South American - African Astronomy Coordination Committee (SA3CC) Meeting Report

April 30 - May 1, 2024

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Executive Summary

This report documents the proceedings of the AmLight SA3CC Meeting, on April 30 – May 1, 2024, from the astronomy community and the Research & Education Networks (REN) of the AmLight project. Researchers from universities, organizations and research institutions from the USA, Latin America, Africa, and Europe participated. The SA3CC Meeting was comprised of two sessions: Science Requirements & Activities Updates, and Providers Updates.

The Science Requirements & Activity updates session started with welcome remarks and an introduction by Co-Chair Julio Ibarra followed by presentations from the Vera C. Rubin Observatory, NOIRLab, NRAO, ALMA, FYST (a.k.a. CCAT), Simons Observatory, CMB-S4, EHT, US-ELT, GMTO, and ngVLA, after which a lively Open Discussion followed. The Providers Updates session included network presentation updates from the Vera Rubin Observatory Network, SANReN/TENET Network, SKA, GÉANT, AmLight-ExP, REUNA, RedCLARA, RNP, rednesp, USDF, Internet2, and ESnet, with another Open Discussion concluding the session.

1 Introduction

1.1 SA3CC Meeting

The South American-African Astronomy Coordination Committee (SA3CC) is comprised of representatives from the various astronomy projects that conduct science and operate observatories in the Americas and Africa. The SA3CC meeting was hosted in-person and virtually by the SLAC National Accelerator Laboratory on April 30-May 1, 2024, from 9am to 5pm to accommodate the different time zones. The meeting program can be found here: SA3CC Meeting 2024.

The two-day meeting gathered 47 astronomy researchers and network engineers (See Appendix A & C for the agenda and participants list). Presentations and lively discussion took place among representatives from the astronomy community, as well as Research and Education Networks, of which the following organizations were in attendance:

- **A**rgentine **I**nstitute of **R**adio-astronomy (IAR)
- **C**herenkov **T**elescope **A**rray **O**bservatory (CTAO)
- **C**osmic **M**icrowave **B**ackground – **S**tage **4** (CMB-S4)
- **C**ouncil for **S**cientific and **I**ndustrial **R**esearch (CSIR)
  - **S**outh **A**frican **N**ational **Re**search **N**etwork (SANReN)
  - **T**ertiary **E**ducation and Research **Net**work of South Africa (TENET)
- **E**nergy **S**ciences **Net**work (ESnet)
- **E**vent **H**orizon **T**elescope (EHT)
  - MIT Haystack Observatory
- **F**lorida **I**nternational **U**niversity (FIU)
  - **Am**ericas Africa **Light**paths (AmLight)
  - **C**enter for **I**nternet **A**ugmented **R**esearch and **A**ssessment (CIARA)
- **F**red **Y**oung **S**ubmillimeter **T**elescope, a.k.a. **C**erro **C**hajnantor **A**tacama **T**elescope (FYST/CCAT)
- **G**iant **M**agellan **T**elescope **O**rganization (GMTO)
- **G**igabit **E**uropean **A**cademic **N**e**t**work (GÉANT)
- **I**ndiana **U**niversity (IU)
  - **Global** **N**etwork **O**perations **C**enter (GlobalNOC)
- Internet2
- **K**orea **I**nstitute of **S**cience and **T**echnology **I**nformation (KISTI)
- Latin American Cooperation of Advanced Networks (RedCLARA)
- **L**awrence **B**erkeley **N**ational **L**aboratory (LBNL)

- Brazilian National Education and Research Network (RNP)
- **N**ational **R**adio **A**stronomy **O**bservatory (NRAO)
  - **A**tacama **L**arge **M**illimeter/submillimeter **A**rray (ALMA)
  - **N**ext-**G**eneration **V**ery **L**arge **A**rray (ngVLA)
- **N**ational **S**cience **F**oundation (NSF)
  - **N**ational **O**ptical-**I**nfrared Astronomy **R**esearch **Lab**oratory (NOIRLab)
- Chilean National University Network (REUNA)
- São Paolo State University (Unesp)
  - **R**esearch and **Ed**ucation **Ne**twork of **S**ão **P**aolo (rednesp)
- Simons Foundation
- **SLAC** National Accelerator Laboratory, a.k.a. **S**tanford **L**inear **A**ccelerator **C**enter (SLAC)
  - **U**nited **S**tates **D**ata **F**acility (USDF)
- **S**quare **K**ilometer **A**rray (SKA)
- **T**exas **A**dvanced **C**omputing **C**enter (TACC)
- **U**nited **S**tates **E**xtremely **L**arge **T**elescope **P**rogram (US-ELTP)
- **U**niversity of **Penn**sylvania (UPenn)
- **U**niversity of **S**ão **P**aolo (USP)
- **U**niversity of **S**outh **C**alifornia **I**nformation **S**ciences **I**nstitute (USC-ISI)
- Vera C. Rubin Observatory, a.k.a. **L**arge **S**ynoptic **S**urvey **T**elescope (LSST)

1.2 Vera C. Rubin NET Meeting

The Vera C. Rubin Network Engineering Taskforce (NET) annual meeting took place on May 2-3, 2024, from 9am to 5pm following the SA3CC meeting. The NET meeting has the objective of continuing the planning, development, and deployment of a collaborative purpose-built network to support the needs of the Vera Rubin Observatory in Chile.

The two-day meeting gathered 29 network engineers from the following institutions (See Appendix B & D for the agenda and participants list): ESnet, Fermilab, FIU AmLight, French National Center for Scientific Research (CNRS), French National Institute of Nuclear and Particle Physics (IN2P3), GÉANT, GlobalNOC, NSF NOIRLab, RedCLARA, REUNA, RNP, SLAC, USP, and Vera C. Rubin Observatory.

2 Goals and Objectives of the AmLight SA3CC Meeting

AmLight-ExP builds upon the results of the WHREN-LILA project, Award# OCI-0441095, and the AmLight IRNC projects, Award# OCI-0963053. Over the last 15 years, these projects have effectively fostered a cooperative and collaborative consortium among R&E network providers and users in the Western Hemisphere. The success of previous U.S. & Latin American networking activities has led to a groundswell of change for research instruments. Data-intensive and data *dependent* instruments operate in South America and South Africa, with new projects in the pipeline. The Vera Rubin Observatory is a significant example of a data-dependent instrument and has from the beginning been part of the planning for AmLight-ExP (NSF award # 1451018 and #2029283). The focus of AmLight-ExP is an open instrument for collaboration that interconnects open exchange points. AmLight-ExP provides a means to leverage collaborative provisioning and network operations that effectively maximize the benefits to all members of the consortium. AmLight-ExP manages the NSF investment in the context of leveraging international partnerships to attain the greatest benefits for all participants (See Appendix A and C for the Agenda and Participants List, respectively). A key goal of the SA3CC meeting is to gather input and collect information from participants about the activities of the astronomy projects and the R&E networks supporting them.

3 Activities of the SA3CC Meeting

The meeting was organized in two sessions and presentations (See appendix A) from the following institutions were included:

3.1 Science Requirements & Activities Updates

- Vera C. Rubin Observatory Operations (Bob Blum)
- NOIRLab – ITOPS (Eduardo Toro)
- ALMA – NRAO Data Transfer (Sanford George)
- ALMA Communication Infrastructure (Jorge Ibsen)
- Simons Observatory (Simone Aiola)
- FYST/CCAT (Mike Nolta)
- CMB-S4 (Eli Dart)
- EHT (Jason SooHoo)
- US-ELTP (Lucas Macri)
- GMTO (Sam Chan)
- ngVLA (David Halstead)

3.2 Research and Education (R&E) Network Providers Updates

- Vera C. Rubin Observatory Network (Cristian Silva)
- South African NREN Connectivity (Renier van Heerden)
- GÉANT – SKA Observatory R&E Networks (Richard Hughes-Jones)
- GÉANT – European and Intercontinental Network Infrastructure (Richard Hughes-Jones)
- AmLight1: Network Connectivity (Jeronimo Bezerra)
- AmLight2: Monitoring and Measurement Improvements (Renata Frez)
- REUNA (Albert Astudillo)
- RedCLARA (Marco Teixeira)
- RNP (Aluizo Hazin)
- rednesp (Ney Lemke)
- Vera C. Rubin Observatory Multi-Site Testing (Richard Dubois)
- Vera C. Rubin Observatory US Data Facility (Matthew Mountz)
- Internet2 (Chris Wilkinson)
- ESnet (Kate Robinson)

4 Science Requirements & Activities Updates

Section 4 summarizes the updates presented by each of the astronomical observatories.

4.1 Vera C. Rubin Observatory Operations (Bob Blum)

The Vera C. Rubin Observatory is progressing towards its primary objective of delivering the Legacy Survey of Space and Time (LSST) to its scientific community. This extensive project aims to capture hundreds of images of the Southern Hemisphere sky every night for a decade, with the purpose of creating a 500 petabyte dataset that aims advance research in four key scientific areas:

- Understanding dark matter and dark energy
- Creating an inventory of the Solar System
- Mapping the Milky Way
- Exploring the transient optical sky. The observatory is on track to achieve this through the Rubin Operations Plan.

A significant component of the observatory, the LSSTCam, is scheduled to be transported to Chile from the SLAC facility in May 2024, to be installed in the large-aperture, wide-field Simonyi telescope located in Cerro Pachón. Initial tests have shown excellent performance, with previous technical issues, such as vacuum integrity, being successfully resolved. Provided the commissioning and installation processes go smoothly, full operation is expected to commence in the latter half of 2025.

Recent updates highlight the satisfactory performance of the Simonyi Telescope, and the successful coating of the Primary and Tertiary mirrors that will be installed. An Operations Rehearsal for Commissioning has been conducted to simulate regular operations, testing the observatory's capacity to take observations and process data, with another rehearsal expected to take place before the commissioning camera (ComCam) is installed. Three Rubin Data Facilities—located in the U.S., France, and the UK—are being developed to manage and process the extensive data generated, with tasks including prompt processing, data release processing, and long-term storage.

Key goals for the second half of 2024 include the continued enhancement of the U.S. Data Facility, along with connecting all three data facilities together, and completing the installation of the secondary mirror and ComCam by mid-year. The LSSTCam is slated for installation on November 2024, with first light expected in early 2025, paving the way for the LSST survey to begin in earnest in late 2025.

4.2 NOIRLab – ITOps (Eduardo Toro)

The National Science Foundation's (NSF) National Optical-infrared Astronomy Research Laboratory (NOIRLab) is the national center for ground-based, nighttime optical astronomy in the United States. Comprised of five programs:

- The Cerro Tololo Inter-American Observatory (CTIO) in La Serena, Chile
- The Community Science and Data Center (CSDC) in Tucson, Arizona, USA
- The International Gemini Observatory (IGO) in Hilo, Hawaii, USA and Cerro Pachón, Chile
- Kitt Peak National Observatory (KPNO) in Arizona, USA
- The Vera C. Rubin Observatory (upcoming) in Cerro Pachón, Chile

NOIRLab aims to advance humanity's understanding of the Universe by exploring key areas of astrophysics such as dark matter, galaxies, and exoplanets. The IT Operations (ITOps) group within NOIRLab plays a crucial role in managing information technology and scientific operations, ensuring that infrastructure, networking, and cybersecurity are robust and effective.

The agenda for NOIRLab highlighted several key topics, including a discussion of IT operations, a recent cybersecurity incident, backbone network activities, program integration efforts, and a network upgrade project, with the primary topic discussed being the cyber-attack and the subsequent response. The incident occurred on August 1, 2023, where systems were compromised but quickly interrupted within the first 40 minutes. The incident response plan included immediate detection, engaging external experts, investigating and remediating the damage, and hardening infrastructure. This subsequently led to the prioritization of planning security enhancements, including secure account management with Role-Based Access Control (RBAC), privileged access management, multi-factor authentication, and stringent remote access protocols. The backbone network activities included efforts at various centers. At the La Serena Center, work focused on fixing Access Control Lists (ACLs) in the border router and ensuring the fiber links between key locations were stable. In Tucson, evaluations of Internet2 link bandwidth with Sun Corridor were in progress, and fiber optics recovery efforts from a previous fire were completed. At the Hilo Center, Internet2 links between the Hilo Center and Hawaii University, as well as Mauna Kea, were functioning as normal.

Program integration efforts within NOIRLab aim to support partners through the CSDC by developing resilient and secure services and offloading system administration tasks. Integration between the Gemini observatories and the Mid-Scale Observatories (CTIO and KPNO) continues to improve through the implementation of secure interconnections between the two programs, as well as leveraging IT infrastructure to enhance services.

Finally, NOIRLab's ongoing network upgrade project includes the completion of the LAN design for the Tucson Center, with equipment procurement underway, and a pending Wi-Fi upgrade for the La Serena Center. Wide-Area Network (WAN) design updates include enhancements to VPN site-to-site matrices, in addition to Next Generation Firewalls (NGFs) and border router standardization to ensure high availability and redundancy across all locations.

4.3 Data Transfer from ALMA to North America (Sanford George)

ALMA, the Atacama Large Millimeter/Sub-millimeter Array, is the largest astronomical project currently in existence. Located on Chile's Chajnantor Plateau, it operates with 66 antennas as an interferometer and has the ability observe multiple projects simultaneously by creating sub-arrays. It is currently supported by three ALMA Regional Centers (ARCs):

- The National Radio Astronomy Observatory (NRAO) in Charlottesville, VA, USA
- The European Southern Observatory (ESO) in Garching, Germany
- The National Astronomical Observatory of Japan (NAOJ) in Mitaka, Japan

After experiencing a seven-week interruption due to a ransomware attack, leading to significant cybersecurity investments, the latest cycle of observations began in October 2023, after proposal calls were completed in April 2023. The ALMA Correlator supercomputer plays a crucial role in converting signals from the antennas into viewable images, handling data outputs between 6 and 60 MBps. Data from the ALMA telescope flows from its antennas to the Correlator, through the Operations Support Facility (OSF), and then to the Santiago Central Office (SCO) before being distributed to the ARCs. A joint agreement between Associated Universities Incorporated (AUI) and the Association of Universities for Research in Astronomy (AURA) ensures a data link between SCO and NRAO with a 1Gbps connection, burstable up to 10Gbps. Although peak data transfer rates typically reach 300Mbps, there have been bursts up to 600Mbps. This reduced network activity is due to most data processing being conducted in the SCO.
The second generation of the ALMA Correlator, known as the Advanced Technology ALMA Correlator (ATAC), is expected to be completed around 2028 as part of the ALMA2030 Wideband Sensitivity Upgrade. This new correlator, located in the OSF and separate from the original, will support upgraded

ALMA receivers with larger bandwidth capabilities. As data sizes continue to grow, with download sizes potentially reaching between 1TB and 125TB during upgrades, annual data transfers are expected to reach between 3.6 and 6.6PB by the 2030s.

Disaster recovery remains a concern, with the current North American ALMA archive holding about 1.3PB of data. In case of data loss, recovery from the main archive in Santiago could take nearly six months with to the current 1Gbps link. While ALMA's data rates have increased more slowly than anticipated, providing time for necessary upgrades, a 10Gbps link is needed within the next one to two years to improve data transfer speeds. This upgrade is especially crucial for handling large datasets and database exports. Most new developments, including the ATAC, are manageable without significantly increasing data rates, which would need to be boosted by only a factor of four.

4.4 ALMA Communication Infrastructure / EVALSO 2.0 (Jorge Ibsen)

The agenda for the ALMA network and communication infrastructure covered several key topics, including the current state of ALMA's network, plans for upgrading the Optical Transport Network (OTN) by the end of 2024, and efforts to support other observatories in the Chajnantor region.

Enabling Virtual Access to Latin-America Southern Observatories (EVALSO) is a project that builds the fiber infrastructure between Antofagasta and the European Southern Observatory (ESO) campus in Santiago. The original partners were ESO, REUNA (who manages the Dense-Wavelength-Division Multiplexing (DWDM) equipment), and Telefónica (who provided fiber, Lambdas, and housing). This infrastructure supports networking access for ALMA, ESO, and the Observatory Cerro Amazonas (OCA) with a shared 10Gbps link.

Currently, ALMA's global network relies on an Optical Transport Network (OTN) using DWDM equipment originally supported by the EVALSO project to connect its Array Operations Site (AOS) and Santiago Central Office (SCO). The network includes a Dark Fiber link between AOS and the Operations Site Facility (OSF) and a backup Microwave Link from OSF to SCO. SCO is further connected to the world through ALMA Regional Centers (ARCs) in North America, the EU, and East Asia. The communication infrastructure features a Dark Fiber pair between AOS and Calama, a dedicated Lambda link between Calama and Antofagasta, and a sub-Lambda link from Antofagasta to Santiago, all managed by REUNA.
With the EVALSO project completed, there is a need to upgrade the current OTU-2 DWDM network to a more robust OTU-4 system. The new backbone will maintain a DWDM-based OTN between Antofagasta and Santiago, managed by REUNA, and will upgrade from a 1Gbps to a 100Gbps network. The integration will include networks for ESO Paranal and ALMA, with the addition of multiple 10Gbps channels. The new ALMA DWDM scope involves upgrading links and equipment across four segments: ALMA-AOS to Calama, Calama to Antofagasta, Antofagasta to Santiago, and Santiago to ALMA-SCO, all of which will transition to OTU-4 with a standardized DWDM equipment setup.

ALMA is also working to assist other observatories on the Chajnantor Plateau with their communication needs. This includes establishing a Memorandum of Understanding (MoU) with REUNA to create a Point of Presence (PoP) at AOS, facilitating network operations for other observatories. Specific agreements have been made to share unused infrastructure resources, enabling minimal impact on the plateau while connecting observatories like the Atacama Astronomical Park (PAA), Fred Young Submillimeter Telescope (FYST/CCAT), and Tokyo Atacama Observatory (TAO).

4.5 Fred Young Submillimeter Telescope, a.k.a. Cerro Chajnantor Atacama Telescope (Mike Nolta)

The Fred Young Submillimeter Telescope (FYST), formerly known as CCAT-prime, is a groundbreaking project led by Cornell University, with contributions from universities including Arizona State University, Cardiff University, the University of Chicago, and the University of Pennsylvania. It is part of a broader consortium that includes universities from Canada, Germany, and Chile, such as the University of Cologne, Max Planck Institute for Astrophysics, McGill University, and the Pontificia Universidad Católica de Chile, among others. FYST, situated on the Chajnantor plateau in Chile, near the ALMA observatory, is designed to be the highest throughput submillimeter telescope ever constructed, operating with a frequency range of 210GHz to 850GHz. The telescope features a 6-meter mirror, high surface accuracy, and precise pointing capabilities, with first light expected in 2026.

FYST will be equipped with several advanced instruments, including the CCAT Heterodyne Array Instrument (CHAI) and Prime-Cam. CHAI is a multi-pixel heterodyne spectrometer that covers two frequency bands and aims to study galactic ecology, star formation, and interstellar medium chemistry. Prime-Cam, a large cryostat-cooled camera, features broadband polarimeter modules and spectrometers designed to study the epoch of reionization, galaxy evolution, cosmic microwave background (CMB) foregrounds, and other phenomena. A scaled-down version of Prime-Cam, known as Mod-Cam, will be tested ahead of its full deployment.

Located at an elevation of 5,612 meters on the eastern slope of Cerro Chajnantor in Chile, has been strategically sited to leverage the optimal atmospheric conditions for submillimeter astronomy. This location offers significantly lower levels of precipitable water vapor (PWV) compared to other major observatories, including the nearby ALMA site. PWV levels are 36% lower than those at the ALMA plateau and can be up to 80% lower in certain regions, making the site twice as effective for observations at the 350μm wavelength as the South Pole. These factors combine to create one of the most favorable environments globally for submillimeter observations, particularly at critical wavelengths, providing a unique advantage for high-precision astronomical research.

The extreme altitude, while beneficial for observing, presents substantial operational and logistical challenges. Chilean regulations governing work at elevations above 5,500 meters require rigorous health and safety protocols, including annual medical evaluations to ensure workers' fitness for the conditions of hypobaria (low atmospheric pressure). Due to the difficulties of accessing such heights, fuel companies do not perform regular deliveries, necessitating a remote power generation solution. Power generators are thus located at the CCAT/TAO service area, situated at a lower altitude, with power lines extending to the observatory.

Alongside the power infrastructure, an agreement has been finalized with the ALMA observatory to connect two dark fiber cables from the CCAT/TAO service area to the ALMA Operations Site (AOS) to facilitate high-speed data transmission. This installation has been fully completed, and enables the telescope to link to REUNA's PoP. Once operational, FYST's primary instruments, CHAI and Prime-Cam, will transmit data at high rates to various international institutions. CHAI will deliver data to the University of Cologne at a rate of approximately 685 Mbps daily, while Prime-Cam will send data to Cornell University at 386 Mbps daily. Both instruments will also transmit data to the University of Toronto at a rate of 13 Mbps per day. Initial network performance tests have shown strong results overall, though some packet loss was observed during UDP down tests between ALMA and Toronto.

The FYST telescope is scheduled to be fully assembled in Germany by July 2024, with shipment to Chile expected by the end of that year. The final assembly and commissioning will take place in Chile, with acceptance of the telescope anticipated by the end of 2025. Full scientific operations are projected to begin in early 2026, with FYST expected to generate approximately 3-8TB of data per day, or about 1PB annually.

4.6 Simons Observatory (Simone Aiola)

The Simons Observatory Collaboration, initially funded by the Heising-Simons Foundation, began with the Simons Observatory Nominal Project and later expanded with additional support from the National Science Foundation (NSF), the Japan Society for the Promotion of Science (JSPS), and UK Research and Innovation (UKRI). The observatory's telescopes include the Small Aperture Telescopes (SATs), which will survey low-dust regions to detect Large-Scale B-modes in the Cosmic Microwave Background, potentially revealing cosmic inflation. The Large Aperture Telescope (LAT) will contribute to a wide array of cosmological research, including studies on primordial perturbations, neutrino mass, and dark energy, by observing 40% of the sky.

The observatory will be situated on the Chajnantor plateau in Chile, chosen for its low levels of ambient water vapor. The LAT will feature a 6-meter primary mirror, an 8° field-of-view, and a resolution of 1.5 arc-minutes at 150GHz, making it the largest cryogenic camera ever built for CMB experiments. Although mirror delays have pushed back scientific observations to 2025, the SATs — each with a 42cm aperture — have already been installed, with two having successfully begun their search for B-modes.

The observatory's timeline includes ongoing observations with the SATs, with sensitivity expected to improve over time, reducing errors in the tensor-to-scalar ratio, a crucial part of B-mode detection. The LAT, once fully equipped with seven optics tubes, will begin observations in 2025 and continue through to 2028, with NSF's Advanced SO Project providing six additional optics tubes for extended research into the 2030s. The NSF is also supporting Simons Observatory's data management, allowing for the release of data to the general public within six months, and transient data in fewer than 30 hours. Additionally, the NSF will supply solar power to the observatory, covering 70% of its total power consumption needs. The JSPS and UKRI are set to contribute a total of three additional SATs, to be deployed in 2026.

The Simons Observatory follows an open-source philosophy regarding its software development, with most of its software packages available on their GitHub page. Many of the observatory's various tools are being developed in-house, including an observatory control system, computing infrastructure, and data processing libraries. Regarding data management, a "librarian" data transfer manager was created, currently in testing, which supports both physical media transfers (SneakerNet) and fiber-optic data transmission. Collaboration with the Cosmic Microwave Background State 4 (CMB-S4) team is also underway, that will be needed for a scaled up version of the implementation.

4.7 Cosmic Microwave Background – Stage 4 (Eli Dart)

CMB-S4 is the fourth generation of ground-based cosmic microwave background experiments, jointly supported by the Department of Energy (DOE) and the National Science Foundation (NSF). Aiming to make groundbreaking discoveries in fundamental physics, cosmology, astrophysics, and astronomy, this ambitious project involves 12 telescopes located at the South Pole and the Atacama Desert in Chile. Over the course of 7-10 years, CMB-S4 will employ 500,000 cryogenically-cooled superconducting detectors to conduct extensive sky surveys to support scientific research.

At Cerro Toco, significant progress has been made in the fiber infrastructure, with the dark fiber build and splicing work now complete. REUNA is currently finalizing the connection to the Simons Observatory (SO). A passive optical multiplexer (mux) will be deployed, connecting REUNA's Point-of-Presence at ALMA to SO Container C1. This setup, which avoids the need for active electronics, reduces the risk of failures and isolates experiments from one another by operating on different frequencies and wavelengths. This design also lowers costs, as it utilizes commodity optics capable of 1Gbps to 10Gbps data transfer over distances of up to 80km. CMB-S4 plans to utilize this connection once the Simons Observatory becomes operational.

CMB-S4, in collaboration with the Simons Observatory, is considering deploying a perfSONAR server at Cerro Toco. This server would provide a lightweight network presence without requiring continuous high-bandwidth testing and would make efficient use of the available space at SO Container C1. The deployment would serve multiple purposes, including demonstrating progress to funding agencies, gaining operational experience with network measurement, and enabling the characterization of network paths as data plans evolve.

For data management, CMB-S4 is exploring the use of Rucio, a library originally developed for particle physics data management, originally for the LHC-ATLAS project, and later adopted by LHC-CMS. Rucio's growing adoption in various scientific fields and strong ongoing support make it a strong choice for a project like CMB-S4 that intends to be in operation for up to a decade. Omar Moreno is leading the efforts in prototyping and testing Rucio, with initial discussions taking place with the National Energy Research Scientific Computing Center (NERSC) regarding deployment on their Spin service, a container-based platform supporting scientific projects. Further efforts in data management and deployment are ongoing.

4.8 Event Horizon Telescope (Jason SooHoo)

The Event Horizon Telescope (EHT) is a groundbreaking array of telescopes that operates at millimeter and sub-millimeter wavelengths, employing Very Long Baseline Interferometry (VLBI) to achieve exceptionally high-resolution observations. By combining data from telescopes located at various sites across the globe, the EHT effectively creates an Earth-sized virtual telescope. This vast array includes multiple stations, where each pair of stations forms a baseline that captures a segment of the enormous aperture. The inclusion of phased array stations like ALMA significantly enhances baseline coverage, leading to more precise and comprehensive observational data.

Data processing within the EHT is a complex and highly coordinated effort. Once the VLBI backend of the EHT receives a signal, it is digitized and recorded onto specialized data modules. These modules are then physically transported to two different correlators for processing: one located at the MIT Haystack Observatory in Massachusetts, USA, and the other at the Max-Plank Institute for Radio Astronomy in Bonn, Germany. The correlated data undergoes rigorous calibration through advanced algorithms, which correct for any discrepancies and align the data. Subsequently, sophisticated imaging techniques are applied to produce detailed images, such as the iconic depictions of the M87 and SgrA* black holes, which have provided unprecedented insights into these enigmatic objects.

The 2024 EHT campaign marked a significant advancement in observational capabilities, with observations carried out at three different wavelengths: 230GHz, 260GHz, and 345GHz. The campaign involved 11 stations, each recording data at a high rate of 64Gbps, generating approximately 2PB of raw data per station. This massive data collection effort was supported by a dedicated team, including on-site EHT observers and specialists, as well as remote staff at the Array Operations Center (AOC) who monitored operations in real-time. Technical Operations Support staff were available to provide remote assistance, ensuring smooth operations and troubleshooting any critical system failures. The campaign also involved crucial VLBI fringe tests, where stations coordinated target observations and sent small data samples back to the correlators. These tests were vital for verifying the configurations and setups of the stations, preventing misconfigurations and ensuring data quality throughout the campaign.

Looking to the future, the EHT aims to transition from annual observations to a more frequent cadence, with plans to conduct monthly, weekly, or even snapshot observations. This shift would enable the EHT to track dynamic targets like the M87 black hole, capturing short-term changes and potentially allowing for the creation of time-lapse videos of the objects being observed. However, this ambition is not without its challenges, achieving this goal will require significant enhancements in sensitivity and bandwidth, leading to an increase in data recording volumes. The EHT is a vast international collaboration with a heterogeneous array of stations, each facing unique challenges and scientific goals. Additionally, there is a need for faster and more reliable networks to transport data to correlators for quicker fringe testing and validation, as well as increased storage capacity at correlators to manage the larger data volumes.

To address these challenges, the EHT is focused on improving its data network and operational procedures. This involves running network tests from stations to correlators to identify bottlenecks and deploying network test nodes as part of the station monitoring system. Simplifying station setup procedures and providing training for local staff, along with the ability to operate stations remotely, are also key areas of focus. Reducing unknowns and uncertainties in station performance is essential to optimize data transport and ensure the success of future campaigns.

Improving the EHT data network is a critical component of this effort, requiring close collaboration with Research Networks that currently support scientific endeavors worldwide. Key contributors to this initiative include the Engagement and Performance Operations Center (EPOC) at Indiana University, Internet2/ESnet, the Correlator at the MIT Haystack Observatory, and EHT stations at Mauna Kea, operated by the University of Hawaii. The path forward involves quantifying the existing network infrastructure, deploying network test nodes (such as perfSONAR) at EHT stations and correlators, and identifying bottlenecks that hinder performance. An upgrade plan will be developed based on these findings, with the goal of demonstrating performance improvements using real EHT data. The long-term plan includes reaching out to additional Research Networks to expand the EHT Data Network, thereby enhancing its capacity to support the increasingly demanding observational campaigns.

In summary, the EHT's ongoing campaigns will continue to rely heavily on high-speed, reliable Research Networks to facilitate its international operations. The long-term objective is to improve data transport on a larger scale, addressing challenges such as enhancing high-speed networks at remote locations and correlators, and optimizing these networks at an international level through collaboration with Research and Education Networks (RENs). In the short term, the focus will remain on sending partial data back to correlators for quick validation, while increasing observation cadences. Continuous improvement of operational processes and procedures, along with network quantification and station monitoring, will be crucial in tracking performance changes and optimizing data transport for future EHT campaigns.

4.9 US Extremely Large Telescope Program (Lucas Macri)

The United States Extremely Large Telescope Program (US-ELTP) is a collaborative initiative between the NSF's NOIRLab and the organizations constructing the Giant Magellan Telescope (GMT) and the Thirty Meter Telescope (TMT). The program aims to provide the U.S. astronomical community with nationally funded access to an all-sky Extremely Large Telescope (ELT) system, enabling broad participation in groundbreaking scientific research. Key objectives include supporting large-scale collaborative research projects through "Key Science Programs" (KSPs) and facilitating rapid responses to new discoveries via "Discovery Science Programs" (DSPs). The program also emphasizes inclusivity, particularly for researchers from smaller or under-resourced institutions, ensuring that all astronomers have the opportunity to engage in ELT science.

A distinctive feature of the US-ELTP is the ability to capture the entire night sky, thanks to the placement of GMT in the southern hemisphere and TMT in the northern hemisphere. The strategic separation in longitude allows scientists at TMT in Hawaii to quickly follow up on discoveries made by GMT in Chile, enhancing the program's scientific potential. Additionally, the US-ELTP is committed to research inclusivity, offering tools and platforms to make data from GMT and TMT accessible to a broader range of researchers. This includes a focus on developing science-ready data products and providing robust user support throughout the Science Data Life Cycle (SDLC), from proposal preparation to data publication.

The TMT's operational structure includes a sea-level headquarters for science operations and a summit site where telescope operators manage nighttime activities. TMT International Observatory (TIO) partners can establish their own Remote Operations Centers (ROCs) to support their own specific communities by allowing for science programs an observations to be done remotely. The TIO Data Management System (DMS) collaborates with NOIRLab to ensure seamless data transfer, validation, and integration into the US-ELTP Science Archive. Data processing involves Data Reduction Pipelines (DRPs) and customizable tools, with a commitment to maintaining open access to pipeline source code for community-driven enhancements.

In summary, the US-ELTP promises to revolutionize U.S. astronomy by providing open access to world-class telescopes and data, coupled with exceptional user support and a focus on inclusivity. NOIRLab's partnership with the scientific community throughout the program's development ensures that the systems and services will meet researchers' needs, fostering a vibrant and diverse research environment.

4.10 Giant Magellan Telescope Organization (Sam Chan)

The Giant Magellan Telescope (GMT) is a revolutionary Gregorian optical-infrared telescope, designed to be the largest of its kind in history. Using seven of the world's largest mirrors to peer deep into space, it offers unparalleled resolution across the widest possible field of view. The GMT is a collaborative effort among 14 leading research institutions from Australia, Brazil, Chile, Israel, South Korea, Taiwan, and the United States.

Recent updates on the GMT include significant progress in the fabrication of its primary mirror optics, known as M1. The casting of the seventh mirror (S7) was completed in January 2024, and inspections indicate that it met all requirements. The first three mirrors (S1 through S3) are also complete, with progress on the remaining mirrors (S4 through S6) ongoing, and plans for a spare eighth segment to be created afterwards. Additionally, the M1 subsystem, which includes the thermal control system and tilt testing, has been developed and tested. The test cell for these components will soon be moved from the University of Arizona (UA) Tech Park to UA Richard F. Caris Mirror Lab (RFCML) for integration with S3 and optical testing.

The Azimuth Mount and Track, essential for the telescope's structural support and precise movement, are also under construction. The system provides three axes of rotation (vertical, horizontal, and rotational) to support the optical structure and instruments, is made of eight sections weighing 172,000 kg. The track is nearly half built, with four of the eight total sections approaching completion.

In terms of network and operations, the GMT's infrastructure requirements are extensive. The telescope's main distribution frame (MDF) will connect to various computer rooms and buildings via multiple fiber optic strands to ensure robust data transmission. The telescope is expected to produce 8TB of data per night, totaling 2.9PB per year, with 31TB of it being scientific data. Backups will be performed hourly to a local data center and nightly to cloud platforms such as Backblaze and AWS. The GMT is anticipated to be fully operational by the early 2030s.

4.11 next-generation Very Large Array (Sanford George)

The next-generation Very Large Array (ngVLA) is designed to provide advanced capabilities in thermal imaging at milli-arcsecond resolution. With a sensitivity 10 times greater and a resolution 10-100 times finer than the current Very Large Array (VLA), the ngVLA aims to bridge the gap between the Square Kilometer Array (SKA) and the Atacama Large Millimeter/submillimeter Array (ALMA). The telescope will focus on deep single-field and small-area mapping, and will be centered around the current VLA location in the Southwestern USA. The ngVLA has been identified as a high-priority project by the Astro2020 Decadal Survey, with a recommendation for construction to start within this decade.

The ngVLA will cover frequencies from 1.2 to 116 GHz and will feature several components: a Main Array consisting of 214 offset Gregorian antennas spread across New Mexico, Texas, Arizona, and Mexico; a Short Baseline Array (SBA) with 19 smaller antennas; and a Long Baseline Array (LBA) with 30 antennas positioned across the continent, allowing for baselines up to 8860 km. The project's prototype antenna passed its Preliminary Design Review in December 2022, with fabrication underway and site acceptance testing expected to start in mid-2024.

Data handling is a significant aspect of the ngVLA, with real-time correlation across all 244 antennas and a data rate capability of up to 20 GHz per polarization. Each antenna will handle 723 Gbps over fiber-optic links, with a total data link capacity of approximately 2.4Tbps at LBA sites. The network infrastructure includes dedicated fiber links within New Mexico, with additional ISP (R&E network) connections for more distant locations.

Data processing for the ngVLA will be done post-facto, with storage options for raw visibilities and a processing system designed for average data throughput. Data rates will average 8GBps, with peaks up to 128GBps. The computational load, expected to require about 60 PFLOPS, is considered challenging but manageable with current technology. An operations model focused on "Science Ready Data Products" will allow principal investigators to receive processed data directly, with options for further data analysis and reprocessing through an archive interface.

The timeline for the ngVLA project began in 2018 with its submission to the Astro2020 Decadal Survey. Following the survey's recommendation in 2021, a proposal was submitted to the NSF in 2022. Key milestones include the delivery of a prototype to the VLA site by 2025, the start of construction in 2027, the initiation of early science operations in 2031, and full science operations by 2038.

4.12 Summary of Science Instruments

The following table summarizes the information on instruments reported in section 4. It contains the name of the instrument with a link to its website, its location, sites where data is archived, what stage the instrument is in (planning, construction, operation), the estimated start and end date, and data flow characteristics from the instrument to archive.

Instrument	Location	Data archive	Stage	Start - End date	Data flow characteristics
Vera Rubin Observatory	La Serena, Chile	US: SLAC, EU: In2p3, UK	construction	Oct 2023-2033	20TB per night, Image must be transferred within 7 seconds from the Base to the USDF. The telescope will produce 10 million transient events per night, which will be distributed in real time within 60 seconds to community brokers. Data flow from Chile to USA and EU. US partners: NSF, DOE, IN2P3; Managed by AURA
Next Generation Very Large Array (ngVLA)	Puerto Rico (Arecibo Site), St. Croix (VLBA Site), Kauai, HI (Kokee Park Obs.), Hawaii, HI (Not MK Site), Hancock, NH (VLBA Site), Green Bank, WV (GBO), Brewster, WA (VLBA Site), Penticton, BC (DRAO), North Liberty, IA (VLBA site), Owens Valley, CA (VLBA site)	Distributed archive	planning	2025-2035	The data rate of 723Gbps per antenna will aggregate to 800Gbps links on ngVLA installed fiber. For example, ~3 antenna LBA site will equal ~1Tbps link. The LBA sites (UPR, U Central Florida, Arecibo Observatory) proposed to NSF a 100Gbps link to I2. US partners: NSF; Managed by NRAO, NSF, and AUI
Atacama Large Millimeter/submillimeter Array (ALMA)	San Pedro de Atacama, Chile	NRAO, Charlottesville, VA, USA; EU: ESO, Garching (Munich), Germany; NAOJ, Mitaka (Tokyo), Japan	operation	2011-present	1TB per day, total volume will be ~220TB; Typical rate obtained during peak data transfer periods is 2-300Mb/s, with bursts up to 600Mb/s. A new correlator will increase the data to 1PB/year in 2030. Data come from Chile to USA, EU, and Japan. US partners: NRAO; Managed by Associated Universities, Inc. (AUI)/NRAO
Simons Observatory	Chajnantor, Chile	USA: NERSC, UCSD/SDSC, Princeton	construction	2023-2028	The data rate is estimated to ~132 Mbps during the day with 40-50 TB data volume per month. The raw data for the 5-year survey will be ~3PB. There is NO strict requirement on data getting to the US. Data flow from Chile to Princeton USA
Cosmic Microwave Background (CMB-S4)	Chile and at the South Pole	NERSC	planning	2029-2036	The compressed data rate is ~1.2Gbps with real time transfer (transient events) to NERSC using FABRIC nodes; 1 month data will be at on-site storage ~400TB connected with 10Gbps and it will take 4 days to clear a month-long backlog. Managed by DOE & NSF

MeerKAT	South Africa	SARAO, Cape Town/CSIR, South Africa	operation	2018-present	Data is archived at Centre for High Performance Computing (Cape Town/CSIR). Academic research and computing are done at Inter-University Institute for Data Intensive Astronomy (Cape Town/UCT) and Ilifu Cloud
FYST (a.k.a. CCAT)	Cerro Chajnantor, Chile	Cornell University, Ithaca, NY, USA, Cologne, Germany Toronto, Canada	construction	2024	~3-8 TB/day; connecting to dark fiber at ALMA Pad 409 Dark Fibers; During CHAI observation, the data will be sent to Cologne, Germany (~685Mbps) and Toronto, Canada (~13Mbps). During pre-Cam observation, the data will be sent to Cornell University, USA (~386Mbps) and Toronto, Canada. Data flow from Chile to Germany, Canada, and USA.
US ELT: GMT & TMT	Chile and Hawaii (or La Palma, Canary Island)	Tucson AZ	construction	2029	Projected 10-40 TB per night. Data flow from Chile and Hawaii; Managed by NSF & NOIRLab
EHT	ALMA, APEX, GLT, JCMT, KP, LMT, NOEMA, SMA, SMTO, and SPT	MIT Haystack Observatory Correlator in Massachusetts, USA and the Max-Planck Institute for Radio Astronomy Correlator in Bonn, Germany	operation	varies	2023 Campaign notes: Observations were at 230GHz & 345GHz, Dual pol and double side band, Station recorders at 64Gb/s, Collecting about ~2PB raw data per station. The data is then shipped to the MIT Haystack Observatory Correlator in Massachusetts, USA and the Max-Planck Institute for Radio Astronomy Correlator in Bonn, Germany for processing.

5 Research & Education Provider Updates

Section 5 summarizes the updates provided by each of the R&E networks supporting the astronomy observatories.

5.1 South African NREN Connectivity (Renier can Heerden)

The South African National Research and Education Network (NREN) is managed through a partnership between the South African National Research Network (SANReN) and the Tertiary Education and Research Network of South Africa (TENET). SANReN focuses on building and expanding the network and developing advanced services while TENET operates the network and hosts the developed services. TENET also represents the South African NREN at UbuntuNet Alliance, where it is a founding member, and launched the South African Broadband Education Networks (SABEN) project to connect Technical and Vocational Education and Training (TVET) colleges across the country.

Internationally, the NREN is linked through several submarine cables, such as the West Africa Cable System (WACS), SAT-3, EASSy, SEACOM, and the South Atlantic Cable System (SACS), which connects South Africa to Europe, Brazil, the U.S., and Eastern Africa. These cables provide significant bandwidth, supporting high-capacity data transfers between South Africa and global research networks. Within Africa, the NREN interconnects with regional networks like ASREN, EUMEDconnect3, WACREN, and the UbuntuNet Alliance, facilitating collaboration across the continent. Domestically, a

100Gbps national backbone, regional extensions at 10Gbps, and metropolitan networks ensure comprehensive connectivity within South Africa.

SANReN's dark fiber backbone includes five dark fiber links, supporting 96 channels at 100Gbps using Dense Wavelength Division Multiplexing (DWDM) technology. Key projects include the procurement of 100Gbps links supporting the South African Radio Astronomy Observatory (SARAO) and the Square Kilometer Array (SKA), with further expansions planned for the South African National Space Agency (SANSA).

SANReN offers several services, including the Performance Enhancement Response Team (PERT), which addresses network throughput issues using perfSONAR, a tool deployed across the network to monitor performance. An upgrade to 100Gbps nodes is underway to further enhance data transfer efficiency. SANReN also runs the Computer Security Response Team (CSIRT), focusing on cybersecurity, incident response, and proactive threat mitigation. CSIRT offers vulnerability assessments, threat intelligence alerts, and hosts an annual ethical hacking contest. Each beneficiary of SANReN services is eligible for a free annual vulnerability assessment to strengthen their network security.

5.2 GÉANT - SKA Observatory R&E Networks (Richard Hughes-Jones)

The Square Kilometer Array Observatory (SKAO) is an intergovernmental organization dedicated to advancing radio astronomy through cutting-edge technology, aimed at enhancing our understanding of the universe. SKAO brings together a diverse group of countries, including Australia, China, Italy, the Netherlands, Portugal, South Africa, Spain, and the United Kingdom as full members, with others like India, Canada, France, and Germany in the process of joining. The observatory is set to operate two powerful radio telescope arrays: SKA-Mid in South Africa and SKA-Low in Australia. These will be controlled from SKAO's global headquarters at Jodrell Bank Observatory in the UK. The SKA-Mid array will include 200 dishes spread across 150 kilometers, operating at frequencies between 350 MHz and 15 GHz, while SKA-Low will feature 130,000 antennas covering 70 kilometers and working in the 50 MHz to 350 MHz range.

Construction is progressing at both sites. At SKA-Low, the installation of antennas is underway, involving collaboration with the native Wajarri Yamaji people, along with the installation of essential infrastructure like power and fiber lines. Meanwhile, at SKA-Mid, the first dish was installed in late 2023 after being shipped from China, and new access roads are being built to the site. Additionally, the data processing systems, particularly the AA0.5 servers, have been successfully installed and configured at the Karoo Array Processor Building.

Regarding data flows for Phase 1 of the arrays, the SKA1-Low array will transmit digitized analog data to the Central Signal Processor (CSP) in Perth at a rate of 9Tbps, after which the data will be processed into sky maps by the Science Data Processor (SDP) and sent to SKA Regional Centers (SRCs) at 100Gbps. SKA1-Mid, with its dishes supporting native digital output, will send 20Tbps of data directly to the CSP in Cape Town, followed by similar processing and distribution to SRCs. These SRCs will provide a robust data management network with distributed processing, analysis tools, and visualization capabilities, ensuring that scientists worldwide can access and interpret SKA data efficiently. The SRC network will be vital for supporting machine learning applications, enabling workflow execution, and providing training to the science community on using SKA data.

The SKA Data Network will establish dedicated data links between the telescopes and academic network hubs in the northern hemisphere, supporting data transfers of 1PB per day from each telescope. These high-speed paths, requiring 100Gbps capacity, will come with operational costs ranging from $1.7 to $3.3 million annually. SKAO will fund the dedicated paths, while shared academic networks will be supported by broader scientific community funding. The data flow from the telescopes to the SRCs will involve a complex system of submarine cables and academic networks, ensuring seamless transmission of Observatory Data Products (ODPs) and Advanced Data Products (ADPs). Data will be replicated across SRCs, with continuous data flow maintained for both processing and storage. Each SRC will send and receive data flows using high-performance networks, making significant use of existing academic networks.

SKAO's network design builds on the architecture of large-scale scientific projects like the Large Hadron Collider Open Network Environment (LHCONE) and the AENEAS project. All data transfers between telescopes and SRCs will use Virtual Routing and Forwarding (VRF) technology and will be optimized for high-latency data transfers with the use of tuned Data Transfer Nodes (DTNs) located in Science DMZs. IPv6-only traffic and large Maximum Transmission Unit (MTU) sizes (9000 byte jumbo frames) will ensure efficient network performance, while the network will be monitored using a mesh of perfSONAR nodes deployed across the SRCs.

Data distribution across countries will follow a fair-share model based on their financial contributions to SKA's construction. This model governs the movement of ODPs and ADPs between the telescopes and SRCs, though it does not account for factors like storage capacity or computing architecture at specific sites. The highest data rates are expected in Australia, South Africa, and the UK, with smaller flows to other countries. Future projections for SKA data rates show that SKA-Low will reach 100Gbps by 2030, while SKA-Mid will handle similar rates. Data traffic between Australia, South Africa, and other SRCs is expected to be particularly intense at approximately 150Gbps, with average data rates into other countries ranging between 10Gbps and 20Gbps.

5.3 GÉANT - EU and Intercontinental Network Infrastructure Update (Richard Hughes-Jones)

The GÉANT Association is a European membership association consisting of 38 European National Research and Education Networks (NRENs) and NORDUnet, representing NRENs from the Scandinavian region. Together, they serve over 10,000 institutions and more than 50 million academic users across Europe. One of their projects, GN4-3N, aims to bridge the digital divide by ensuring that all NRENs have access to high-speed transmission capabilities. It also seeks to develop a sustainable fiber infrastructure that will serve Europe's Research and Education (R&E) community for the long term. The GN4-3N project began with extensive community involvement, including workshops with NRENs across Europe to identify capabilities, needs, and challenges. At the project's outset, many European countries were on short-term fiber contracts or leased lines, which are costly and inefficient. However, through an investment of over €50 million, the network now includes an additional 16 countries, providing a solid infrastructure capable of supporting Europe's R&E needs for the next 15 years. Significant contributions from NRENs have further improved network accessibility by making spectrum lines more available than initially anticipated.

Additionally, a three-year packet layer renewal project launched in early 2022 aimed to enhance network capacity, particularly in Europe's peripheral areas. The current infrastructure, using Juniper routers, has reached maximum capacity, so GÉANT has procured Nokia routers capable of handling 18Tbps per slot. These routers are fully redundant and will support future advancements, such as 800G optics, once available. This renewal ensures that global partners can connect at or near landing stations, improving network connectivity and resilience.

As part of the GN5-1 network upgrades, GÉANT has completed its backbone reconfiguration, enhancing network capacity and resilience across Europe. By March 2024, the Western ring's capacity will have doubled to 2x400G, while the Central ring will maintain consistent 300G speeds, including a new high-speed link between Frankfurt and Prague. The Eastern ring will be stabilized at 200G, completing a robust high-capacity circuit across key eastern nodes, and the Brussels-Paris link has been upgraded to 100G.

The GN5-IC1 International Connectivity project, launched in December 2022 with €15 million in European Commission funding, focuses on expanding GÉANT’s global network reach. This project aims to establish connectivity with at least two world regions, with North America and the Asia-Pacific region being top priorities due to their high traffic volume—75% and 19% of GÉANT's intercontinental traffic, respectively. The first region, Asia, now benefits from a new 100G link between Marseille and Singapore via the AAE-1 cable. This connection, made under a seven-year Indefeasible Rights of Use (IRU), contributes to the Asia-Pacific Europe ring, improving network resilience and providing mutual backup. The second region, North America, is a critical focus due to the anticipated traffic from projects like the High-Luminosity Large Hadron Collider (HL-LHC). GÉANT aims to secure 25% of a fiber pair on at least two transatlantic cable systems, collaborating with partners like ESnet to share spectrum across multiple cables, potentially achieving 20Tbps of capacity. GÉANT is currently consulting to navigate compliance and tax challenges while considering the use of managed spectrum to minimize its presence in the US.

5.4 AmLight: Network Connectivity (Jeronimo Bezerra)

AmLight is an international distributed academic exchange facility, designed to facilitate collaboration between Latin America, Africa, and the US. Supported by the National Science Foundation (NSF) through its Office of Advanced Cyberinfrastructure (OAC) and the International Research and Education Network Connections (IRNC) program, AmLight operates under the award number OAC-2029283 for the period of 2021-2025. AmLight’s partnerships with Research and Education (R&E) networks across the U.S., Latin America, Africa, and the Caribbean are built on mutual trust and shared resources, enabling a collaborative infrastructure for academic and research purposes. The AmLight Express and Protect (ExP) project aims to enhance collaboration among researchers in the U.S., Latin America, and Africa by providing scalable, reliable, and high-performance network connectivity. The project focuses on supporting science applications driven by Service Level Agreements (SLAs), improving network management, and integrating AmLight with network-aware science drivers. New cloud services and network operations automation are also being introduced to reduce operator intervention. With a capacity of 6x100Gbps between the U.S. and Latin America and 1x100Gbps to Africa, AmLight provides extensive international connectivity through multiple Points of Presence (PoPs) in Florida, Georgia, Brazil, Chile, Puerto Rico, Panama, and South Africa.

Since 2023, AmLight has completed several upgrades, including the replacement of legacy devices with fully programmable P4 switches, resulting in improved network resilience, visibility, and expanded 100G interfaces. A notable update is the increase of spectrum on Monet from 75GHz to 112.5GHz, with a plan to upgrade U.S.-Brazil bandwidth to 1.1Tbps. Future enhancements involve activating a new submarine cable between Argentina and Brazil and installing additional programmable switches in Argentina.

In terms of network provisioning, AmLight has evolved its Software Defined Networking (SDN) architecture from a basic setup in 2014-2020 to a more sophisticated framework in 2021-2025. This includes programmable switches, enhanced telemetry through P4/In-Band Network Telemetry (INT), and a new intelligence plane for automated traffic engineering. The new control plane, Kytos-ng, is an open-source SDN controller designed for AmLight’s operational needs, offering features like multi-metric pathfinding, bandwidth reservation, and per-packet telemetry. The intelligence plane integrates real-time telemetry and makes data-driven recommendations for traffic management, aiming for sub-second reaction times to network events.

AmLight supports the SA3CC community by offering a robust and complex network topology with numerous paths and bandwidth options. With more than 25 possible paths from Chile to Jacksonville, the system is designed for load balancing and packet-loss-intolerant applications. The new architecture allows AmLight to handle SLA-driven applications with sub-second response times, automating many operational activities through its closed-loop control, and without human intervention. This positions AmLight to anticipate and mitigate network issues before they affect scientific applications.

5.5 AmLight: Monitoring and Measurement Improvements (Renata Frez)

AmLight employs a variety of tools and frameworks to monitor and measure its network performance, ensuring reliable infrastructure management. A Zabbix server monitors the entire network and IT infrastructure, while perfSONAR provides network measurement results, accessible online. Recent updates include new nodes in Boca Raton, San Juan, and Atlanta, along with an updated São Paulo node. More tests are planned for ESnet. Additionally, AmLight provides a status[1] page for the community to track ongoing events and link utilization, which can be viewed online. Other monitoring tools include SNMP for general monitoring, Juniper Telemetry Interface (JTI) for detailed data on Juniper devices, In-band Network Telemetry (INT) for troubleshooting short-term events, and sFlow for addressing unusual traffic patterns.

AmLight utilizes multiple interfaces for efficient network monitoring, with SNMP polling every 14 seconds, JTI sending telemetry data every two seconds, and INT enabling real-time packet monitoring every 100ms. These faster polling rates allow for the detection of traffic spikes that may otherwise go unnoticed, providing a more comprehensive view of network performance. For network testing, AmLight uses a traffic generator to assess traffic through switches in key locations like Miami, Boca Raton, São Paulo, and Santiago. The system automatically tests paths between switches, shrinking the path to identify problematic areas. By periodically running tests and isolating sections of the network, AmLight can pinpoint issues without manual intervention from network engineers, improving troubleshooting efficiency.

Overall, tools like JTI and INT are integral to daily operations, greatly enhancing network visibility. Combining various monitoring tools enables AmLight to track performance issues and respond to user complaints effectively. perfSONAR tests are essential for evaluating the user experience between two points, and future upgrades, such as the deployment of perfSONAR 5 and a new Zabbix 6 server, are under consideration. The team continues to explore new methods for improving monitoring capabilities to optimize network performance.

5.6 REUNA Updates (Albert Astudillo)

REUNA has connected 50 organizations over its 30-year history, promoting Chile's digital development through 18 Points of Presence (PoPs) across major cities. One of its major initiatives is a collaboration with the Patagonia Project to lay 1,300 kilometers of networking to provide connectivity to the southern city of Punta Arenas. However, delivering high-quality connectivity in Chile proves to be extremely difficult due to its geography, which includes remote, hard-to-reach locations at high altitudes and uneven terrain. Supplier shortages in rural areas, the country's narrow width limiting geographically diverse routes, and environmental factors such as heavy rains, wildfires, and climate change also hinder infrastructure development. Rising equipment costs and limited access to fiber or spectrum add to these difficulties. Despite the challenges, these contributions to Chile's research network infrastructure will provide vital connectivity to various research projects, particularly in the area of Astronomy.

One notable project in this regard is the Chajnantor PoP, in collaboration with the Atacama Large Millimeter/submillimeter Array (ALMA) Observatory, which is aimed at providing fast and secure connectivity to international astronomical projects on the Chajnantor Plateau. The PoP will be installed at the ALMA Array Operations Site (AOS), with agreements in place for last-mile connectivity to various observatories like the Simons Observatory, which will be the first telescope connected. The deployment of CWDM infrastructure to deliver different wavelengths to each project is planned. REUNA is also part of

[1] AmLIght Status Page, https://status.amlight.net/

the EVALSO 2.0 initiative, which involves collaborating with the European Southern Observatory and ALMA to meet the increasing demands of astronomical observations. This project aims to increase data throughput from 8Gbps to 80Gbps, with future potential expansion to 100Gbps. The infrastructure, based on DWDM OTU4, is expected to be operational by the second half of 2024.

The Patagonia Project includes the installation of a PoP in Punta Arenas by May 2024, which will use a mix of fiber, satellite, and wireless connections. The project has agreements with the local government and may engage with satellite providers, potentially opening up greater connectivity to Antarctica. In Antarctica, limited digital connectivity exists, with few satellites, low bandwidth, and high costs. To address this, a feasibility study funded by CAF bank and Chile's Telecommunication Subsecretary is planned for 2024 to explore better connectivity solutions for the region, which is critical for global research on climate change and other phenomena.

5.7 RedCLARA Updates (Marco Teixeira)

RedCLARA (Latin-American Cooperation of Advanced Networks) is a non-profit organization aimed at establishing a high-capacity digital network across Latin America to support research and education. Its foundation relies on collaboration between National Research and Education Networks (NRENs) in countries such as Brazil, Colombia, Costa Rica, Chile, Ecuador, Guatemala, Mexico, and Uruguay. RedCLARA's network spans a region larger than the United States and the European Union, enhancing regional connectivity for educational and scientific collaboration. The network is equipped with advanced technology, including the Ciena Waveserver AI, which offers up to 2.4Tbps in a compact form, and the ASR9904, which delivers up to 16Tbps across a larger form factor. Key network paths include routes between Santiago and Buenos Aires, as well as Buenos Aires and Porto Alegre, with long-term contracts supporting high-capacity services and spectrum availability. These connections are critical for facilitating data flow across vast distances, strengthening regional ties.

RedCLARA is also driving the BELLA II project, a four-year initiative designed to enhance the digital ecosystem in Latin America and the Caribbean. The project aims to foster collaboration among companies, research centers, academic institutions, and networks, focusing on education, science, technology, and innovation. Strategic areas of interest include shared infrastructure, human-centered connectivity, and creating synergies across stakeholders. The project seeks to close digital gaps in connectivity, high-performance computing (HPC), blockchain, cybersecurity, artificial intelligence (AI), and the Internet of Things (IoT). To support this vision, RedCLARA is organizing consortia to unite government, educational, financial, business, and social sectors. These consortia will focus on advancing connectivity and providing value-added services. RedCLARA will contribute financially to these initiatives through the BELLA II project, with the majority of funding directed toward enhancing network connectivity. Additionally, efforts are underway to establish new NRENs in countries such as Argentina, El Salvador, Peru, Paraguay, Panama, Bolivia, Venezuela, Nicaragua, and Honduras, further expanding RedCLARA's reach and impact.

5.8 RNP Updates (Aluizo Hazin)

The Brazilian National Research and Education Network (RNP) is a non-profit organization that offers secure, high-capacity connectivity to around 1800 sites and four million users. Supported by ministries including Science, Technology, and Innovation (MCTI), Education (MEC), Communications (MCom), Health (MS), and Defense (MD), RNP operates a dedicated Dense Wavelength Division Multiplexing (DWDM) system covering 15,000 km of fiber, with plans to extend this to over 20,000 km by 2026.

One of RNP's significant projects is the Sustainable Integrated Amazon Program (PAIS), created by MCom to expand communication infrastructure in the Amazon region through fiber-optic cables laid under the rivers. The pilot project, Infovia 00, connects five cities and is the first of eight planned infoways. Upon completion, these infoways will connect 77 cities, covering 12,000 km of optical cables, benefitting 10 million people while preserving 68 million trees. Launched in 2015, PAIS is expected to conclude by 2026 with a total cost of $350 million. Another major project is the Conecta and Capacita Program, running from 2024 to 2026, that aims to enhance the quality, scope, and security of connectivity for education in Brazil. The program includes the deployment of 18 information highways and 79 metropolitan networks across Brazilian states, with eight highways expected to be operational by 2026. The program plans to lay 40,000 km of fiber, 20,000 km of which will be completed by 2026. Additionally, new IP/MPLS equipment will be installed across more than 30 Points of Presence (PoPs).

RNP's Centros Nacionais de Dados (CND) provides academic and research institutions with new services such as colocation (including high-performance computing when required), off-site backup for business continuity, and cloud services. These services are integrated into RNP's "Rede Ipê" and "Rede de e-Ciência" networks, further enhancing academic and research capabilities in Brazil. Internationally, RNP partners with initiatives like Bella (RedCLARA/GÉANT) and AmLight, with connection points in cities such as Fortaleza, São Paulo, and Porto Alegre. Dark fiber connections are established in Fortaleza and São Paulo, linking to critical sites and data centers. Additionally, RNP is planning a capacity upgrade for the Monet submarine cable system in collaboration with Florida International University (FIU).

5.9 Rednesp Updates (Ney Lemke)

The Research and Education Network of São Paulo (rednesp), previously known as the ANSP network, connects numerous education and research institutions across São Paulo and abroad. It collaborates with international academic networks like AmLight and RedCLARA. Managed by a committee comprising the University of São Paulo (USP), São Paulo State University (UNESP), and the State University of Campinas (UNICAMP). rednesp plays a crucial role in advancing research and education in the region.

The network's first major effort centers on financial investment, primarily funded by the São Paulo Research Foundation (FAPESP), which has provided $5 million annually over the past 16 years. This funding supports crucial transoceanic links between Miami (USA), Santiago (Chile), and São Paulo. In 2023, a new contract was signed to enhance investments in human resources, infrastructure, and administrative needs. In terms of technical collaboration, rednesp oversees international connections through resilient links, each offering 2x100Gbps, funded by FAPESP and provided by partner organizations like Lauren. Additionally, through the Monet link provided by AmLight and the Ella link under the Bella Program, rednesp strengthens its global connectivity in collaboration with European partners and RNP in Brazil.

Infrastructure evolution is another priority, as rednesp upgrades from outdated 100Gbps equipment to a more robust 400Gbps infrastructure. A $500,000 investment enabled the acquisition of modern Juniper equipment with a capacity of up to 14.4Tbps per slot, significantly enhancing data transmission capabilities for research and education. Additionally, the Backbone-SP project focuses on integrating eight academic institutions in São Paulo with 100Gbps links, ensuring high-availability connectivity. Institutions such as USP, UNICAMP, UNESP, and others will benefit from this infrastructure, which facilitates the interconnection of research centers throughout the state.

In the realm of software-defined networking (SDN), rednesp developed Kytos-ng in collaboration with FIU, an open-source SDN platform designed to orchestrate SDN switches connecting São Paulo to Florida via a Pacific/Atlantic ring. The platform offers features such as E-Line, network topology discovery, pathfinding, and network telemetry, and can be controlled via REST APIs or web UIs. At the Super Computing 2023 (SC 2023) conference, rednesp achieved a 400Gbps data transfer speed between Brazil and the U.S., with plans to increase this to 600Gbps for SC 2024, pending hardware upgrades. Lastly, rednesp is adding new projects, including the Cherenkov Telescope Array (CTA), which aims to connect its observatory in Chile to Europe to explore dark matter, Lorentz invariance, and supermassive black holes.

5.10 Vera C. Rubin Observatory: Multi-Site Testing (Richard DuBois)

The Vera C. Rubin Observatory in Chile is set to generate vast amounts of data once operational, with the management system capable of processing up to 20TB of raw data nightly. The observatory will capture 30-second sequential images that cover the visible sky every few days, leading to approximately 10 million alerts per night on transient and variable sources. These results will be updated every 60 seconds via alert streams, and stored in the Prompt Products Database every 24 hours. Additionally, the observatory will monitor around 6 million solar system objects. Over the course of 10 years, the system will make annual data releases, culminating in a final dataset including 5.5 million 3.2Gpx images and a catalog containing 37 million objects.

The United States Data Facility (USDF) will implement a hybrid on-premises and cloud-based system, with data stored at the SLAC facility while users access it via the cloud. This setup ensures better security, burst response capabilities, and risk reduction. Data flows from the Chilean base site to the USDF archive at a rate of 20TB per night, with USDF responsible for processing Prompt Data Products. Data Release Processing will be distributed across the USDF (35%), the French Data Facility (40%), and the UK Data Facility (25%).

By the tenth year of operation, it is anticipated that the total dataset will reach between 200 and 300PB, with a maximum data transfer rate of 50Gbps in and out of SLAC. Technologies like PanDA for workflow management and Rucio for data management and movement have been adopted to handle the vast scale of data processing. Rucio, initially developed for LHC ATLAS, will manage data classification and movement, supporting multi-site testing and replication across different facilities. The workflow system will integrate technologies such as iDDS to manage dependencies and cvmfs for software distribution, ensuring seamless collaboration between sites. Data management will utilize a distributed system with the Butler repository for metadata coordination and access to Rubin data, synchronized with Rucio for efficient data movement. Local Butler instances at processing sites will handle the last stages of data processing, with datasets registered through Rucio and distributed as needed.

Currently, multi-site testing is progressing, with tools being developed to extract and transfer files across facilities. Early tests show that bandwidth can be fully utilized, though transfer rates are being optimized for larger files. Multi-site integration has advanced, with thousands of processing cores available at both the French and UK data facilities. Rucio has been installed and configured across all sites, demonstrating successful data exchange. The system is now gearing up for full multi-site capability, with final steps focused on synchronizing Rucio and Butler for efficient data processing.

5.11 Vera C. Rubin Observatory: US Data Facility Networking Update (Matthew Mountz)

The Vera C. Rubin Observatory's US Data Facility (USDF) at SLAC is undergoing significant networking upgrades to accommodate the massive data demands of the observatory. The S3DF server and storage enclave is currently connected via multiple 100Gbps links to SLAC's routing infrastructure, with plans to upgrade to Nx400Gbps by 2024-2025. The facility only supports an aggregate network capability of 400Gbps currently, between SLAC and other sites using multiple ESnet 100Gbps links. SLAC's connection to the Energy Sciences Network (ESnet) is enhanced by two optical nodes located on-site, which form part of the Bay Area's optical ring.

The S3DF networking infrastructure is in progress, with S3DF housed in the SRCF-II facility, which consists of 97 racks distributed across seven rows. The networking plan aims to achieve a 2Tbps aggregate connection to ESnet, with 100Gbps ethernet connections for each compute node and 200Gbps (2x100Gbps) per storage server. The system will feature 45 top-of-rack (TOR) switches with 32 x 400Gbps ethernet ports, utilizing a fat-tree topology for high-capacity distribution to Layer 3 routers or direct connections to those routers. In total, the facility will accommodate 5,040 100Gbps ethernet connections, utilizing 1,260 breakout connections (4x100Gbps) to ensure efficient data transfer and processing capabilities.

5.12 Internet2 Updates (Chris Wilkinson)

The Internet2 consortium is a U.S.-based non-profit organization that operates an advanced Internet Protocol (IP) network, primarily serving research and educational institutions. It connects over 60,000 entities in the U.S. and is a collaborative effort between academia, industry, and government. Internet2 provides a secure environment for research and network testing. Its infrastructure includes a high-capacity fiber-optic network with cutting-edge hardware from vendors like Cisco, Ciena, Juniper, and Corning, facilitating advanced networking services such as peer exchange, cloud connectivity, and DDoS protection. Internet2's hardware architecture relies on Cisco's Terabit-scale edge and core transport, Ciena's 400G-800G transponders, and Corning's fiber optic cables, along with perfSONAR for network testing. Its services include using regional infrastructure in conjunction with I2's network for cloud resource access, a peer exchange platform for accessing commercial networks, and extensive DDoS protection for community institutions. The network's Layer 1 services offer point-to-point 10G, 100G, and 400G links across 26,000 kilometers of fiber, with robust backbone waves and a flexible open line system. Layer 2 and 3 services support wide-area Ethernet technology with over 539 CloudConnect connections, various interconnect interfaces, and advanced DDoS protections.

The Internet2 backbone packet network features 94 400Gbps backbone links with 27,600 Tbps deployed capacity. It integrates Cisco's disaggregated switching and routing platforms for efficient, resilient traffic management. Spectrum management and pluggable transponders, such as the Ciena WaveServer 5 and Acatia's 400G QSFP-DD coherent optical modules, provide high-performance network scalability with minimal latency, though they face trade-offs in power consumption and complexity.

Internet2 offers multiple use cases, such as the Coherent Onramp, for partners without direct router access, coast-to-coast 400G links minimizing latency, and specialized research and education traffic support. The network facilitates low-latency access to major cloud platforms like AWS, Google Cloud, and Microsoft Azure, and offers high-speed links for content delivery with providers like Google and Zoom. The Insight Console, Internet2's management tool, enables users to visualize and troubleshoot network services, manage virtual networks, and execute live commands. Future improvements will include enhanced routing management and expanded functionality for global exchange points.

Internationally, Internet2 supports collaboration across research and education networks (NRENs) via 400G global exchange points and transatlantic connections. Notable partnerships include Advance North Atlantic (ANA) and the Asia Pacific Oceanic Network (APONET), enhancing connectivity across continents. These initiatives facilitate data sharing, satellite communications, and network research on a global scale. In North America, the NA-REX collaboration focuses on improving connectivity and network research, leveraging dedicated links for experimental traffic and research applications, with plans to expand 400G links and improve network monitoring tools in 2024.

5.13 ESnet Updates (Kate Robinson)

The Energy Science Network (ESnet), funded by the U.S. Department of Energy's (DOE) Office of Science, is a high-performance, unclassified network designed to support scientific research. It provides networking services to over 50 DOE research sites, ensuring connectivity for critical scientific projects.

ESnet has recently completed several significant upgrades to its Trans-Atlantic and European Union network infrastructure. This includes a 400G and 100G link between New York and London, a 100G link between Boston and Amsterdam, and a 400G link connecting Boston and CERN. Collaboration with GÉANT has also enabled the implementation of a 400G Europe ring, with future plans to expand to 2x400G by September 2024. Current projects include a 400G link between Boston and London, with an ambitious goal to reach over 3 terabits per second (Tbps) by the end of 2027. These efforts are driven largely by the requirements of the High-Luminosity Large Hadron Collider (HL-LHC) project. In terms of future US-Europe connectivity, ESnet is working closely with GÉANT to acquire optical spectrum across at least four diverse subsea cables. This collaboration aims to enhance network resiliency and capacity. While ESnet's targeted cables are already determined, GÉANT's plans are still variable. Depending on GÉANT's procurement timelines, ESnet may explore additional 400G lit services to provide interim diversity.

For US-Europe routing, ESnet follows a policy known as "cold-potato" routing. This strategy emphasizes accepting traffic into ESnet as close to its source as possible and delivering it to its destination while keeping it within ESnet's network for as long as possible. To optimize traffic between the U.S. and Europe, ESnet configures its routers to load-balance traffic across all available Trans-Atlantic paths, with up to six options, including the ability to weigh some paths more heavily than others. Additionally, ESnet has established cloud connectivity through several high-bandwidth private fiber interconnects. These include 5x100G links to Google and 3x100G links to Oracle, as well as 6x100G connections to both Microsoft and Amazon through fabric providers. ESnet also maintains private cloud interconnects with other providers, such as PacketFabric and Equinix Fabric, offering flexibility for end-to-end network provisioning and expanding its cloud service capabilities.

6 Appendix A. Program for the SA3CC Meeting

Tuesday, April 30, 2024

9:00 – 9:10 Welcome (Julio Ibarra) | Download presentation

Session I: Science Requirements & Activities Updates

9:10 – 9:30 Vera Rubin Observatory Operations (Bob Blum, Christian Silva) | Download presentation
9:30 – 9:50 NOIRLab – ITOPS (Mauricio Rojas, Eduardo Toro) | Download presentation
9:50 – 10:10 ALMA NRAO (Sandy George) | Download presentation
10:10 – 10:30 ALMA Network Infrastructure (Jorge Ibsen) | Download presentation
10:30 – 11:00 *Break*

11:00 – 11:20 FYST (a.k.a. CCAT) (Mike Nolta) | Download presentation
11:20 – 11:40 Simons Observatory (Simone Aiola, James Aguirre) | Download presentation
11:40 – 12:00 CMB-S4 (Eli Dart) | Download presentation
12:00 – 12:20 EHT (Jason G SooHoo) | Download presentation
12:20 – 13:30 *Lunch*

13:30 – 13:50 US-ELT (Lucas Macri) | Download presentation
13:50 – 14:10 GMTO (Sam Chan) | Download presentation
14:10 – 14:30 ngVLA (Sandy George) | Download presentation
14:30 – 14:50 Open discussion
14:50 -15:20 *Break*

15:20 – 15:30 Walk to the meeting point
15:30 – 16:45 Historic Tour of SLAC

Wednesday, May 1, 2024

9:00 – 9:10 Welcome

Session II: Providers updates

9:10 – 9:30 Vera Rubin Observatory Network (Cristian Silva) | Download presentation
9:30 – 9:50 SANREN/TENET Network (Renier van Heerden, Ajay Makan) | Download presentation
9:50 – 10:10 SKA network (Richard Hughes-Jones) | Download presentation
10:10 – 10:30 UK & France Data transfer (Richard Hughes-Jones) | Download presentation
10:30 – 11:00 *Break*

11:00 – 11:20 AmLight1: International links (Jeronimo Bezerra) | Download presentation
11:20 – 11:40 AmLight2: Monitoring and Measurement Improvements (Renata Frez) | Download presentation
11:40 – 12:00 REUNA (Albert Astudillo) | Download presentation
12:00 – 12:20 RedCLARA (Marco Teixeira) | Download presentation
12:20 – 13:30 *Lunch*

13:30 – 13:50 RNP (Ari Frazão, Aluizio Hazin) | Download presentation
13:50 – 14:10 rednesp (Ney Lemke) | Download presentation
14:10 – 14:30 USDF data movement and multi-site processing (Richard Dubois) | Download presentation
14:30 – 14:50 USDF infrastructure (Matthew Mountz) | Download presentation
14:50 -15:20 *Break*

15:20 – 15:40	Internet2 (Chris Wilkinson) | Download presentation
15:40 – 16:00	ESnet (Kate Robinson) | Download presentation
16:00 – 16:20	Open discussion
16:20	*Adjourn*

7 Appendix B. Program for the Vera Rubin Observatory NET Meeting

Thursday, May 2, 2024

9:00 – 9:10	Welcome, Goals, and Objectives (Philip DeMar, Cristian Silva, and Julio Ibarra)
9:10 – 9:20	Rubin Observatory Network Status Overview (Cristian Silva)
9:20 – 9:30	Q&A

Session I: LHN network infrastructure updates

Objective: Report on the network infrastructure since the 2023 Rubin Observatory NET meeting. Physical and logical topology representations of the portion of your network that supports the Rubin Observatory is requested.

Europe

9:30 – 9:40	GEANT (Richard Hughes-Jones)
9:40 – 9:50	RENATER/IN2P3 (Fabio Hernandez)
9:50 – 10:00	UK/JANET (George Beckett)
10:00 – 10:05	SLAC-Europe (Matthew Mountz)
10:05 – 10:10	ESnet-Europe (Kate Robison)
10:10 – 10:20	*Break*

South America

10:20 – 10:30	Rubin Observatory Network (Christian Silva)
10:30 – 10:40	REUNA (Albert Astudillo)
10:40 – 10:50	RedCLARA (Marco Teixeira)
10:50 – 11:00	RNP (Aluizio Hazin)
11:00 – 11:10	AmLight and Huawei Bypass (Jeronimo Bezerra)
11:10 – 11:20	*Break*

Contiguous United States

11:20 – 11:30	FIU-AmLight (Jeronimo Bezerra)
11:30 – 11:40	SLAC (Mark Foster)
11:40 – 11:50	ESnet (Kate Robinson)
11:50 – 12:00	Q&A and closing remarks
12:00 – 13:30	*Lunch*

Outcome: Diagrams and description to be made available for LSE-78, LSE-479 and other Rubin documents.

Session II: Review and update NET activities and milestones

Objective: To identify activities and milestones to accomplish before the start of Operations.
13:30 – 13:50 Review construction roadmap
Outcome: Update the Baseline Milestones for LHN project plan.

Session III: Troubleshooting operations procedures

Objective: Open discussion to brainstorm the notifications and procedures when there are outages in the LHN.

13:50 – 14:50 Procedures to discuss:

- Troubleshooting of recent SLAC case
- Trouble Ticket System for the LHN
  - Ticket system will be managed by Rubin Observatory
  - Demonstration of the Jura Ticket System
- How are operators going to conduct maintenance?
- Slack announcements
- How are operators going to conduct failover testing?
- What are the workflows that each operator uses?
- Role of the VNOC

14:50 – 15:00 Break

Session IV: Change management procedures, announcements

15:00 – 16:00 Procedures to discuss:

- What are the notifications:
  - Slack Summing-Announce channel
  - Tools, workflows between LHN operators and VNOC
  - How to balance change management system vs. Slack
- Priorities (four suggested levels:
  - LHN operating at full-service level
  - LHN functioning at full-service level, but operating at reduced capacity level
  - LHN operating at degraded level
  - LHN service interrupted
- How will maintenance be performed from a common perspective?
- Tools

16:00 – 16:10 Wrap up and adjourn

Friday, May 3, 2024

9:00 – 9:10 Welcome, Goals, and Objectives (Philip DeMar, Cristian Silva, and Julio Ibarra)

- Overviews of May 2 meeting and roadmap for Day 2

Session V: LHN network operators' response to Vera Rubin SLA requirements

Objective: Understand what the Rubin Observatory NET must accomplish to satisfy Vera Rubin Observatory management, such that the NET network operators can demonstrate that their networks are responding to the Rubin SLA and are ready for verification and acceptance tests.

How operators are responding to the Rubin LHN SLA

9:10 – 9:15 Primary: Paths are dedicated by the end of FY24 (including Boca – Atlanta in Q2 FY 24). By definition, there is no need for QoS on the dedicated primary (only Vera Rubin traffic)

9:15 – 9:20 Secondary: SLA expectation that by the start of FY24, there will be a 40G minimum (during observation, 10 hours per night) required on your secondary.

- What is the methodology each operator is using to provide the 40G minimum?
- Show a diagram of what each LHN operator has implemented and provide a description of how the failover mechanism works (Vera Rubin, REUNA, AmLight, ESnet to present 1-2 slides each)

9:20 – 9:25 Summit to Base – Vera Rubin (Hernan Stockebrand)
9:25 – 9:30 Base to Santiago – REUNA (Albert Astudillo)
9:30 – 9:35 Santiago to Atlanta – AmLight (Renata Frez)
9:35 – 9:40 Atlanta to SLAC – ESnet (Kate Robinson)

Outcome: To document what methods the LHN operators are using to respond to the Rubin SLA.

Session VI: USDF Updates and Embargo Rack

Objective: To inform the NET of updates from the USDF regarding the Embargo Rack and its network configuration.

9:40 – 10:00 USDF updates on Embargo Rack (Richard Dubois, Omar Quijano)
10:00 – 10:10 Q&A and discussion
10:10 – 10:20 *Break*

Session VII-a: Data Movement Experiments from Summit to SLAC

10:20 – 10:40 Present the measurement infrastructure for the LHN. Tests for Primary and Backup paths.

- Initial USDF throughput tests (rtn-065) (Christian Silva, Carlos Barria Young)
- Retransmits reported in the perfSONAR reports. Are retransmits impacting experiment results?

10:40 – 11:10 Report on Rubin telemetry data transfer from Summit to SLAC

- Throughputs, problems, plans for the future, etc.
- Q&A

11:10 – 11:20 Break

Session VII-b: Update of Measurement Infrastructure

LHN End-to-End measurements/monitoring, what version of perfSONAR

11:20 – 11:25 Summit to USDF Storage (Julio Constanzo, Matthew Mountz)
11:25 – 11:30 Base to SLAC Border (Julio Constanzo, Matthew Mountz

LHN Domain-level measurements (intra-domain & cross-domain), what version of perfSONAR

11:30 – 11:35 Summit to Base – Vera Rubin (Julio Constanzo, Matthew Mountz)
11:35 – 11:40 Base to Santiago – REUNA (Albert Astudillo)
11:40 – 11:45 Santiago to Atlanta – AmLight (Renata Frez)
11:45 – 11:50 Atlanta to SLAC – ESnet (Kate Robinson)
11:50 – 12:00 What version of perfSONAR should be operating when Operations starts?

Outcomes:

- Document the mechanism to export measurement data. Relevant for the VNOC.
- Update relevant documents (e.g. LSE-479) with Measurement Infrastructure information.
- Prepare the End-to-End Test plan document for submission to the Rubin Observatory CCB for baseline.

12:00 – 13:30 Lunch

Session VIII-a: VNOC Status Updates Part 1

Objectives:

- Updates from operators exporting data to VNOC (diagrams, experience future)
- What information is each LHN operator exporting to the VNOC?
- How is the information being exported?

13:30 – 13:40 Vera C. Rubin Observatory
13:40 – 13:40 REUNA
13:50 – 14:00 AmLight
14:00 – 14:10 ESnet
14:10 – 14:20 SLAC
14:20 – 14:30 Q&A
14:30 – 14:40 *Break*

Session VIII-b: VNOC Status Updates Part 2

14:40 – 15:00 Dashboards
15:00 – 15:15 Data received
15:15 – 15:30 Ticketing integration between VNOC and observatory operations
15:30 – 15:50 Q&A

Session IX: Roadmap and Next Steps

15:50 – 16:10 Roadmap and vision (Bob Blum)
16:10 – 16:30 Q&A
16:30 *Adjourn*

8 Appendix C. List of Participants for SA3CC Meeting April 30-May 1, 2024

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9 Appendix D. List of Participants for Vera Rubin Observatory NET Meeting May 2-3, 2024

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