AARClight - New opportunities for South Atlantic R&E Network collaboration between Africa, Brazil, and the US

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Abstract

Higher education and research science is being conducted in an era of information abundance. Sharing educational resources (e.g. Libraries, Curriculums, Online courses) and science resources, such as data commons, instrumentation, technology, and best practices, across national borders, can promote expanded global education goals and scientific inquiry and has the potential to advance discovery. Providing robust diverse Research and Education Networks (RENs) linking the U.S., Brazil (S. America) and African researcher and education communities is an increasingly strategic priority. Africa has developed research and education communities with unique biological, environmental, geological, anthropological, and cultural resources. Research challenges in atmospheric and geosciences, materials sciences, tropical diseases, biology, astronomy, and other disciplines will benefit by enhancing the technological and social connections between the research and education communities of these three continents via a S. Atlantic route to complement the existing North Atlantic routes via Europe.

This paper will discuss the availability of new submarine cable spectrum for RENs via SACS between Luanda, Angola and Fortaleza, Brazil and the Monet cable between Fortaleza and Florida in the U.S. for use by research and education communities. This new infrastructure creates an unprecedented opportunity for the stakeholders to coordinate planning efforts to strategically make use of the offered spectrum towards serving the broadest communities of interest in research and education. The new links will be a foundational layer for the employment of R&E networks outfitted with leading edge technologies (e.g. Science DMZ, SDN, SDX, cybersecurity etc.).

The paper seeks to leverage a discussion of opportunities for a new R&E Exchange point at Luanda, Angola, other connectivity options, and to further promote discussion and identify synergies with UbuntuNet members.

Florida International University and AmLight consortium partners are planning, designing, and defining a strategy for high capacity connectivity research and education network connectivity between the US and Southwest Africa, called Americas Africa Research and eduCation Lightpaths (AARCLight). Furthermore, the other "end" of the SACS cable is being connected to an Open Fortaleza R&E Exchange point in Brazil. The new academic exchange point, South Atlantic Crossroads (SAX), is managed by Rede Nacional de Ensino e Pesquisa (RNP), where AmLight connects and continues on the Monet spectrum to Boca Raton Miami Florida. Having the transport service opened in Fortaleza will allow RENs from South America to collaborate with partners in Africa with significantly less delay, (at least 150ms lower) than using the current paths available. Interactive high-resolution video and big data applications will benefit from the establishment of the SAX international exchange point in Fortaleza.

Keywords: Research and Education Networks, Exchange point, US-Brazil-Africa Collaboration

1. Introduction

Linking South and North America via a South Atlantic high-performance Research & Education Network (REN) with the nations of Africa's researchers, students, knowledge creation and knowledge sharing communities has become an increasingly strategic priority[1]. Africa offers research and education communities with unique biological, environmental, geological, anthropological, and cultural resources. Research challenges in atmospheric and geosciences, materials sciences, tropical diseases, biology, astronomy, and other disciplines will benefit by enhancing the technological and social connections between the research and education communities of the US, Brazil, and Africa. For many years, we have seen the dramatic benefits of high-performance networking in all areas of science and engineering.

We present AARCLight (Americas Africa Research and eduCation Lightpaths) to provide a bridge from the current infrastructure, to one that will provide unprecedented resources for research and education communities.

2. New submarine cables in the South Atlantic

Several existing and new cable systems are interconnecting the continents in the South Atlantic as shown in Figure 1. The MONET cable which connects Boca Raton which further connect to Miami, Florida (USA) to Fortaleza (Brazil) is operational. The 6,165km South Atlantic Cable System (SACS) between Fortaleza (Brazil) to Sangano (Angola) was completed in Q3 2018 [2] and is operational. SACS is 100% owned and managed by Angola Cables who has entered into an agreement with Florida International University (FIU) for effectively 100 Gbps provisioned over spectrum using coherent WDM technology. SACS offer a total design capacity of 40 Tbit/s between Fortaleza (Brazil) and Luanda (Angola). Almost at the same time in September 2018 [3], the completion of the close to 6000km marine installation South Atlantic Inter Link (SAIL), Fortaleza (Brazil) to Kribi (Cameroon) was announced. The EllaLink system [4], Fortaleza (Brazil) to Sines (Portugal) is currently planned and aims to be Ready For Service (RFS) in 2020. The 17,500km America Movil (AMX-1) cable system, from Fortaleza (Brazil) to Jacksonville and Hollywood (USA) has been operational since 2015 [5]. AMX-1 has multiple landing points in Colombia, Brazil, the Dominican Republic, Puerto Rico, Guatemala, Mexico, and the United States. Seaborn's SABR cable system [6] is currently being developed to connect Cape Town (South Africa) to Recife (Brazil), and eventually the USA and will be RFS in 2029. Fortaleza (Brazil) is a landing point for all these cables, except for SABR.

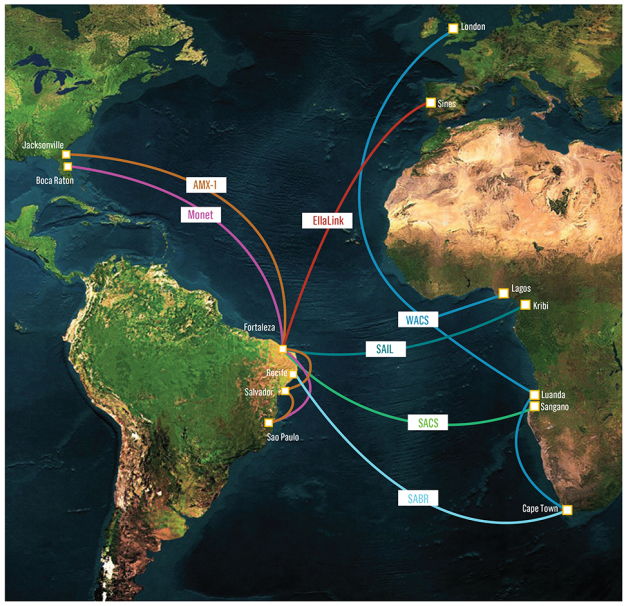


Figure 1 Submarine cables in the South Atlantic

3. Network performance to Latin America

In June of 2018 network performance tests (Table 1) from Cape Town to Latin America and the U.S. shows quantified improvement. The current latency data was provided by TENET over the UbuntuNet, GEANT and Internet2 links. The Estimated via SACS column shows improved performance using data collected from the Angola Cables IP network. The Possible Improvement column shows the percentage of the estimated improvement, ranging from 20% to 71% in reduced latency.

Table 1 Estimated performance improvement using SACS cable system

From Cape Town to:	Currently via TENET, UbuntuNet, GEANT, and I2 *	Estimated via SACS	Possible Improvement
New York	241ms	192ms	20%
Miami	272ms	161ms	41%
Fortaleza, Brazil	336ms	97ms	71%
Sao Paulo, Brazil	381ms	142ms	63%
Santiago, Chile	382ms	183ms	52%
La Serena, Chile	392ms	193ms	51%

* Data column 2 provided by TENET/Len Lotz June 2018, except NY. All else from Angola Cables

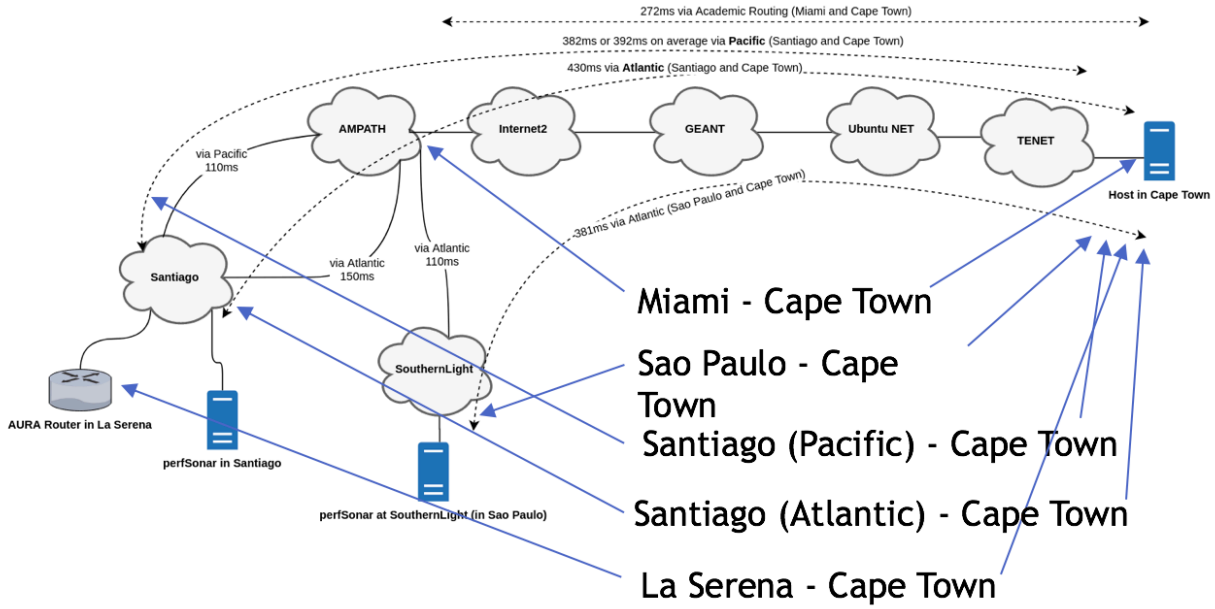


Figure 2 Conceptual network diagram of the tested network path

Figure 2 shows the conceptual network diagram of the domains involved in the tested path.

4. Americas Lightpaths Express and Protect (ExP)

AmLight ExP is a hybrid network that uses optical spectrum (Express) and leased capacity (Protect) to build a reliable leading-edge network infrastructure for research and education. It is connected at AMPATH and open exchange points in Brazil, Chile, Panama, etc. The total production bandwidth provided by AmLight ExP between the U.S. and South America will grow to more than 680G. Consortium members include FIU, Association of Universities for Research in Astronomy (AURA), Large Synoptic Survey Telescope (LSST), Rede Nacional De Ensino E Pesquisa (RNP), Academic Network of Sao Paulo (ANSP), Cooperación Latino Americana de Redes Avanzadas (RedCLARA), Red Universitaria Nacional (REUNA), Florida Lambda Rail (FLR), Telecom Italia Sparkle, Angola Cables and Internet2 (www.amlight.net).

Established in 2001, AMericas PATHway (AMPATH) is an Open R&E eXchange Point (RXP) in Miami - Florida, managed by the Center for Internet Augmented Research and Assessment (CIARA) at FIU. AMPATH serves as the premiere interconnection point for U.S., Latin America, and Caribbean RENs. AMPATH works as a major research facility recognized by the U.S. National Science Foundation (NSF) and the US Department of Energy (DOE), and supporting international e-science.

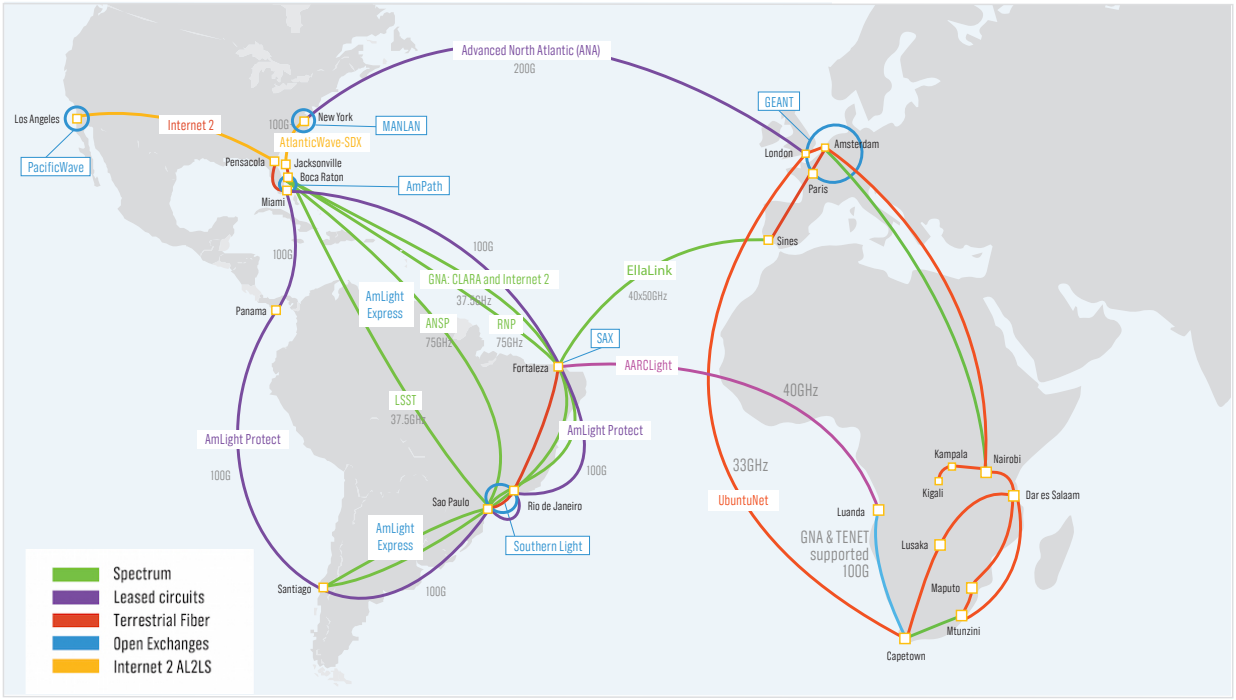


Figure 3 AmLight Conceptual Network Map

Currently, AmLight ExP operates an international network with multiple links connecting U.S. RENs to Central and Latin America: a 100G ring Miami-Fortaleza, Fortaleza-Sao Paulo, Sao Paulo-Santiago, Santiago-Panama City, and Panama City-Miami, a 10G ring from Miami-Sao Paulo-Miami for protection, and a 10G Miami-Santiago link for protection. The 100G and 10G rings are diverse, operating on multiple submarine cables. Total upstream capacity presently is at 230Gbps. AmLight network transports varieties of academic applications which requires reliable monitoring and troubleshooting tools. Figure 3 shows a conceptual network map of AmLight ExP and the network connections to South America, Africa, and Europe.

5. South African National Research & Educational Networks

The Tertiary Education and Research Network of South Africa (TENET) is South Africa's national research and education network organization. TENET operates the South African National Research Network (SANReN). SANReN and TENET jointly form South Africa's NREN (SA NREN) and operates an exchange point in Cape Town called ZAOXI. SA NREN has ownership of 7.4% of the WACS cable allowing it to light capacity between any 2 landing stations. AARCLight and AmLight are forming a collaborative partnership with SA NREN. The UbuntuNet Alliance can participate in this project through its connection in Cape

Town. Additionally, UbuntuNet can participate by helping to establish an Exchange Point in Luanda. SA NREN can light capacity between ZAOXI and the new exchange point using WACS. Collaborative partners can utilize capacity as needed on the SACS cable, WACS cable, AARCLight etc. to connect to AmLight in Fortaleza, ZAOXI in Cape Town or any other connected Exchange point. SA NREN's WACS connectivity may be extended to reach other landing stations to add new collaborative partners to the project.

6. Opportunity for new R&E Exchange point at Luanda, Angola

With two submarine systems (WACS and SACS) with landing stations in Angola (Figure. 4), an open exchange point in Luanda would act as a catalyst for revolutionary change in the Angolan research and education community. Currently, the universities all procure only commodity Internet connectivity. A task force has been organized to develop and build out an Angolan National Research and Education Network. Viable NRENs in West Africa are part of the focus of the European Union's AfricaConnect2 and AfricaConnect3 projects. As such, an open exchange point in Luanda could become a point of interconnection with WACREN. Furthermore, through both the 2010 MOU between Internet2 and UbuntuNet Alliance, as well as the UbuntuNet Alliance strategic plan, fostering interconnectivity between the U.S. research and education networking communities and those of UbuntuNet is considered to be mutually desirable.

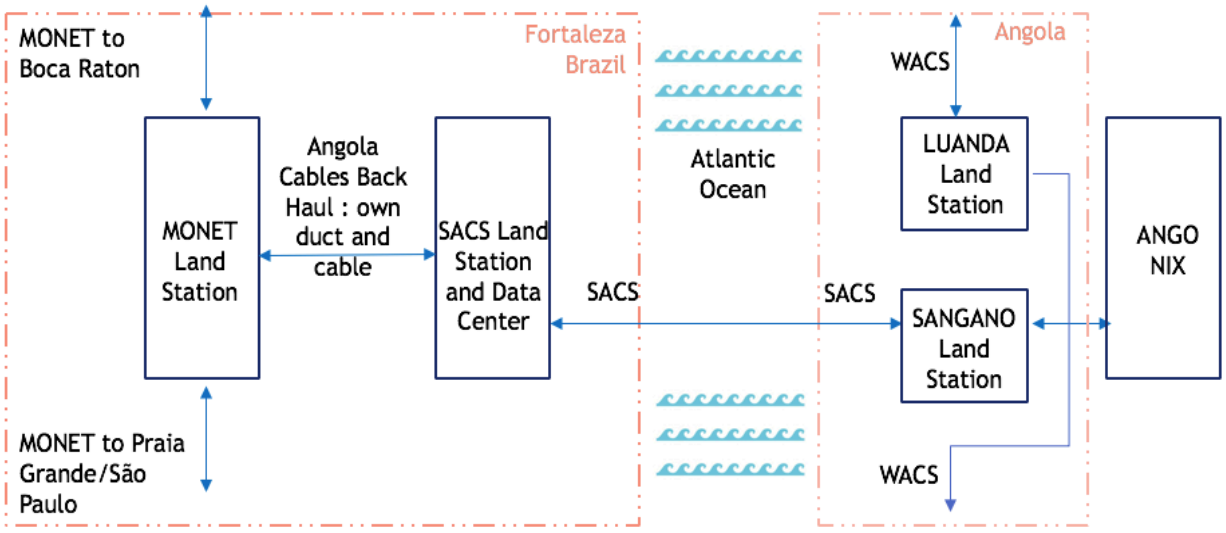


Figure 4 Logical diagram of landing station of SACS and WACS cable systems in Angola

The AARCLight project acts as a first direct physical infrastructure to support the long-standing desire for furthering Africa, Brazil, US network-enabled collaboration. AARCLight constitutes more than an incremental change in the infrastructure enabling collaboration. It is a technological tipping point that will enable the U.S., Brazil, Angola, WACREN, UbuntuNet Alliance, SaNREN, and TENET to exponentially increase the rate of collaboration, discovery, and learning.

7. New GOLE/GXP in Fortaleza: South Atlantic Crossroads (SAX)

The South Atlantic Crossroads (SAX) is a new academic exchange point, managed by RNP [7] in Fortaleza, Brazil. SAX connects to many Points of Presence (PoPs) within Brazil. In addition, RNP participates in the Global R&E Networks CEO Forum, and in particular in the planning of

the Global Network Architecture (GNA) [8], which seeks to provide a rational global R&E network infrastructure. The GNA team has already identified Fortaleza as a critical point in the future design of this global network, due to its location at the narrowest part of the South Atlantic Ocean, thus providing an optimal location for exchanging traffic between Europe, Africa, and the Americas. Having the connectivity coming from Sao Paulo, Florida and Angola in Fortaleza allows R&E networks from South America to collaborate with partners in Africa with significantly less delay, (at least 150ms lower) than using the current paths available. High resolution video and big data applications will benefit from the establishment of the SAX international exchange point in Fortaleza. An opportunity for using spectrum to reach continental US (via MONET), African R&E researchers could collaborate with partners in Brazil and the U.S., also with reduced delay, at least 100ms lower, compared to the current paths available.

Additionally, Fortaleza is a key aggregation point in the South Atlantic because of the multiple cable systems landing there. For example, the MONET cable, the SACS cable to Angola, and forecasted EllaLink cable to EU RFS 2020, and via RedCLARA to Los Angeles, CA, and future connections with other partners.

SAX is designed to be compliant with both GNA and Global Lambda Integrated Facility (GLIF) initiatives. GLIF is an international consortium that promotes the interconnection of lambdas around the world. GLIF International lambdas act as an integrated facility with the goal to support data-intensive scientific research. Since 2005, via conferences and workshops, it gathers the discussing equipment, requirements for connections, and essential engineering functions and services [9]. International partners, such as RedCLARA, AmLight ExP and GEANT, are crucial to providing the new circuits reaching SAX.

8. Americas Africa Research and eduCation Lightpaths (AARCLight)

Science is being conducted in an era of information abundance. Sharing science resources, such as data, instrumentation, technology, and best practices, across national borders, can promote expanded scientific inquiry and has the potential to advance discovery. Linking the U.S., Brazil, and the nations of Africa's research and education communities is an increasingly strategic priority. Africa offers research and education communities with unique biological, environmental, geological, anthropological, and cultural resources. Research challenges in atmospheric and geosciences, materials sciences, tropical diseases, biology, astronomy, and other disciplines will benefit by enhancing the technological and social connections between the research and education communities of Africa, Brazil and the US. FIU and AmLight consortium partners are planning, designing, and defining a strategy for high capacity research and education network connectivity between the US and West Africa, called Americas Africa Research and eduCation Lightpaths (AARCLight) [10] (NSF Award #1638990).

This planning project is largely based on the availability of submarine cable spectrum for use by research and education communities. It has created an unprecedented opportunity for the stakeholders in the U.S., S. Africa, and Brazil to coordinate planning efforts to strategically make use of the offered spectrum towards serving the broadest communities of interest in research and education.

9. Science Drivers

Multiple ongoing collaborative projects between the researchers from the U.S., Brazil and African communities can potentially benefit from the network connections in the South Atlantic. Here we are presenting only a few of the major projects involving astronomy, medical, agricultural and genomics research.

South African Astronomy applications: The South African Astronomical Observatory (SAAO) [11] is a facility of the National Research Foundation (NRF) [12], which operates optical telescopes, outreach and research located in Sutherland under the Department of Science and Technology. The Southern African Large Telescope (SALT) [13] is the largest single optical telescope in the southern hemisphere and among the largest in the world managed by SAAO. SALT is funded by a consortium of international partners from South Africa, the U.S., Germany, Poland, India, the U.K., and New Zealand. Other SAAO Hosted Research Telescopes are BiSON [14], KELT-South [15], LCOGT [16], MONET [17], Solaris [18], SuperWASP-South [19].

The MeerKAT [20] 64-antenna array radio telescope located in the Karoo region is a precursor to the Square Kilometre Array (SKA) [21] and will be merged into the SKA1 (2020) with current data at a rate of 4.7 Gbps. SKA High frequency dishes will produce ten times the current global internet traffic and generate 960,000 Tb/day with rate ~160 Gb/s. SKA will be the largest array telescope in the southern hemisphere (2024) with collaborators from USA, Canada, India, Japan, China, Australia, France, UK, Italy, Finland, Germany. SKA Phase two will include telescopes from New Zealand, Botswana, Ghana, Kenya, Mauritius, Madagascar, Mozambique, Namibia and Zambia.

Brazilian Research and Educational Network (RNP) applications: RNP supports many science drivers complimentary to collaboration with African research interests. An agricultural collaborative research involving pest control on army worm (*lagarta do cartucho*) attacking maize and sorghum, is conducted between Brazil, U.S., South Africa, and nine other African countries and supported by Embrapa (Brazilian Corporation for Agricultural Research in the Ministry of Agriculture). Multiple ongoing collaborative medical projects with the African nations of the Community of Portuguese -Speaking Countries (CPLP) are established by the Brazilian Ministry of Health - Osvaldo Cruz Institute (FIOCRUZ) in collaborations with the National Institute of Infectiology in Mozambique on clinical research and clinical tests. CPLP consists of the following countries: African countries: Angola, Cape Verde, Equatorial Guinea, Guinea-Bissau, Mozambique, and São Tomé and Príncipe. Non-African full members: Brazil, Portugal, and Timor-Leste. The scope of those projects includes infectious diseases as Malaria, STI, AIDS, Viral Hepatitis, and Tuberculosis. Another FIOCRUZ and Federal University of Rio de Janeiro (UFRJ) project in Angola is collaborating with the National Institute for Health Research (NIHR) of the Angolan Ministry of Health de Angola, currently investigating the genotyping and resistance of HIV-1 to anti-retroviral drugs.

The Atlantic International Research Centre (AIR-Centre) has agreements between the EU-BR-ZA for collaborative research activities in the South Atlantic and Southern Oceans
The ambition of the AIR Centre is to be a long-term platform for North-South, South-North, East-West and West-East collaboration in the Atlantic towards a holistic, integrative and systemic approach to knowledge on space, oceans, climate change impacts, energy and data

sciences, while fostering an inclusive perspective to science, technology and economic development [22].

MoRENeT (Mozambique NREN has a long-standing collaboration with RNP participating annually in the RNP Forum since 2014. Activities include exchange of good practices in management and governance of research networks, IT training (including 25 techies in 2017 in Brazil), and exchange of information on technical and operational management.

Additional information about science drivers is gathered via the ongoing AARCLight project research survey. The 11th UbuntuNet Connect conference in Zanzibar, Tanzania created an opportunity to assess the e-cyberinfrastructure or the participating African NRENs and several responses from the CEOs, Senior Managers, and other African NREN representatives expressed a lot of enthusiasm in engaging in collaborative research between the U.S., Brazil, and the African communities using the increased capacity via the SACS network connection opportunity in the South Atlantic. Survey results will be published by year's end in the AARCLight Annual Report to the NSF.

10. Conclusion and suggested next steps

Based on multiple interactions with the stakeholders of AARCLight we have formulated five goals to guide continued collaboration toward full utilization of the new opportunities for South Atlantic R&E Network collaboration between Africa, Brazil, and the US. The goals are as follows:

10.1 Investigation of an Open Exchange point in West Africa

We have begun systematically collecting data via a survey of potentail AARCLight partners to determine the strategic value to the R&E community to establish an open exchange point in Angola, or alternatively, to focus on extending an AARCLight link on the SACS cable to another location. Early results from the UnbuntuNet Connect Conference are being tabulated. At this time the collaborating partners are not at the stage to advocate the establishment of an Open Exchange point in Luanda, Angola. The nascent Angola NREN has not taken shape yet. The AARCLight team should continue to evaluate infrastructure enhancement. We have collectively agreed to employ exisiting infrastructure to effect connections on SACS, WACS, and AmLight-ExP between Africa and the Americas.

10.2 Develop a new network design in collaboration with AARCLight partners

AARCLight partners are engaged now, developing the equipment configuration to fully leverage the SACS and Monet submarine cable systems' spectrum allocation. The new network design shall respond to the following questions: How spectrum shall be used on the operational SACS cable? How to represent and describe interconnections to AARCLight partners in the U.S., Africa, Brazil, and the Americas? How to represent and describe connections to science projects and resources in Africa?

10.3 Develop additional goals and strategies to expand the scope of work based on findings from previous activities

Collaboratively develop an expanded project plan grounded on the findings and recommendations from AARCLight activities during 2017-18. Explore the feasibility of submitting a new five-year proposal to the NSF and other country partner funding agencies based on our findings.

10.4 Develop an assessment plan for the following objectives

First, assess the engagement level of the community of interest by conducting a formative and summative evaluation (see Survey Appendix A). Second, develop an assessment plan for the engagement level of the community of interest, the spectrum utilization, the shared vision and goals by the AARCLight partners, and the level of engagement with the potential new infrastructure.

10.5 Develop a plan for community engagement collaboratively with the stakeholders

Conferences, meetings, workshops and other relevant venues attended by representatives of the RENs and science application communities are important for AARCLight members to attend either in person or virtually. AARCLight PI, Co-PIs, and senior personnel shall continue attending relevant venues in Africa Brazil, and the U.S. attended by representatives of the RENs and science application communities. It is important to develop a plan for engaging communities of interest. For example, CANARIE (Canada's NREN) is a strategic partner for SKA (regional data center) and could be a strategic partner for AARCLight. The AARCLight team plans a future investigation for possible collaboration with the Canadian SKA Data center processing facility with regards to an alternative route via South Africa, Brazil, Florida, and Montreal (where the center will be located).

By diligently adhering to the above goals while concurrently moving forward to light the spectrum on SACS and make a connection to WACS the AARCLight project will successfully achieve a new beneficial international R&E network link in the South Atlantic for all stakeholders.

11. Acknowledgments

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Appendix A



1. Please enter your contact information below:
   (Veuillez entrer vos coordonnées ci-dessous:)

   Name (Prénom)
   Position
   Email
   Organization (Organization)
   Country (Pays)

2. What cyber e-infrastructure do you manage? Please include the network, HPC, and any science or online learning special services that are international in nature.
   (*Quelle cyber-infrastructure gérez-vous? Veuillez inclure le réseau, le HPC et toute science ou services spéciaux d'apprentissage en ligne de nature internationale.)*

3. Are you a member of: (select all that apply)
   (Êtes-vous membre de: (cochez toutes les réponses qui s'appliquent))

   WACREN
   UbuntuNet Alliance
   SANReN
   Others

4. What capacity does your network currently has? Please address connection points and bandwidth for commodity Internet and / or Research & Education Networking.
   (Quelle est la capacité actuelle de votre réseau? Veuillez indiquer les points de connexion et la bande passante pour les réseaux Internet et / ou le réseau de recherche et d'éducation.)

5. How many research institutions is your network currently supporting? Please list the number of universities, laboratories, and other big data producing connectors.
   (Combien d'institutions de recherche votre réseau soutient-il actuellement? Veuillez indiquer le nombre d'universités, de laboratoires et d'autres connecteurs produisant des données volumineuses.)

6. Do you have a plan to connect more research organization in the near future? If yes, please describe the type of organizations and your timeline?
   (Avez-vous un plan pour connecter plus d'organisations de recherche dans un avenir proche? Si oui, veuillez décrire le type d'organisations et votre calendrier.)

7. Do you have collaboration in South & North America that will benefit from a South Atlantic research and education network connection? If yes, please describe the collaboration by

Country, State, City, type of science and / or education, and other details that will help us facilitate an end-to-end high-performance network connection.
(Avez-vous une collaboration en Amérique du Sud et du Nord qui bénéficiera d'une connexion au réseau de recherche et d'enseignement de l'Atlantique Sud? Si oui, veuillez décrire la collaboration par pays, État, ville, type de science et / ou d'éducation, ainsi que d'autres détails qui nous aideront à faciliter une connexion réseau de haute performance de bout en bout.)

8. Please describe how the connection in the South Atlantic route brings benefits to your organization in addition to your answer in Q7 above, if any.
(Veuillez décrire en quoi la connexion sur l'Atlantique Sud présente des avantages pour votre organisation, en plus de votre réponse au Q7 ci-dessus, le cas échéant.)

9. What challenges would your NREN face to access the bandwidth capacity on the new South Atlantic (SACS) cable?
(Quels défis votre NREN devra-t-il relever pour accéder à la capacité en bande passante du nouveau câble (South Atlantic) SACS?)

10. Please add any other comments you may have below.
(Veuillez ajouter tout autre commentaire que vous pourriez avoir ci-dessous.)