	Trans Perf, PS	Eng	infra	R / E	S
168	SOX	SOX	Cons	6/7/21	6/30/21	DTN	Eng	infra	O	-
169	NIST	FRGP	Cons	6/10/21		DMZ, DTN	Eng	TBD	R	L
170	LEARN	LEARN	Cons	6/21/21		PS	Eng	infra	R	S

5. Deep Dives

Deep Dives aim to understand the full research pipeline for collaborative teams and suggest alternative approaches for the scientists, local CI support, and national networking partners as relevant to achieve the long-term research goals via workflow analysis, storage and computational tuning, and identification of network bottlenecks. We have adapted the ESnet facilities approach for work with individual science groups, which is documented at: https://epoc.global/wp-content/uploads/Application-Deep-Dive-Description.pdf. Jason Zurawski is the lead for this area.

5.A Shift to Virtual Deep Dives

As COVID-related travel restrictions continue, EPOC engaged in a number of conversations internally, with community members, and with our advisory board, to evaluate strategies to adjust our approach to Deep Dives to work in a virtual environment. The new approach involves a video session to "train the trainers" and help the local IT staff understand the Deep Dive structured conversation approach so they can work with the individual science groups to fill out the application Case Studies. Once the Case Studies are collected, we schedule a series of Focus Group video calls, each no more than 2 hours in length, to walk through a subset of the Case Studies and try to identify the CI needs and requirements. The full set of participants then update the Case Studies and we combine that data and observations from the focus groups into a report that is reviewed and then made public. An article on this process was published as part of the Quilt Circle magazine [Publication #28].

Once travel restrictions are lifted, we will engage with other sites to see if we can return to hybrid events that feature an in-person component. For now, these approaches are still a work in progress, and are expected to continue.

5.B In Progress Deep Dives

The following Deep Dives activities are in progress:
- **Arizona State University / Sun Corridor Network - In Person**: In August, 2019, Arizona State University reached out to EPOC to host a potential Deep Dive of campus and regional requirements. An in-person event is strongly desired, so it is likely this will be rescheduled for early 2022.
- **Oregon State University - In Person:** In April 2019, members of Oregon State University contacted EPOC staff about a possible EPOC Deep Dive to profile their campus research and the regional network for the state, LinkOregon. Dates and focus areas were discussed but have stalled due to COVID-19.
- **University of Central Florida (UCF)- Virtual**: Staff from UCF approached EPOC to stage a Deep Dive for the campus. Due to COVID-related travel restrictions, most of the

activities to discover and discuss the scientific drivers were done virtually in late 2020 and early 2021. The goal is to produce content that can be used to justify a CC* proposal for campus in October 2021. UCF is still interested in hosting an eventual live event in late 2021 or early 2022.

- **University of South Dakota (USD) - Virtual**: Staff from USD approached EPOC to stage a Deep Dive for the region, pulling in participants from other local institutions, including South Dakota State, Black Hills State, and Northern State. Due to COVID-related travel restrictions, most of the activities to discover and discuss the scientific drivers were done virtually in late 2020 and early 2021. Virtual meetings with researchers and IT staff from the region were held on May 24, 2021, and June 8, 2021. The goal is to produce content that can be used to justify a CC* proposal for the region in October 2021, as well as a document that lists strategic science drivers for the region.
- **NOAA Marine Mammal Acoustics (NOAA NMFS)- Virtual**: Staff from NOAA N-WAVE approached EPOC to profile a NOAA science area and to learn about the Deep Dive process so it can be adapted to other NOAA use cases. Virtual meetings with researchers and IT staff from NOAA were held on June 22, 2021, and July 27, 2021, and a final presentation is planned for NOAA's JETI conference on August 5, 2021. The effort will complete with a final report published in the summer of 2021.
- **Texas A&M University San Antonio (TAMUSA)**: Staff from TAMUSA approached EPOC regarding Science DMZ design help, but were challenged in designing a network that fit scientific requirements. EPOC, LEARN, and TAMUSA started a Virtual Deep Dive to gather scientific use cases and will complete this activity in summer of 2021.

5.C Metrics

Table 3: Metrics for Deep Dive activities.

Meet Date	Appl name	Public/ Private	Audience	Offered or Req	Head Count	Issues Identified	Complete Date
Planned 2022	Arizona State Univ, Sun Corridor	Priv	ASU, UofAZ, NAU, and Sun Corridor Network staff	Req		TBD	TBD
Planned 2022	Oregon State	Priv	OSU, UofO, and Link Oregon Staff	Req		TBD	TBD
Virtual - 2020/ 2021	Univ Central Florida	Priv	University Researchers & Staff, Florida Lambda Rail	Req	20 virtual	Increased HPC, access to network testbeds, storage.	Expected Fall 2021
Virtual - 2020/ 2021	Univ South Dakota	Priv	Staff from GPN, USD, SDSU, Black Hills State, and others	Req	40 virtual	Regional compute and storage, CI expertise, software integration	Expected Summer 2021
Virtual - 2021	NOAA N-Wave	Priv	NOAA N-Wave staff and scientists	Req		TBD	Expected Fall 2021
Virtual- 2021	TAMUSA	Priv	TAMUSA, LEARN staff	Req		TBD	TBD

6. NetSage Deployments and Analysis

Understanding application performance and network measurement are two sides to a single coin - one doesn't make sense without the other. The EPOC project uses the NetSage tool (http://www.netsage.global) to collect and evaluate common network measurement data. The initial NetSage software was developed and deployed on the NSF-funded international networks. It was meant to work with sparse, international circuits, and for end users primarily consisting of circuit owners and operators. EPOC has expanded the use of this software to work with more densely defined networks and to support additional analysis and visualizations, and data for all of the NetSage deployments are now available online at http://all.netsage.global. More information about NetSage and EPOC is online at https://epoc.global/wp-content/uploads/Network-Analysis.pdf. Jennifer Schopf and Dan Doyle jointly lead this activity.

6.A NetSage Development and Presentations

Different components of NetSage can be deployed in different ways, depending on the requirements of the customer. During Year 4 Quarter 1, the NetSage development team released versions 1.8.0 and 1.8.1, each of which were deployed on all of the EPOC partner deployments. Both of these releases included numerous bug fixes and minor adjustments. A summary of key changes in these releases is as follows:
- NetSage 1.8.0 fixed a subtle but critical error that would sometimes result in flows being incorrectly shown in an individual flows context.
- NetSage 1.8.1 was a minor fix with some internal cross-linking as a result of changes in 1.8.0.

In addition, Schopf discussed NetSage as part of the WOMBIR meeting [Meeting #8], and presented on NetSage for the LHC [Meeting #11, Presentation #26]. In addition, a presentation was made to the Sun Corridor Network on how they can make better use of their NetSage deployment [Presentation #33].

6.B Current Deployments

The status of the current deployments for NetSage network-related dashboards for the EPOC partners includes:
- **PNWGP/PacificWave:** The PNWGP/PacificWave deployment of NetSage, which had been supported by the NSF IRNC program, is now being supported by EPOC. This data is available at https://pacwave.netsage.global/.
- **Front Range GigaPop (FRGP)**: The FRGP flow data deployment of NetSage was made public in December 2019 at https://frgp.netsage.global/.
- **Great Plains Network (GPN):** The NetSage SNMP and flow dashboard for the GPN associated circuits (http://gpn.netsage.global) was initially deployed in October 2018 for SNMP data and in May 2020 deployed flow data collectors as well.

- **iLight/Indiana GigaPop:** Flow data collection for the five Indiana GigaPop routers began in mid-April 2019, and continues to be publicly available at http://ilight.netsage.global.
- **KINBER:** Collection of flow data for the PennREN network began at the end of October 2019 and remains publicly accessible at https://kinber.netsage.global/.
- **LEARN:** At their 2019 All Hands Meeting, LEARN staff expressed an interest in moving forward to deploy NetSage for the state of Texas network. We made contact with the new LEARN CEO, and expect work on this to continue later in the year.
- **OARnet**: We met with OARnet's new CEO in January, 2021. The CEO stated that a NetSage deployment for the Ohio R&E network could not go forward until they had done a network redesign (currently in the planning stages) to split R&E traffic off from commercial traffic.
- **SoX:** The SoX NetSage deployment for flow data started receiving data at the very end of June, and was made public in July 2020 at https://sox.netsage.global/. We continue to work with SoX to expand the datasets that we are collecting to include SNMP.
- **Sun Corridor Network:** An initial NetSage deployment for Sun Corridor was made public in March 2021 at https://suncorridor.netsage.global/. A presentation was given to the SCN Technical Committee [Presentation #33], during which they expressed additional interest in using SWIP and adding SNMP data in the future.
- **TACC**: TACC Flow data has been available since July 2020 and is accessible at https://tacc.netsage.global/.

The Archive site deployment was funded by the NSF IRNC NetSage project but is also being used by the various EPOC partners. NetSage uses a software package called Tstat to collect flow data as well as retransmits from the archives. The deployments include:
- **TACC/LEARN:** The TACC deployment remains active, though sometimes requires working with them to restart it based on changes in their environment. No major changes have been made on the EPOC side and this work is running in a stable state.
- **University of Hawai'i Astronomy:** A temporary installation of Tstat for the Astronomy archives was replaced with a permanent solution early in Year 2. This work is running in a stable state.
- **NCAR/FRGP:** A Tstat archive was sent to the lab at NCAR's site in Wyoming in early 2019 and was up and running in July. It has since been running and providing data stably. This work is running in a stable state.
- **National Energy Research Scientific Computing Center (NERSC):** NERSC was the first deployment for IRNC NetSage and the Tstat software. This archive is widely used internationally and domestically for energy science related data sets. This work continues to run in a stable state, periodically communicating with them to coordinate upgrades or resolving issues.

6.C Network Performance Detection

In Year 3, EPOC staff used NetSage to actively investigate performance issues for data transfers related to COVID-19 research. In Year 4, Quarter 1, we expanded this activity to look at performance issues across all science domains. This is an extension of the original project milestone of using NetSage to detect or analyze network "disturbances". We used NetSage to look at patterns in data movement, volume, and rate to identify and analyze flows with suspected poor data transfer performance or unexpected routing. We then engaged with partner networks and end users to see if we could work together to improve performance. Investigations we pursued in Quarter 1 are described as part of Roadside Assistance Cases 164 and 165.

6.D Metrics

Table 4: Metrics for NetSage activities for Year 4, Q1.

Where Regional	Data	Date Live	# Monitored Devices	# Large Flows	# Unique Src Orgs	# Unique Dest Orgs
PNWGP	SNMP, Flow	2/18	7 routers	48,285,708	3,049	6,508
GPN	SNMP, Flow	10/18	2 routers	30,434,772	2,100	4,614
iLight	Flow	4/19	5 routers	64,826,068	4,792	11,884
KINBER	Flow	11/19	2 routers	18,643,322	3,252	4,495
FRGP	Flow	1/20	1 router	64,455,868	4,070	6,401
SoX	Flow	7/20	3 routers	25,233,773	2,807	2,442
TACC (LEARN)	Flow	7/20	1 router, 4 head nodes	2,473,813	1,107	961
TACC (LEARN)	Tstat	1/19	6 head nodes	1,180,582	111	121
UHawaii Astro	Tstat	5/19	1 DTN	481,405	163	614
NCAR (FRGP)	Tstat	7/19	1 DTN	10,814,122	263	2,032
NERSC	Tstat	3/18	10 head nodes	845,516	111	114

7. Data Mobility Exhibition/Baseline Performance Testing

The Data Mobility Exhibition provides institutions with a neutral, third-party set up to evaluate a measurable baseline of data transfer performance. Many institutions have been awarded NSF CC* grants to develop Science DMZs or upgrade network bandwidth capacity, however, they have not previously had a way to see the external effects of these deployments. EPOC is currently recommending that institutions aim to be able to transfer **one TeraByte of data in an hour,** which is equivalent to 2.22 Gb/s average network throughput on a 10G connected host.

Those institutions that cannot achieve this are candidates to work with EPOC to determine bottlenecks in their path.

The Current DME set up consists of five remote test sites as well as two cloud sites. These well tuned sites host datasets that range in number from a single file to over 100,000 files, and the file sizes vary from 100MB to 5TB. When the users have completed moving the datasets to and from their institutions, they receive a summary of the upload or download speeds in MB/s rates. EPOC has been pushing the guideline that institutions should be able to move a Terabyte in an Hour, which works out to 2.22 Gb/s average network throughput. Ken Miller is the lead for this area. More information is available at: https://fasterdata.es.net/performance-testing/2019-2020-data-mobility-workshop-and-exhibition/2019-2020-data-mobility-exhibition/.

During Year 4 Quarter 1, we gave one presentations [#21] that included details of the Data Mobility Exhibition. We expect this to increase as we increase the information around moving a Terabyte in an hour. For the DME, 5,218 tests were performed between April 2021 and June 2021. These included tests by member institutions of our Regional Networking Partners, including KINBER and SoX. EPOC will be working with sites that request assistance to understand and improve data architecture, tuning, and usability of the resources for science use cases.

On the technical side, three of the remote DME testing endpoint sites currently have limited access to the test files, but we are working with the Globus team to reestablish those endpoints. In addition, a set of DME automation scripts were developed to assist with this testing, and are available online: https://github.com/vasv/dme-utils These scripts provide a way to do automated testing via a command line interface instead of running manual tests through the Globus GUI. One site, University of Alabama Birmingham, produced a majority of the results and was contacted to gather more details about their automated testing.

8. Managed Services (aka "In a Box")

EPOC is developing a set of service definitions for common R&E infrastructure components that could be run by a third party as a managed service. The goal of these definitions is to provide guidance for our Regional Networking Partners to implement, maintain, and operate (potentially for a fee) the service as a benefit for downstream connectors. In doing so, the costs associated with design, specification, and installation could be ameliorated for a larger population than would otherwise have access to this technology due to the burdens of entry which may include not having knowledgeable staff or enough compelling use cases to invest time and money.

The typical design and implementation involves an EPOC regional partner expressing interest in working on managed services to be deployed/managed centrally or targeted directly at a member school. However, due to pandemic-related access restrictions and the resulting shifting priorities at our partner institutions, these efforts were stalled in mid 2020 and for the foreseeable future. More information about the Managed Service activity is available online at

https://epoc.global/wp-content/uploads/Managed-Services.pdf. Jason Zurawski is the lead for this area.

The only Managed Service in active development at this time is the Modern Research Data Portal (MRDP), as detailed at http://es.net/science-engagement/technical-and-consulting-services/modern-research-data-portals/. The MDRP design pattern makes use of the Science DMZ model and DTNs to scale up the data transfer functionality of a data portal. EPOC is experimenting with the concept of a self-contained Data Portal to assist scientific data sharing needs. The goal is to create an easy to install set of software that can be run on campus or regional hardware and expose a set of scientific data. The current Pilot Portal is based on MRDP and uses Docker and supports a front end with federated authentication and a custom pointer file to any existing site DTN. This setup installs a custom project or site front end with an API call to existing and collaborative Globus Endpoints.

The initial trails of the pilot portal were with the University of Hawaii Astronomy group and LEARN member Baylor. Early results have focused on technical implementation details, including ease of deployment and integration with existing campus infrastructure. We have started additional testing with scientific users to see if prior concerns have been addressed. Globus has now containerized the Globus Connect Server (https://github.com/globus/globus-connect-server-deploy) and included a number of other automation options. We plan to reach out to the pilot sites to gauge their interest in continuing this work. Globus is still in the process of updating the MDRP into a docker container as well as a django application (https://github.com/globus/django-globus-portal-framework-example).

9. Training

EPOC is continuing the successful training that ESnet and IU lead as part of the Operating Innovative Networks (OIN) program. This includes training for network engineers to be coordinated with existing cyberinfrastructure support teams. While training programs like OIN emphasized the design and deployment of technology, we have pivoted to train staff on the use of these tools and the improvement of scientific use of networks through them. In addition to training on tools such as perfSONAR, we offer training for network engineers on interacting with their researchers through teaching them how to perform Application Deep Dives. All EPOC training materials are available online, including lecture materials, exercises, and recorded sessions, when possible.

9.A Collaboration with University of South Carolina

EPOC continues to work with members of the University of South Carolina Cyber Training team funded via NSF #1829698. EPOC staff are assisting with a set of workshops on high performance networking technologies. Zurawski is also serving on the Advisory Committee for this project.

The audience of this work includes IT educators, IT professionals, CI engineers, high performance computing specialists, research systems administrators, and security professionals. Topics include science DMZs, TCP, BGP, perfSONAR, and Zeek. One facet that makes this training unique is the use of a virtual laboratory environment, which allows for easy set-up, scaling, and quick creation of custom training scenarios using open source tools. Students engage in hands-on training exercises that simulate real world networking leading to better understanding of complex topics. There are over 50 virtual labs associated with the live lectures, which are meant to be completed by attendees at their own pace after a workshop ends.

EPOC staff participated in the virtual USC Cyber Training Workshop sponsored by Southern Crossroads / Southern Light Rail (SOX / SLR), the Engagement and Performance Operations Center (EPOC), the Research Computing (RC) Group at University of South Carolina, Clemson University, Oklahoma University, Alabama A&M University, and the University of South Alabama on April 8, 2021 and April 15, 2021 [Meeting #4, presentations #18, 19, 20, 21]. The workshop had over 100 registered attendees for the 2 day meeting. Audience members included engineers, higher education staff, and college educators.

EPOC staff continue to work with the USC team to plan events that utilize a virtual lab environment. EPOC staff are discussing possible training sessions with other regional networks in 2022.

9.B PerfSONAR Training

In addition to the training that was part of the USC Cyber Training Workshop [Meeting #4, Presentation #19], EPOC staff lead perfSONAR training sessions at the GPN annual meeting [Meeting #13, Presentation #30] and the LEARN Technical Advisory Group [Meeting #14, Presentation #31]]. These sessions focused on using perfSONAR to detect and troubleshoot the types of complex network problems that arise as R&E transfers cross multiple network domains, as well as the importance of maintaining healthy, available perfSONAR resources for others in the R&E community to use.

EPOC staff use perfSONAR extensively as part of the Roadside Assistance and Consulting project, as detailed in Section 4. As such, outreach efforts that increase perfSONAR presence and knowledge are valuable to both EPOC and the larger R&E community as a whole. We also participated in the Second European perfSONAR User Meeting in April [Meeting #6, Presentation #22].

10. Travel and Virtual Meeting Participation

EPOC staff participated in various meetings to support ongoing deployment, collaboration, and training. Starting in February 2020, activities that involved travel were severely impacted by COVID-19. The EPOC activities shifted from in-person to remote/virtual interactions.

During the Year 4 Quarter 1, meeting participation by the team listed here and referred to throughout the report with the reference number listed:

1. Addleman attended the Large Facilities Workshop, April 7, 2021, https://www.largefacilitiesworkshop.com/apr21workshop/. Addleman participated in discussions on the challenges faced during the COVID-19 pandemic and how public outreach helped continue missions virtually.

2. Schopf attended the Spring CASC 2021 Membership Meeting, April 7-9, 2021, https://casc.org/event/casc-spring-2021-membership-meeting/. Schopf participated as a role member of the Executive Committee.

3. Addleman attended the FABRIC Experimenters Workshop, April 8-9, 2021, https://whatisfabric.net/events/fabric-experimenters-workshop-2021. Addleman participated in discussions on FABRIC installation status, talks by experimenters planning to use FABRIC, and a demonstration showing how experiments can use FABRIC.

4. Zurawski, Miller, Robb, and Southworth presented the USC Cyber Training Workshop April 8, 2021 & April 15, 2021, http://ce.sc.edu/cyberinfra/nsf_cc_workshop.html. Zurawski, Miller, Robb, and Southworth presented on data architecture, perfSonar, DTNs, and data mobility.

5. Addleman attended the Cybersecurity as Big Data Science Interactive Workshop, April 12, 2021, https://nebigdatahub.org/cybersecurity-as-big-data-science-workshop/. Addleman participated in discussions of both common and unique data science challenges for cybersecurity including privacy, collection, storage, and sharing of data.

6. Southworth presented at the Second European perfSONAR User Workshop, April 14 2021, https://wiki.geant.org/display/perfSONAR/2nd+European+perfSONAR+User+Workshop. Southworth gave an overview of two success stories which demonstrated the day-to-day usefulness of perfSONAR as a network troubleshooting tool for complex networking problems.

7. Moynihan attended the VRO-NET meeting, April 15-16, 2021. Moynihan participated in discussions on trans-Atlantic networking support for the VRO and contributed to writing documentation on international connectivity.

8. Schopf attended the NSF Workshop on Overcoming Measurement Barriers to Internet Research (WOMBIR 2021), April 15-16, 2021, https://www.caida.org/workshops/wombir/2104/. Schopf participated in discussions around internet measurements and use cases.

9. Addleman attended the Internet2 Online session on Identifying Cyberinfrastructure Gaps, April 20, 2021, https://internet2.edu/i2-online-recommendations-identifying-cyberinfrastructure-gaps/. Addleman participated in a discussion about the barriers to research computing for campuses.

10. Zurawski attended the 2021 KanREN Annual Meeting, April 21-22, 2021, https://www.kanren.net/annual-meeting/. Zurawski participated in discussions about research and institutional network needs.

11. Moynihan and Southworth attended the High Luminosity Large Hadron COllider (HL-LHC) Data Challenge Monitoring Workshop, April 27, 2021, https://indico.cern.ch/event/1027287/. Moynihan and Southworth participated in several discussions about monitoring solutions for the upcoming LHC Data Challenge later this year. Southworth presented on how NetSage could be used to provide real-time and post-event analysis.
12. Zurawski, Miller, and Robb attended the GlobusWorld 2021 event, May 12-14, 2021, https://www.globusworld.org/conf/. Robb presented on recovery work for the Arecibo Observatory.
13. Schopf, Addleman and Southworth attended the GPN 2021 Virtual Annual Meeting, June 2-4, 2021, https://www.greatplains.net/gpn2021-virtual-annual-meeting/. Schopf and Addleman lead a BOF on how EPOC supports the NSF CC* program.. Southworth held perfSONAR training workshops.
14. Southworth attended the LEARN Technical Advisory Group(TAG) Meeting, June 8-10, 2021. Southworth held perfSONAR training workshop sessions during the meeting.
15. Schopf, Addleman and Meade attended the GNA-G Community VCs Meeting, June 14-15, 2021, https://www.gna-g.net/attend-a-meeting/gna-g-community-vcs-2021q2/. Schopf presented on the status of the Routing Working Group.
16. Moynihan and Schopf attended the TNC 2021 event, June 21-25, 2021, https://tnc21.geant.org. Moynihan participated in several update sessions including on AfricaConnect3, NORDUnet, and GEANT. Schopf led a BOF session on the new Routing Working Group.
17. Moynihan attended the Pacific Research Platform (PRP) Capstone event June 22, 2021, https://drive.google.com/file/d/18njsRQ7lFjMNq1_a_lIePnHfrvjLWEZG/view. Moynihan participated in talks on the history, accomplishments, and the future plans of the PRP.

11. Presentations and Publications

For Year 4 Quarter 1, the EPOC presentations, invited posters, and publications are listed here and referred to throughout the report with the reference number listed:
1. Zurawski, J., "Designing, Building & Maintaining a Data Architecture", Invited Talk, USC Cyber Training Workshop, April 8, 2021, Slides available online at https://drive.google.com/file/d/1i6fSwsJx8JyD5JtgT_8pU3Z_ZMC2tr_J/view?usp=sharing
2. Southworth, D., "perfSONAR Introduction & Motivation", Invited Talk, USC Cyber Training Workshop, April 8, 2021, Slides available online at https://drive.google.com/file/d/1jX0JAzDbJswDhdW_GY_aEqC4XJhLReP4/view?usp=sharing
3. Robb, G., "Move That Data! DTN Elements", Invited Talk, USC Cyber Training Workshop, April 8, 2021, Slides available online at https://drive.google.com/file/d/1lWfuPXnipY9aQmne6kYedIP4d4Rg3EJ0/view?usp=sharing

4. Miller, K., "Data Mobility Exhibition – DME", Invited Talk, USC Cyber Training Workshop, April 8, 2021, Slides available online at https://drive.google.com/file/d/1SteTKEMqe4DzkRV9zvdIwKsdEnAFs1bw/view?usp=sharing

5. Southworth, D., "In the Wild: Real-world Troubleshooting with perfSONAR", Invited Talk, Second European perfSONAR User Workshop, April 14, 2021. Slides available online at: https://wiki.geant.org/display/perfSONAR/2nd+European+perfSONAR+User+Workshop?preview=/138747020/255557730/pS%20in%20the%20wild%20-%20IU-DS.pdf

6. EPOC Team, "Continuing Arecibo's Legacy", Article, April 21, 2021, Available at: https://www.tacc.utexas.edu/-/continuing-arecibo-s-legacy

7. EPOC Team, "Continuing Arecibo's Legacy", Article, April 21, 2021, Available at: https://itnews.iu.edu/articles/2021/Continuing-Arecibos-legacy-.php

8. EPOC Team, "Arecibo Data Recovery: Behind the Scenes with Jason Zurawski", Article, April 21, 2021, Available at: https://lightbytes.es.net/2021/04/21/arecibo-data-recovery-behind-the-scenes-with-jason-zurawski/

9. Southworth, D., "NetSage- A Tool to Understand Data Transfers", Invited Talk, HL-LHC Data Challenge Monitoring workshop, April 27, 2021. Slides available online at: https://indico.cern.ch/event/1027287/contributions/4335173/attachments/2234274/3786518/LHC%20NetSage.pdf

10. Robb, G., "The Arecibo Observatory: Disaster, Recovery and What Comes Next", Invited Talk, Globus World 2021, May 13, 2021, Slides available online at: https://www.slideshare.net/globusonline/globusworld-2021-arecibo-observatory-data-movement

11. Zurawski, J., Schopf, J., "EPOC Trials Virtual Deep Dives to Enhance Cyberinfrastructure Workflows", Invited Article, The Quilt Circle, Pg 13, June, 2021. Article available online at: https://www.thequilt.net/quilt-circle/epoc-trials-virtual-deep-dives-to-enhance-cyberinfrastructure-workflows/

12. Schopf, J., and Addleman, H., "NSF CC* BoF", Invited Talk, GPN 2021 Virtual Annual Meeting, June 2, 2021, Materials available online at: https://gpn2021.sched.com/event/jC0F/nsf-cc-bof?iframe=no&w=100%&sidebar=no&bg=no

13. Southworth, D., "perfSONAR Training", GPN 2021 Virtual Annual Meeting, June 2, 2021, Slides available online at: https://drive.google.com/drive/folders/18NVEB qm_AxGsD-hIIadFlOSIr6F5OzBW?usp=sharing

14. Southworth, D., "perfSONAR Training", LEARN Technical Advisory Group(TAG) Meeting, June 8 & 10, 2021, Slides available online at: https://drive.google.com/drive/folders/1ZSgwlrzwfZ7gS-NBtLrEc7ejRSI98M-y?usp=sharing

15. Schopf, J., "Routing WG Overview", Invited Talk, GNA-G Community VCs Meeting, June 14, 2021. Slides available online at: https://drive.google.com/file/d/18jY7-HGpbCam9rhUQP01kxpe_O7PkZ8U/view

16. Schopf, J., "NetSage, EPOC, and the AZ Tri-University Network" Invited Talk, Sun Corridor Network Engineers Meeting, June 14, 2021. Slides available online at:

https://drive.google.com/file/d/1RF0_r_q6Lw3BdSgLQ7ZoBPEq4fWSDoMb/view?usp=sharing

17. Schopf, J., "Routing WG Overview", Invited Talk, TNC21, June 25, 2021. Slides available online at: https://drive.google.com/file/d/1jEvF_Kb04zZPz1ciaGifsLRc6eUqvfgR/view?usp=sharing

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12. Networking Partner Activities

EPOC is partnered with the eleven Networking Partners:

- **Front Range GigaPop (FRGP)** is the regional collaboration of networks that cover the western states, including Colorado, Wyoming, Arizona, Idaho, Utah, and New Mexico.
  - Roadside Assistance and Consultation Cases: 63, 76, 166, 169
  - Deep Dive: Discussions are taking place with NOAA for a virtual Deep Dive
  - NetSage: http://frgp.netsage.global, deployment February 2020, and discussions are ongoing for an SNMP deployment. Also, NetSage Tstat deployment at the NCAR Wyoming Data Center.
- **iLight** is the regional network for Indiana.
  - NetSage: http://ilight.netsage.global, deployment May 2019, working on ASN splitting with SWIP.
- **The Great Plains Network (GPN)** is the regional network that serves North Dakota, South Dakota, Nebraska, Iowa, Minnesota, Kansas, Missouri, and Arkansas.
  - Meetings: Zurawski attended the 2021 KanREN Annual Meeting [Meeting #10], and Schopf, Addleman and Southworth attended the GPN 2021 Annual Meeting [Meeting #13] at which they ran a BoF on EPOC support for the NSF CC* program [Presentation #29] as well as a perfSONAR Training Workshop [Presentation #30].
  - Roadside Assistance and Consultation Cases: 153
  - Deep Dives: Virtual Deep Dive with University of South Dakota ongoing.
  - NetSage: http://gpn.netsage.global, SNMP and Flow data
- **The Keystone Initiative for Network Based Education and Research (KINBER)** is the regional network for Pennsylvania.
  - Roadside Assistance and Consultation Cases: 105
  - NetSage: http://kinber.netsage.global Deployment November 2020, working on ASN extensions with SWIP.
- **The Lonestar Education and Research Network (LEARN)** is the regional network for Texas.
  - Meetings: Attended the LEARN Technical Advisory Group (TAG) Meeting [Meeting #14] and gave a perfSONAR workshop [Presentation #31].
  - Roadside Assistance and Consultation Cases: 113, 155. 162, 167, 170 (Note: we include these for both LEARN and TACC)
  - Deep Dives: Discussions are taking place with TAMUSA for a virtual Deep Dive
  - NetSage: Continued discussion for deployment.
- **NOAA N-wave,** the R&E network for NOAA
  - Roadside Assistance and Consultation Cases: 63, 166
  - Deep Dives: Discussions taking place for a Virtual Deep Dive
- **The Ohio Academic Resources Network (OARnet)** is the regional network for Ohio.
  - NetSage: A NetSage deployment will not be feasible until the R&E network is restructured.

- **Pacific Northwest GigaPop (PNWGP)** provides access to next generation internet services and technologies throughout the Pacific Rim, but in the US primarily in California, Oregon, and Washington State.
  - Roadside Assistance and Consultation Cases: 117, 142
  - NetSage: Flow and SNMP now hosted by epoc, started with previous IRNC support
- **Southern Crossroads (SoX)** is the regional network for much of the southeastern part of the US, including parts of Alabama, Georgia, South Carolina, and Tennessee
  - Roadside Assistance and Consultation Cases: 168
  - NetSage: Deployment of NetSage for Flow data went live in July 2020, in discussions for SNMP deployment.
- **Sun Corridor Network (SCN)** is the regional network for the state of Arizona
  - Roadside Assistance and Consultation Cases: 143, 160
  - NetSage: A presentation was given to the SCN Engineers Meeting [Meeting #48] , leading up to a deployment that went live in March 2021.
  - Deep Dive: Discussions for a Deep Dive to take place in 2021 are ongoing.
- **Texas Advanced Computing Center (TACC)** at the University of Texas at Austin, United States, is an advanced computing research center
  - Roadside Assistance and Consultation Cases: 107, 113, 135, 155 (Note: we include some of these for both LEARN and TACC)
  - NetSage: Deployment for TACC completed in July 2020. Archive deployment in production since 2019.

In lieu of the normal face-to-face summer meetings that are not taking place this year, we are planning to check in with each of these partners in Quarter 2 and have begun to In schedule these meetings.

13. Data Privacy and Security

Basic security measures are being maintained and there were no security incidents to report for Year 3. Continuing training for Addleman, the Security Officer for the team, took place in the form of attending the Large Scale Facility meeting [Meeting #1], The CyberSecurity as Big Data Science workshop [Meeting #5], and the Internet2 Online session on Identifying Cyberinfrastructure Gaps [Meeting #9].

No PII is shared in the Roadside Assistance or Consultation summaries or reports, which are made public. There may be PII in other documents in a Roadside Assistance Case Folder, for example IP addresses, but this information is locked down and access is controlled and only shared with specific staff working on a particular issue.

In addition, NetSage does not collect PII. The IRNC NetSage privacy docs were updated for EPOC and are available online at https://epoc.global/wp-content/uploads/Data-Privacy-Policy.pdf.

14. Reporting Against Deliverables

Table 5 lists the current deliverables and their status.

WBS #	Deliverables	Status
RA	**ROADSIDE ASSISTANCE AND CONSULTATIONS**	
RA.1	Adaptation of IN@IU, ESnet science engagement, and IRNC NOC PET process with expanded focus	Compl Y1
RA.2	Advertising roadside assistance and consulting	Ongoing
RA 3	Assist with ongoing RAs - Partners	
RA 3.1	iLight RA/C	
RA 3.1.1	C - IU-NOAA (24)	Started Y2Q1, Compl Y2Q2
RA 3.2	FRGP RA/C- Includes NOAA	
RA 3.2.1	C - Mines (4)	Started Y1, Compl Y2Q2
RA 3.2.2	C - Tribal (6)	Compl Y1
	See also RA 3.1.1 (24)	
RA 3.2.3	C - AIHEC (39)	Started Y2Q3, Compl Y2Q3
RA 3.2.4	C-ASU (49)	Started Y2Q3, Compl Y2Q3
RA 3.2.5	C - NOAA (63)	Started Y2Q3, Compl Y4Q1
RA 3.2.5	RA - NCAR (76)	Started Y2Q4, Compl Y4Q1
RA 3.2.6	C- FRGP (106)	Started Y3Q2, Compl Y3Q2
RA 3.2.7	C - FRGP (110)	Started Y3Q2, Compl Y3Q2
RA 3.2.8	C- CSU/NOAA (116)	Started Y3Q3, Compl Y3Q3
RA 3.2.9 (NEW)	C- NOAA (166)	Started Y4Q1, Ongoing
RA 3.2.10 (NEW)	C- NIST (169)	Started Y4Q1, Ongoing
RA 3.3	LEARN/TACC RA/C	
RA 3.3.1	C - PVAMU (14)	Started Y1Q4, Compl Y2Q1
RA 3.3.2	C - TAMU (23)	Started Y2Q1, Compl Y2Q3
RA 3.3.3	C- Trinity (31)	Started Y2Q2, Compl Y2Q2
RA 3.3.4	C- PVAMU (36)	Started Y2Q2, Compl Y2Q3
RA 3.3.5	C- LEARN (62)	Started Y2Q3, Compl Y3Q4
RA 3.3.6	C - Baylor (66)	Started Y2Q4, Compl Y2Q4
RA 3.3.7	C- UTSA (69)	Started Y2Q4, Compl Y3Q2
RA 3.3.8	RA-Texas Tech (71)	Started Y3Q1, Compl Y3Q1
RA 3.3.9	RA-Arecibo (107) – formerly 4.57	Started Y2Q2, Compl Y4Q1
RA 3.3.10	C- TAMU (113)	Started Y2Q3, Compl Y4Q1
RA 3.3.11	C- TAMU (115)	Started Y2Q3, Compl Y3Q4
RA 3.3.12	C- LEARN (123)	Started Y2Q3, Compl Y3Q4
RA 3.3.13	C- TACC (135)	Started Y3Q4, Compl Y4Q1
RA 3.3.14	C- LEARN (145)	Started Y3Q4, Compl Y3Q4
RA 3.3.15	C- TAMUSA (155)	Started Y3Q4, Compl Y4Q1
RA 3.3.16 (NEW)	C- LEARN (162)	Started Y4Q1, Compl Y4Q1
RA 3.3.17 (NEW)	C- LEARN (167)	Started Y4Q1, Compl Y4Q1
RA 3.3.18 (NEW)	C- LEARN (170)	Started Y4Q1, Ongoing
RA 3.4	OARnet RA/C	

RA 3.4.1	C - UCinn (21)	Started Y2Q1, Compl Y2Q2
RA 3.4.2	C- OSC (32)	Started Y2Q2, Compl Y2Q3
RA 3.4.3	C- Kent (35)	Started Y2Q2, Compl Y3Q2
RA 3.4.4	C - Kent (51)	Started Y2Q3, Compl Y3Q3
RA 3.4.5	C - UHawaii-OSU (57)	Started Y2Q3, Compl Y3Q1
RA 3.4.6	C- UCinn (68)	Started Y2Q4, Compl Y2Q4
RA 3.4.7	C-Kent State (93)	Started Y3Q1, Compl Y3Q1
RA 3.4.7	C- Kent State (111)	Started Y3Q2, Compl Y3Q3
RA 3.4.8	C- U Miami (131)	Started Y3Q3, Compl Y3Q3
RA 3.4.9	C- KSU (144)	Started Y3Q4, Compl Y3Q4
RA 3.4.10	C- OARnet (151)	Started Y3Q4, Compl Y3Q4
RA 3.5	**GPN RA/C**	
RA 3.5.1	C - WSU (12)	Started Y1Q2, OBE Y1Q3
RA 3.5.2	C - UWisc-OneNet (25)	Started Y2Q1, Compl Y2Q1
RA 3.5.3	RA - Iowa-NCAR (27)	Started Y2Q1, Compl Y2Q3
RA 3.5.4	C- NDSU (48)	Started Y2Q3, OBE Y2Q4
RA 3.5.5	C- MSU Deep Dive (50)	Started Y2Q3, Compl Y3Q1
RA 3.5.6	RA SLU-Amazon (59)	Started Y2Q3, Compl Y3Q3
RA 3.5.7	C- U Missouri (61)	Started Y2Q3, Compl Y2Q3
RA 3.5.8	C- KanREN (65)	Started Y2Q3, Compl Y2Q4
RA 3.5.9	C- GPN (72)	Started Y2Q4, Compl Y3Q1
RA 3.4.10	C- OneNet (86)	Started Y3Q1, Compl Y3Q2
RA 3.4.11	C- UA (133)	Started Y3Q3, Compl Y3Q4
RA 3.4.12	C- OneNet (148)	Started Y3Q4, Compl Y3Q4
RA 3.4.13	C- SLU (153)	Started Y3Q4, Compl Y4Q1
RA 3.6	**KINBER RA/C**	
RA 3.6.1	C - F&M (17)	Started Y2Q1, Compl Y2Q1
RA 3.6.2	C - Duquesne (19)	Started Y2Q1, Compl Y2Q3
RA 3.6.3	C- Arcadia (29)	Started Y2Q2, Compl Y2Q2
RA 3.6.4	C- Penn State (42)	Started Y2Q2, Compl Y2Q2
RA 3.6.5	C- Duquesne (70)	Started Y2Q4, Compl Y2Q4
RA 3.6.6	C- Duquesne (73)	Started Y2Q4, Compl Y3Q3
RA 3.6.7	C- Penn State (87)	Started Y3Q1, Compl Y3Q2
RA 3.6.8	C- Lafayette (105)- Formerly 4.56	Started Y3Q2, Compl Y4Q1
RA 3.6.9	C- PSU (130)	Started Y3Q3, Compl Y3Q4
RA 3.6.10	C- Allegheny (132)	Started Y3Q3, Compl Y3Q3
RA 3.7	**ESIP RA**	Ongoing
RA 3.8	**ICNWG RA**	OBE
RA 3.9	**IU GC RA**	Ongoing
RA 3.10	**UHawaii RA**	Ongoing
RA 3.10.1	PANStarrs (1)	Compl Y1; 3x improvement
RA 3.10.2	U Hawaii (119)	Started Y3Q3, Compl Y3Q4
	See also RA 3.4.6	

RA 3.11	MWBDH RA	Ongoing
RA 3.12	OSN RA	OBE
RA 3.13	SoX RA	
RA 3.13.1	C- Vanderbilt (20) -prev. RA 4.11	Started Y2Q1, Compl Y2Q1
RA 3.13.2	C- U Southern Carolina (60) - prev. RA 4.32	Started Y2Q3, Compl Y2Q4
RA 3.13.3	C- ORNL (88)	Started Y3Q1, Compl Y3Q1
RA 3.14.4	C- SoX (129)	Starter Y3Q3, Compl Y3Q4
RA 3.14.5 (NEW)	C- SoX (168)	Starter Y4Q1, Compl Y4Q1
RA 3.15	Sun Corridor RA	
RA 3.15.1	Sun Corridor (81)	Started Y3Q1, Compl Y3Q3
RA 3.15.2	ASU (83)	Started Y3Q1, Compl Y3Q2
RA 3.15.3	ASU (99)	Started Y3Q2, Compl Y3Q2
RA 3.15.4	AZ Comm Colleges (118)	Started Y3Q3, Compl Y3Q4
RA 3.15.5	ASU (141)	Started Y3Q4, Compl Y3Q4
RA 3.15.6	ASU (143)	Started Y3Q4, Ongoing
RA 3.15.7	AMNH (160)	Started Y3Q4, Ongoing
RA 3.16	CENIC RA	
RA 3.16.1	Allen Inst (74) Formerly RA 4.35	Started Y2Q4, Compl Y3Q4
RA 3.16.2	LBNL (101) Formerly RA 4.52	Started Y3Q2, Compl Y3Q4
RA 3.16.3	Allen Inst (104) Formerly RA 4.55	Started Y3Q2, Compl Y3Q4
RA 3.16.4	Allen Inst (117)	Started Y3Q3, Ongoing
RA 3.16.5	UAF (142)	Started Y3Q4, Ongoing
RA 3.16.6	USC (146)	Started Y3Q6, Compl Y3Q4
RA 4	Other RA/C	
RA 4.1	LHC Pakistan (2)	Compl Y1; 10x improvement
RA 4.2	C - New York University School of Medicine (5)	Compl Y1
RA 4.3	C – AMNH (7)	Started Y1, Compl Y2Q2
RA 4.4	C- UF (8)	Compl Y1
RA 4.5	C- LSU Health (9)	Started Y2Q1, Compl Y2Q1
RA 4.6	C- SANReN (10)	Started Y2Q1, OBE Y2Q3
RA 4.7	C- PNNL (11)	Started Y2Q1, Y2Q4
RA 4.8	C - Compute Canada (13)	Compl Y1
RA 4.9	C- UC Merced (15)	Started Y2Q1, Compl Y2Q3
RA 4.10	C - LSU Health Deep Dive Templates (18)	Started Y2Q1, Compl Y2Q1
RA 4.11	Now RA 3.12.1	
RA 4.12	C - UWisc - MichSt (26)	Started Y2Q1, OBE Y2Q3
RA 4.13	C - UC Merced (28)	Started Y2Q1, Compl Y2Q1
RA 4.14	C- SANReN(30)	Started Y2Q2, Compl Y2Q2
RA 4.15	C- AMNH (33)	Started Y2Q2, Compl Y2Q3
RA 4.16	C- U Mich (34)	Started Y2Q2, Compl Y2Q4
RA 4.17	C- UNCG (37)	Started Y2Q2, Compl Y2Q4
RA 4.18	C- U Mich (38)	Started Y2Q3, Compl Y2Q3
RA 4.19	C- AAMU (40)	Started Y2Q3, OBE Y2Q3

RA 4.20	C- UC Davis (41)	Started Y2Q3, OBE Y2Q3
RA 4.21	C-MGHPC (43)	Started Y2Q3, Compl Y2Q3
RA 4.22	C-AMNH (44)	Started Y2Q3, OBE Y2Q4
RA 4.23	C - Wayne (45)	Started Y2Q3, Compl Y2Q3
RA 4.24	C- U Wisc (46)	Started Y2Q3, Compl Y2Q3
RA 4.25	C-UCentral FL (47)	Started Y2Q3, Compl Y2Q3
RA 4.26	C- U Montana (52)	Started Y2Q3, Compl Y2Q4
RA 4.27	C- CalTech (53)	Started Y2Q3, Compl Y2Q4
RA 4.28	C-Globus (54)	Started Y2Q3, Compl Y2Q3
RA 4.29	C- U Montana (55)	Started Y2Q3, Compl Y2Q4
RA 4.30	C- U Montana (56)	Started Y2Q3, Compl Y2Q4
RA 4.31	C-OSHEAN (58)	Started Y2Q3, OBE Y2Q4
RA 4.32	Now RA 3.12.2	
RA 4.33	C-U Southern California DMZ (64)	Started Y2Q3, Compl Y2Q4
RA 4.34	C - VA (67)	Started Y2Q4, Compl Y3Q1
RA 4.35	Now RA 3.16	
RA 4.36	C - Reed (75)	Started Y2Q4, Compl Y3Q4
RA 4.37	C - Compute Canada (77)	Started Y2Q4, Compl Y3Q1
RA 4.38	C - MIT (79)	Started Y2Q4, Compl Y2Q4
RA 4.39	C - UCentral FL (80)	Started Y2Q4, Compl Y3Q1
RA 4.40	SanREN (84)	Started Y3Q1, Compl Y3Q1
RA 4.41	MDREN (85)	Started Y3Q1, Compl Y3Q1
RA 4.42	OSHEAN (89)	Started Y3Q1, Compl Y3Q1
RA 4.43	UCSC-ASTAR (90)	Started Y3Q1, Compl Y3Q2
RA 4.44	RNP (91)	Started Y3Q1, Compl Y3Q2
RA 4.45	UCF (92)	Started Y3Q1, Compl Y3Q3
RA 4.46	NLM/ASGC (94)	Started Y3Q1, Compl Y3Q3
RA 4.47	CCNY/JGN (95)	Started Y3Q1, Compl Y3Q4
RA 4.48	Yale (96)	Started Y3Q1, Compl Y3Q2
RA 4.49	UCF (97)	Started Y3Q1, Compl Y3Q2
RA 4.50	126.com (98)	Started Y3Q2, Compl Y3Q2
RA 4.51	EBI (100)	Started Y3Q2, Compl Y3Q3
RA 4.52	Now RA 3.16.3	
RA 4.53	USDA (102)	Started Y3Q2, Compl Y3Q4
RA 4.54	VRO/LSST (103)	Started Y3Q2, Compl Y3Q2
RA 4.55	Now RA 3.16.3	
RA 4.56	Now RA 3.6.8	
RA 4.57	Now RA 3.3.10	
RA 4.58	KAUST (108)	Started Y3Q2, Compl Y3Q4
RA 4.59	NIH (109)	Started Y3Q2, Compl Y3Q3
RA 4.60	U South Carolina (112)	Started Y3Q2, Compl Y3Q4
RA 4.61	NYU (114)	Started Y3Q3, Compl Y3Q4
RA 4.62	Yale (120)	Started Y3Q3, Compl Y3Q4

RA 4.63	EHT (121)	Started Y3Q3, Ongoing
RA 4.64	SUNY Medical (122)	Started Y3Q3, Compl Y3Q4
RA 4.65	Oregon State (124)	Started Y3Q3, Compl Y3Q4
RA 4.66	WSU (125)	Started Y3Q3, Compl Y3Q4
RA 4.67	KAUST (126)	Started Y3Q3, Compl Y3Q3
RA 4.68	HHU (127)	Started Y3Q3, Compl Y3Q3
RA 4.69	EBI/ NYGC (128)	Started Y3Q3, Compl Y3Q4
RA 4.70	U Miss (134)	Started Y3Q3, Compl Y3Q4
RA 4.71	Yale (136)	Started Y3Q4, Compl Y3Q4
RA 4.72	SingaREN (137)	Started Y3Q4, Compl Y3Q4
RA 4.73	SingaREN (138)	Started Y3Q4, Compl Y3Q4
RA 4.74	PPPL (139)	Started Y3Q4, Compl Y3Q4
RA 4.75	SingaREN (140)	Started Y3Q4, Compl Y3Q4
RA 4.76	SARAO (147)	Started Y3Q4, Ongoing
RA 4.77	Arecibo (149)	Started Y3Q4, Compl Y3Q4
RA 4.78	UNC-C(150)	Started Y3Q4, Compl Y3Q4
RA 4.79	Brown (152)	Started Y3Q4, Compl Y4Q1
RA 4.80	NyserNet (154)	Started Y3Q4, Compl Y4Q1
RA 4.81	HARNET (156)	Started Y3Q4, Compl Y3Q4
RA 4.82	Syracuse (157)	Started Y3Q4, Compl Y4Q1
RA 4.83	NYULH (158)	Started Y3Q4, Compl Y4Q1
RA 4.84	Yale (159)	Started Y3Q4, Compl Y4Q1
RA 4.85	RPI (161)	Started Y3Q4, Compl Y4Q1
RA 4.86 (NEW)	Yale (163)	Started Y4Q1, Compl Y4Q1
RA 4.87 (NEW)	KNU (164)	Started Y4Q1, Compl Y4Q1
RA 4.88 (NEW)	NII *165)	Started Y4Q1, Compl Y4Q1
DD	**DEEP DIVE**	
DD.1	Adaptation of ESnet facility deep dive process for use with applications	Compl Y1
DD.2	Over project period, goal is to offer at least 2 deep dives per regional partner	Ongoing
DD.2.1	iLight Deep Dives	Ongoing
DD 2.1.1	Purdue University	Compl - Event Y2Q1, report Y2Q3
DD.2.2	FRGP Deep Dives- Also includes NOAA	Ongoing
DD 2.2.1	NOAA and NASA Deep Dive (with Training)	Compl Y1
DD 2.2.2	Now DD 2.13.1	
DD 2.2.3	N Arizona	OBE (COVID)
DD 2.2.4	NOAA Virtual	Virtual started Y3Q4
DD 2.3	LEARN Deep Dives	Ongoing
DD 2.3.1	Trinity University	Compl - Event Y2Q1, report Y2Q3
DD 2.3.2	Baylor	Compl - Event Y2Q4, report Y3Q4
DD 2.3.2	TAMUSA	Virtual started Y3Q4
DD 2.4	OARnet Deep Dives	Ongoing

DD 2.4.1	University of Cincinnati	Compl - Event Y2Q1, report Y2Q3
DD 2.5	GPN Deep Dives	Ongoing
DD 2.5.1	Training - KSU Agronomy	Compl - Event Y2Q1, report Y2Q3
DD 2.5.2	University South Dakota	Virtual started Y3Q4
DD 2.6	KINBER Deep Dives	Ongoing
DD.2.6.1	Arcadia Bioinformatics (with training)	Compl - Event Y2Q1, report Y2Q2
DD 2.7	ESIP DD	Ongoing
DD 2.8	ICNWG DD	OBE
DD 2.9	IU GC RDD	Ongoing
DD 2.10	UHawaii DD	Ongoing
DD 2.11	MWBDH DD	Ongoing
DD 2.12	OSN DD	OBE
DD 2.13	SCN Deep Dive	
DD 2.13.1	Arizona State/Sun Corridor	On hold (COVID)
DD.3	Other Deep Dives	Ongoing
DD.3.1	QUILT/University Maryland (with Training)	Compl Y1
DD.3.2	University of Wisconsin	Event Y2Q1, report expected Y3Q1
DD 3.3	PEARC'19	Compl (no report)
DD 3.4	Oregon State Univ	On hold (COVID)
DD 3.5	Quilt Briefing	Compl Y2Q4
DD 3.6	University Central Florida	Virtual started Y3Q4
NS	NETSAGE	NOTE: Renumbering took place in Y2Q2
NS.1	NetSage prototypes for regional partners	Ongoing
NS1.1	NetSage for iLight	Ongoing
NS 1.1.1	SNMP for iLight	Not needed
NS 1.1.2	Flow for iLight	Initial Y2Q1, Ongoing support
NS 1.2	NetSage for FRGP	Ongoing
NS 1.2.1	SNMP for FRGP	Discussion Ongoing
NS 1.2.2	Flow for FRGP	Initial Y2Q4, Ongoing support
NS 1.2.3	Tstat for NOAA	Compl -Deployed Y2Q1, OBE
NS 1.2.4	Tstat for NCAR	Compl Y2Q2
NS 1.3	NetSage for LEARN/TACC	Ongoing
NS 1.3.1	SNMP for LEARN	Discussion Year 3
NS 1.3.2	Flow for LEARN	Discussion Year 3
NS 1.3.3	Tstat on TACC archives	Compl Y1, updated Y2
NS 1.3.4	SNMP for TACC	Discussion ongoing
NS 1.3.5	Flow for TACC	Initial Y3Q2, Ongoing support
NS 1.4	NetSage for OARnet	Ongoing
NS 1.4.1	SNMP for OARnet	OBE

NS 1.4.2	Flow for OARnet	OBE
NS 1.5	NetSage for GPN	Ongoing
NS 1.5.1	SNMP for GPN	Initial Y1, Ongoing support
NS 1.5.2	Flow for GPN	Initial Y2Q2, Ongoing support
NS 1.6	NetSage for KINBER	Ongoing
NS 1.6.1	SNMP for KINBER	OBE
NS 1.6.2	Flow for KINBER	Initial Y2Q3, Ongoing support
NS 1.7	NetSage for Sun Corridor Network (SCN)	Ongoing
NS 1.7.1	SNMP for SCN	Discussion Ongoing
NS 1.7.2	Flow for SCN	Initial Y3Q4, ongoing support
NS 1.8	NetSage for SoX	Ongoing
NS 1.8.1	SNMP for SoX	Discussion Ongoing
NS 1.8.2	Flow for SoX	Initial Y3Q3, Ongoing support
NS 1.9	NetSage for CENIC/ Pacific Wave	Ongoing
NS 1.9.1	SNMP for CENIC	Transition from IRNC Y3Q4
NS 1.9.2	Flow for CENIC	Transition from IRNC Y3Q4
NS 2	NetSage deployments related to other partners	Ongoing
NS 2.1	University Hawaii	Ongoing
NS 2.1.1	Tstat on Astronomy Archive	Compl Y2Q1, ongoing support
NS 3	Adaptation of NetSage analysis for network disturbance detection	Ongoing
NS 3.1	Examine COVID-related data transfer performance	Started Y3Q1, Ongoing
D/P	Data Mobility Exhibition	Note: Restructured Y3Q1
DP 1	Data Mobility Exhibition Setup	Ongoing
DP 2	Data Mobility Exhibition Support	Ongoing
MS	MANAGED SERVICE	Note: Numbering reworked Y2Q3
MS 1	Define Managed Services	Ongoing
MS 1.1	Define perfSONAR Managed Service (PS MS)	Started Y1, Ongoing
MS 1.2	Define DMZ Managed Service (DMZ MS)	Delayed (COVID)
MS 1.3	Define Data Transfer Managed Service (DT MS)	Delayed (COVID)
MS 1.4	Tester Managed Service	Definition Compl Y2
MS 1.5	Portal Prototype Development	Ongoing
MS2	MS deployments	Ongoing
MS 2.1	iLight MS	TBD
MS 2.2	FRGP MS	TBD
MS 2.2.1	PS MS for Tribal Colleges	Completed Y2
MS 2.3	LEARN MS	Underway Y2
MS 2.3.1	LEARN DMZ MS	Delayed (COVID)

MS 2.3.2	LEARN DT MS	Delayed (COVID)
MS 2.3.3	Portal with Baylor (LEARN)	On hold
MS 2.4	OARnet MS	TBD
MS 2.4.1	OARnet DT MS	OBE
MS 2.4.2	Testset Loan to Kent State	OBE
MS 2.5	GPN MS	TBD
MS 2.5.1	GPN and KanREN DT MS	Delayed (COVID)
MS 2.5.2	Portal wirth GPN member	On hold
MS 2.6	KINBER MS	Started Y1, Ongoing
MS 2.6.1	KINBER and Arcadia PS MS	Completed Y3Q4
MS 2.6.2	Testset Loan to Duquesne	OBE
MS 2.7	Other MS Deployments	Ongoing
MS 2.7.1	U Hawaii Astronomy Data Portal MS	On hold
T	TRAINING	
T 1	Set up public site for training materials	Compl Y1
T 2	Technical training	Ongoing
T 2.1	SOX - perfSONAR	Compl Y1
T 2.2	GPN LCI - perfSONAR, DMZ	Compl Y2Q1
T2.3	LEARN - PS, DMZ, DTN, Security	Compl Y2Q1
T 2.4	NWT Star/FRGP - PS, DMZ, DTN, Security	Compl Y2Q2
T 2.5	CyberTraining w/USC -PS, DMZ, DTN, Engagement	Compl Y2Q2
T 2.6	Managed Service PS with KINBER, Arcadia	Delayed (COVID)
T 2.7	CyberTraining w/USC - BGP, PS, DMZ	Compl Y3Q1 (virtual)
T 2.8	CyberTraining w/USC - BGP, PS, DMZ	Delayed Y3Q3 (virtual)
T 2.9	PS Training for LEARN	Compl Y3Q2 (virtual)
T 2.10	CyberTraining w/USC - BGP, PS, DMZ for SoX	Compl Y3Q4 (virtual)
T 2.10	LEARN PS train with lab	Compl Y3Q4 (virtual)
T 2.11 (NEW)	USC Cyber Training April 2021	Compl Y4Q1 (virtual)
T 2.12 (NEW)	GPN PS training	Compl Y4Q1 (virtual)
T 2.13	LEARN PS train	Compl Y4Q1 (virtual)
T 3	Deep Dive training	Ongoing
T3.1	NOAA DD Training	Compl Y1
T 3.2	QUILT DD Training	Compl Y1
T 3.3	KINBER DD Training	Compl Y2Q1
T 3.4	GPN DD Training	Compl Y2Q1
T 3.5	PEARC DD Training	Compl Y2Q2
T 3.6	Quilt DD Training	OBE (changed to overview on request)
T 3.7	DD Training 6	TBD (COVID)
T 3.8	DD Training 7	TBD (COVID)

T 4	Other Related General Activities	TBD as requested by community
T 4.1	Finding Researchers	iLight - Compl Y2Q1
T 4.2	Data Mobility Expo	Compl Y2Q2
T 4.3	BGP BOF at I2 TechEx	Compl Y2Q3
T 4.4	BGP BOF at I2 Global Summit	Delayed (COVID)
T 4.5	PS NSRC Updates	Compl Y3Q4
T 4.6	10G Easy DTN Video	Started Y3Q1, ongoing
T 5	Reworking Training during COVID	Ongoing
T 5.1	New plan development	Ongoing