

Developments in the South Atlantic

EXPLORING MODELS FOR SHARING SUBMARINE CABLE CAPACITY

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Outline

A. South Atlantic Cable System (SACS), between Brazil and Angola, is operational and we have acquired capacity for REN network

B. West African Cable System (WACS), between South Africa and Europe, is operational and connects to SACS in Angola

C. South America eXchange (SAX), the GXP (GNA eXchange Point) in Fortaleza, Brazil, is ready to connect SACS to AmLight ExP connections

D. We have the ingredients to create a resilient South Atlantic REN interconnection





Sangano (Luanda, Angola) is the cable land station built in 2010 to receive the WACS cable

South Atlantic Cables up to 2021

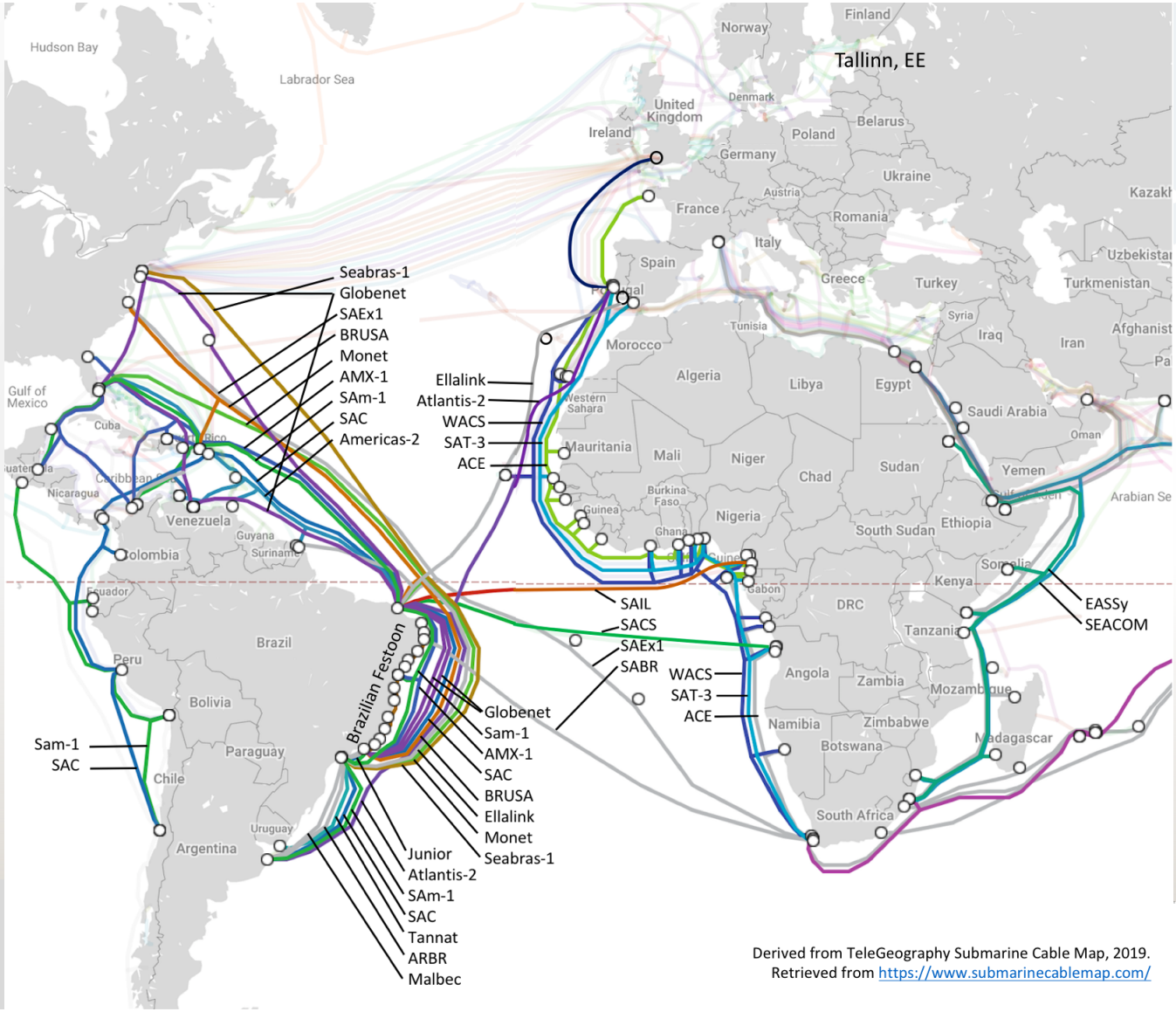
N & S America		Africa-Europe	
Name	**Year**	**Name**	**Year**
Americas-2	2000	SAT-3/WASC	2002
SAC	2000	SEACOM	2009
GlobeNet	2000	EASSy	2010
SAm-1	2001	WACS	2012
AMX-1	2014	ACE	2012
Monet	2017		
Seabras-1	2017		
BRUSA	2018		

South America transatlantic

Name	**Year**
Atlantis-2	2000
SACS	2018
SAIL	2018
EllaLink	2020
SABR	2021
SAEx1	2021

South America (internal)

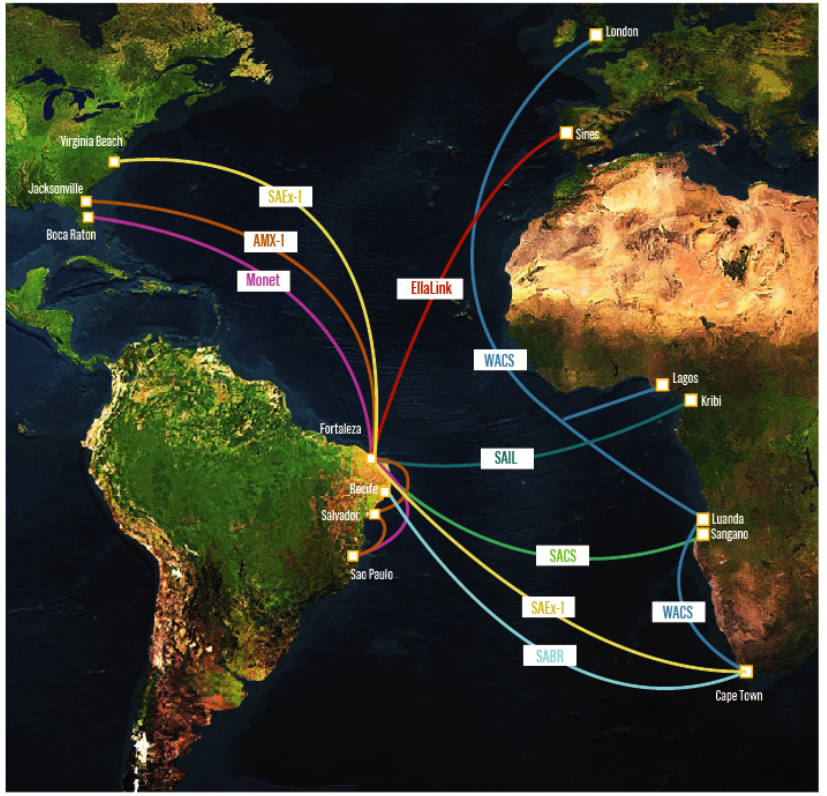
Name	**Year**	**N-S Cable extended**
BR Festoon	1996	Americas-1/2
Tannat	2018	Monet (Google, Antel)
Junior	2018	Monet (Google)
Malbec	2020	GlobeNet
ARBR	2021	Seabras-1



Derived from TeleGeography Submarine Cable Map, 2019.
Retrieved from https://www.submarinecablemap.com/

New submarine cables in the South Atlantic

- **Monet**: Boca Raton, FL - Fortaleza, BR. Operational
- **South Atlantic Cable System (SACS):** Fortaleza, BR - Sangano, Angola. Operational
- **America Movil (AMX-1):** Fortaleza, BR - Jacksonville and Hollywood, FL. Operational
- **SAEx1:** Virginia Beach, VA- Cape Town, SA, RFS 2021 Q1
- **SABR:** Cape Town, SA - Recife, BR. RFS 2019
- **South Atlantic Inter Link (SAIL):** Fortaleza, BR - Kribi, Cameroon. RFS 2018
- **EllaLink:** Fortaleza, BR - Sines, Portugal. RFS 2020
- Fortaleza is a landing point for all cables, except for SABR

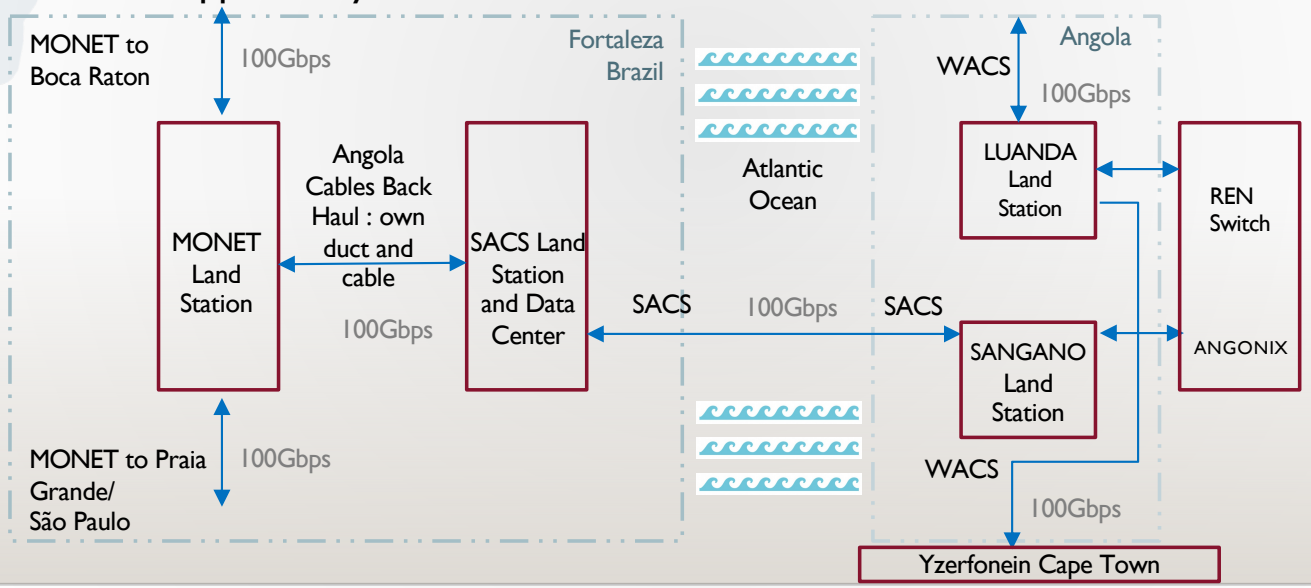


Current REN Infrastructure in the South Atlantic

- 225GHz of spectrum on Monet committed in AmLight-ExP project
- 40GHz of spectrum on SACS is available to the R&E community, currently 100G Ethernet. (FIU & Angola Cables MoU in place)
- TENET operates capacity on WACS in 100G increments growing to >800G (FIU & TENET MoU in place)
- R&E exchange point in Cape Town operated by SANReN and TENET connected to WACS
- South America eXchange point (SAX) in Fortaleza, operated by RNP
- R&E exchange point in Lagos, operated by WACREN – not on WACS yet

REN Infrastructure in the South Atlantic

- SACS and WACS are connected at Sangano Cable Station in Angola, with possibility of being extended to Luanda via AC backhaul
- Angola Cables Data Centre (ANGONIX) in Luanda could be significant exchange point to a future Angola REN
- SACS creates an opportunity to connect Africa to Brazil and the USA



Americas Lightpaths Express and Protect (ExP)

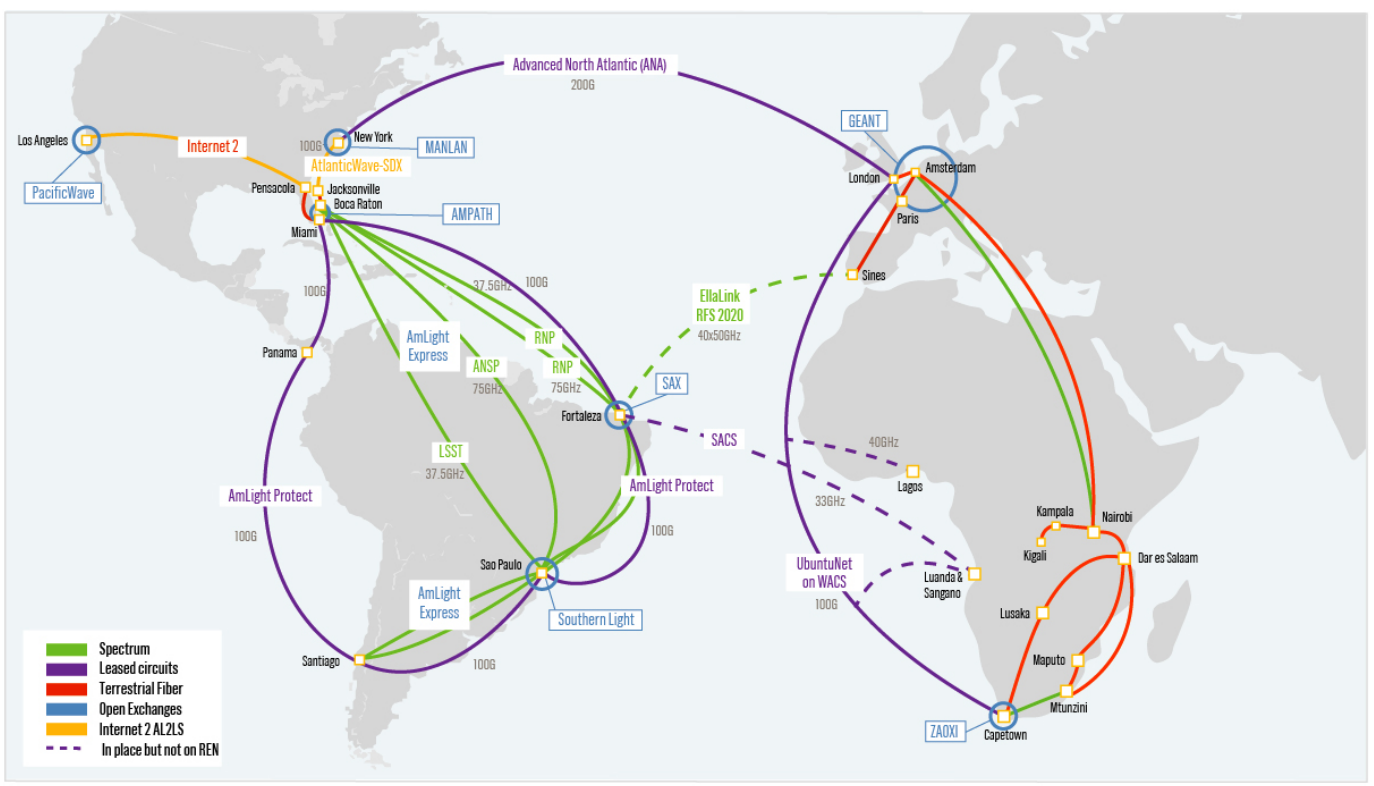
AmLight ExP is a hybrid network that uses Optical spectrum (Express) and Leased capacity (Protect) to build a reliable leading-edge network infrastructure for research and education

Links:

- 100G ring Miami-Fortaleza, Fortaleza-Sao Paulo, Sao Paulo-Santiago, Santiago-Panama City, Panama City-Miami
- 10G ring from Miami-Sao Paulo-Miami for protection
- 10G Miami-Santiago for protection
- 100G and 10G rings are diverse, operating on multiple submarine cables
- Total upstream capacity presently at 230Gbps

(NSF Award# ACI-1451018 2015-2020)

Americas Lightpaths Express and Protect (ExP) (Conceptual)



AARCLight planning project

Award #OAC-1638990, at FIU

Purpose - define a strategy for research and education network connectivity between the US, Brazil and Africa

- Build a partnership between the stakeholders
- Seek long-term spectrum on a trans South Atlantic cable – sufficient for 100G connection
- Identify potential users
- Define and articulate the interconnection and switching infrastructures at the relevant intermediate exchange points
- Develop a plan to integrate science users with the network strategy



UbuntuNet Connect 2018, 22-23 November 2018 in Zanzibar, Tanzania: https://ubuntunet.net/category/events/ubuntunet-connect/

The SA NREN = TENET & SANReN

TENET

- Created in 2000 as a non-profit company. Membership is primarily universities (all 26) and research institutions, but serves a much wider constituency
- Funded through cost recovery from beneficiaries
- Operates network deployed by SANReN, but also deploys some network components
- Delivers services

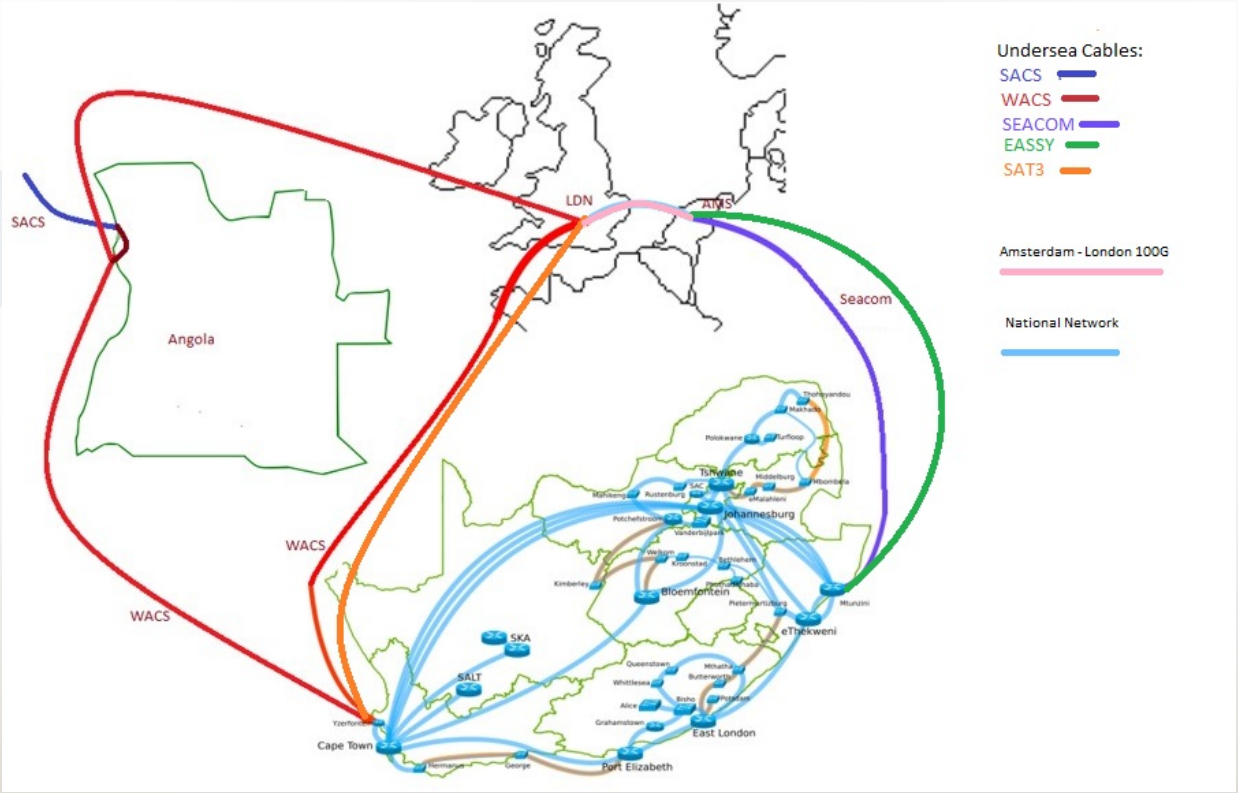
SANReN

- Created in 2006 as a business unit in the Council for Scientific and Industrial Research
- Funded through a State grant (Department of Science and Technology)
- Designs, acquires and implements networks and network components, from metro to international level
- Develops and incubates services

SA NREN

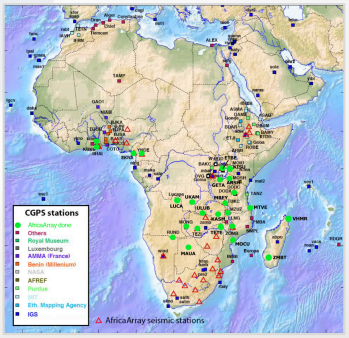
- SA NREN (TENET and SANReN) operates an exchange point in Cape Town – ZAOXI.
- SA NREN has ownership of 7.4% of the WACS cable allowing it to light capacity between any 2 landing stations between Cape Town and London.
- AARCLight and AmLight are forming a collaborative partnership with SA NREN.
- UbuntuNet will participate in this project by connecting to ZAOXI.
- Once an exchange point is established 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.

SA NREN Connectivity to Angola & London & Amsterdam

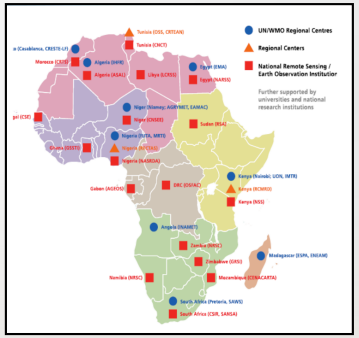


Science Driver collaborations Africa & The Americas

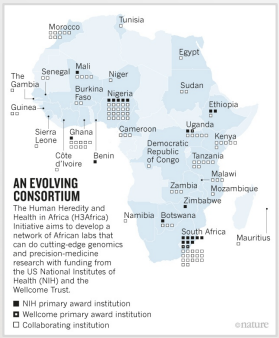
- Astronomy
- Medical
- Other Science Disciplines



Global Positioning System (CGPS) in Africa. Source: https://www.unavco.org/community/publications_and_reports/reports/reports.html



Earth Observation Institutions
Torman, Y. (2017). *AfREN and AfriGEOSS.* Paper presented at the AfriGEOSS Symposium 2017, Sunyani, Ghana.



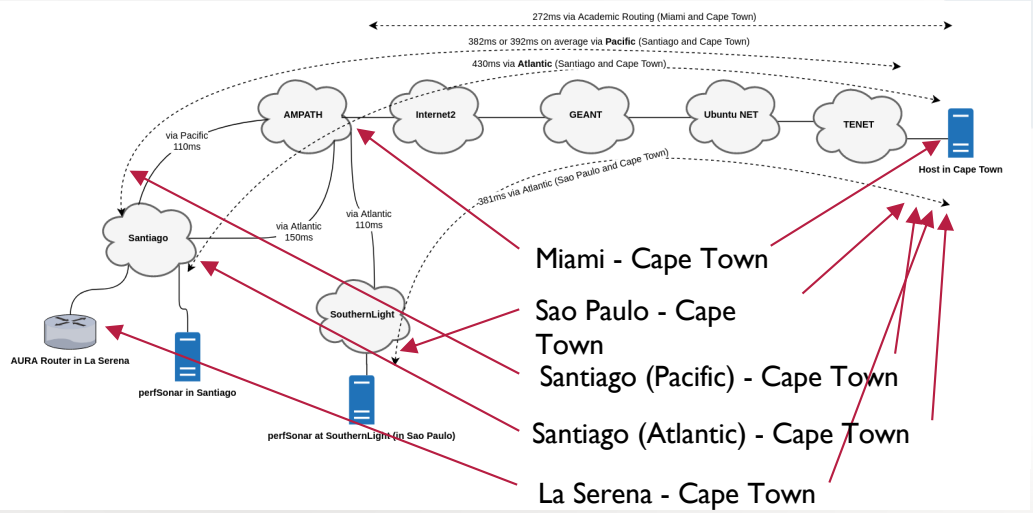
Human Heredity and Health in Africa (H3Africa)
Nordling, L. (2017). How the genomics revolution could finally help Africa. *Nature News*, *544*(7648), 20.



Telescope sites across Africa, with its core in the Northern Cape
Potgieter, P. (2015). GIS in constructing the SKA. Retrieved from https://www.ee.co.za/article/gis-constructing-ska.html

Network performance to Latin America

Current Academic networks transited were TENET, UbuntuNet, GEANT, Internet2, AmLight, REUNA, RNP and ANSP



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 Len Lotz June 2018, except NY. All else from Angola Cables.

Science Drivers: South African's radio telescopes MeerKAT & Square Kilometre Array (SKA)

- The MeerKAT 64-antenna array radio telescope in the Karoo region
- Collaborators: USA, Canada, India, Japan, China, Australia, France, UK, Italy, Finland, Germany
- MeerKAT is a precursor to the SKA
  - Will be merged into the SKA1 (2020)
  - SKA will be the largest array telescope in the southern hemisphere (2024)
  - Currently data at a rate of 3.5 Gbps



https://www.ska.ac.za/science-engineering/meerkat/about-meerkat/

- SKA will generate
  - 160Gbits per second from each radio dish to a central processor
  - High frequency dishes will produce ten times the current global internet traffic!
  - Phase two will include telescopes from New Zealand, Botswana, Ghana, Kenya, Mauritius, Madagascar, Mozambique, Namibia and Zambia.
- The SKA will generate 960,000 Tb/day



https://www.skatelescope.org

Science Drivers: South African Astronomical Observatory (SAAO)

- SAAO is a facility of the National Research Foundation
  - Operates under the Department of Science and Technology
- The Southern African Large Telescope (SALT) is the largest single optical telescope in the southern hemisphere and among the largest in the world.
- SALT is funded by a consortium of international partners from South Africa, the USA, Germany, Poland, India, the UK, and New Zealand
- SAAO Hosted Research Telescopes: BiSON, KELT-South, LCOGT, MONET, Solaris, SuperWASP-South
  - SALT generates 5-50 GB/night, with future instrumentation ~250 GB/night



Science Drivers: Genomic, Proteomic and HIV Research

A number of South African Universities and Research Institutions including University of Cape Town, University of Witwatersrand, University of the Western Cape, Centre for Proteomic & Genomic Research, The Medical Research Council and the Agricultural Research Council are interacting with Research Entities globally in these fields.



NIH Projects in Africa. Source: https://report.nih.gov/award/#tab4

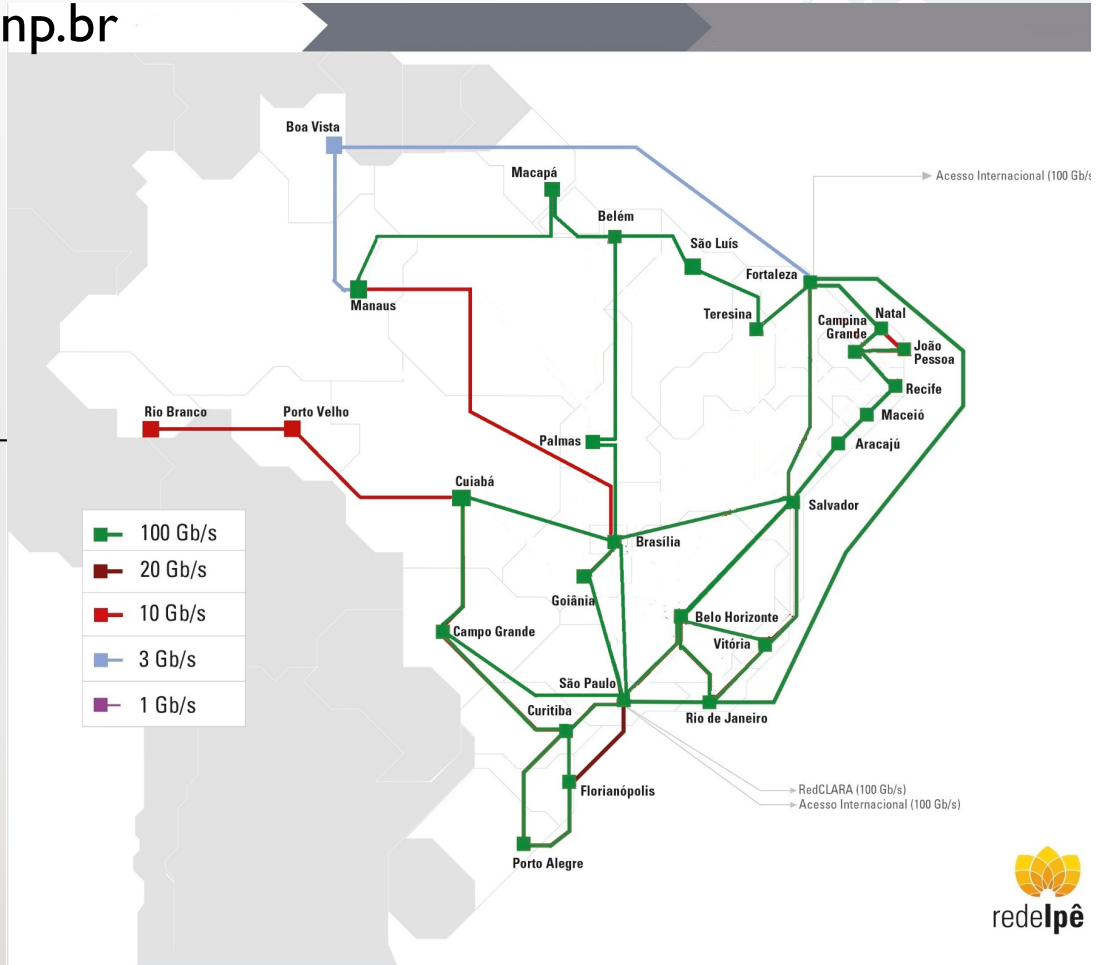
Participation of UbuntuNet and WACREN:

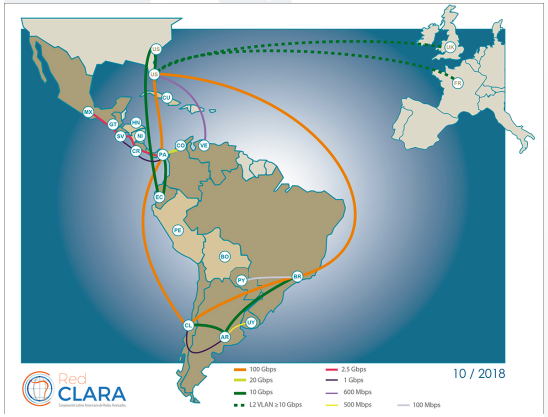
Access to a wealth of Research undertakings by their Member NRENs
Letters of Collaboration from the CEO's
Cape Town is an aggregation point for these networks until more can be opened

RNP - the Brazilian NREN - www.rnp.br

- Brazil (8M km2) occupies about 40% of South America, and has a diameter of about 4000 km.
- Population (2017) of 219 million.
  Largest Portuguese-speaking country.
  9th largest economy (GDP) in the World.
- Independent since 1822, became a Federal republic (1889) with 26 states and Federal District (DF).
  Capital: Brasília (1960)

- RNP, a private non-profit company, operates the federal government-supported NREN and its international connection since 1992.
- Based on a national backbone, with a PoP in each state, RNP provides connectivity to around 1500 sites.
- The map shows the expected backbone topology and capacities in 2020, Already some of the links have been upgraded to 100G
- International connections are currently to the USA (Amlight ExP with 100G links) and to the rest of Latin America via RedClara (Latin American regional REN), serving about 14 mainland countries south of the USA.





RedClara: Latin American REN (www.redclara.net)

Redclara Backbone (significant funding from the EU from 2003)

- 18 targeted countries (2002): 12 have a connected "LA-NREN"
- a single PoP in each participating country
- external links to the USA, and thence to Europe

BELLA
Building the Europe Link to Latin America



BELLA is being implemented by a Consortium of the Regional Research and Education Networks of Europe (GÉANT) and Latin America (RedCLARA) and the National Research and Education Networks (NRENs) of Brazil, Chile, Colombia, Ecuador, France, Germany, Italy, Portugal and Spain.

Funding for BELLA is provided by the European Union through three European Commission (EC) Directorates (DG-CONNECT, DG-DEVCO and DG-GROWTH) and by the Latin American NREN community.

BELLA initiative (Building Europe Link to Latin America)

- Objective: build 100G RedClara network with a new direct link to Europe
- funding from EU (through GÉANT), RedCLARA, South American NRENs
- 2 components: BELLA-S (submarine), BELLA-T (terrestrial)
- BELLA-S: acquire life-time IRU for 3/8 spectrum of a fibre pair on a new, direct cable EU-Brazil; contracted 2018 with EllaLink cable: RFS 2020
- BELLA-T: acquire long-term IRUs for mostly terrestrial optical spectrum in South America; ready by 2020
- Major drivers: Copernicus; ESO and ALMA observatories in Chile; LHC

The Evolution of Connectivity in the South Atlantic

We can identify 2 parts to the story:

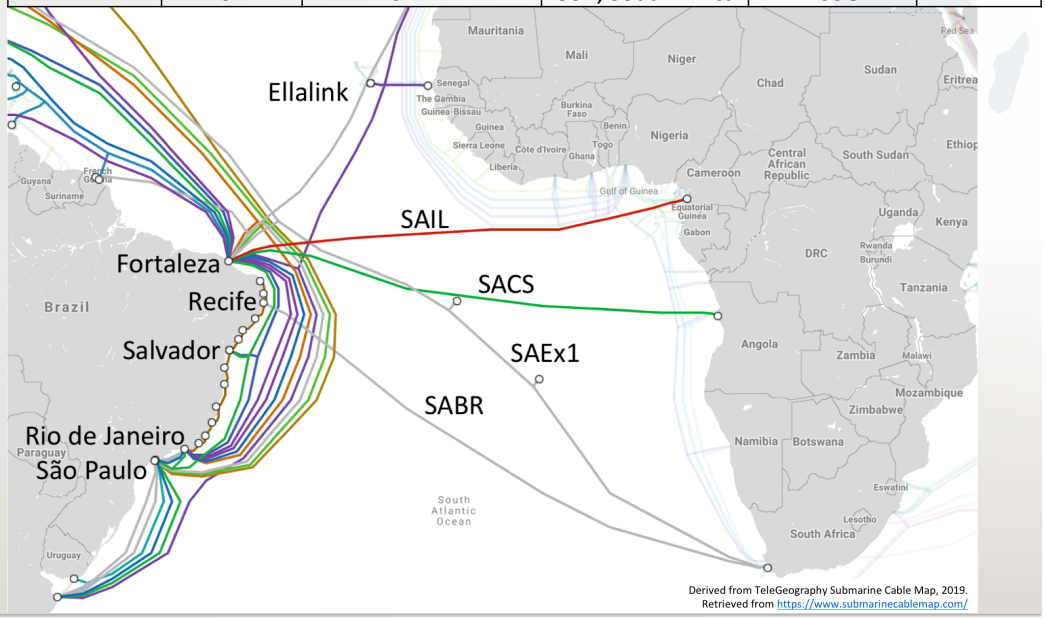
1. The development of separate cable systems around the continents on both sides of the South Atlantic: South America (SA) and Africa (AF)
2. The very recent deployment of transatlantic cables in the South Atlantic

It should be noted that 4 of the 5 new and future transatlantic cables land in Fortaleza (and the 5th in Recife), in NE Brazil.

Additionally, all except one of the 7 N. & S. American cables also land in Fortaleza

Thus, with 10 cable landings Fortaleza is an excellent choice for interconnecting these cables

Phase	Period	Cables	Connecting to	Bandwidth	Fortaleza?
1 (SA): Only intra-Americas connections	2000-2001	SAC, GlobeNet, SAm1	N & S America (focus on Florida)	2.5 and 10G	Y
	2014	AMX-1		100G	Y
	2017	Seabras-1	N & S America	100G	N
	2017-2018	Monet, BRUSA		100G	Y
1 (AF): Africa - Europe	2010	EASSy	Africa - Europe (just N-S)	10G	n/a
	2012	WACS, ACE		10G	n/a
2: 100G	2017-2018	SAC, GlobeNet, WACS		upgrade 100G	
3: Also trans-Atlantic connections	2018	SACS, SAIL	Angola, Cameroon	100G	Y
	2020	EllaLink	Portugal	100G	Y
	2021	SABR	South Africa	100G	N
	2021	SAEx1	USA, South Africa	100G	Y



Derived from TeleGeography Submarine Cable Map, 2019.
Retrieved from https://www.submarinecablemap.com/

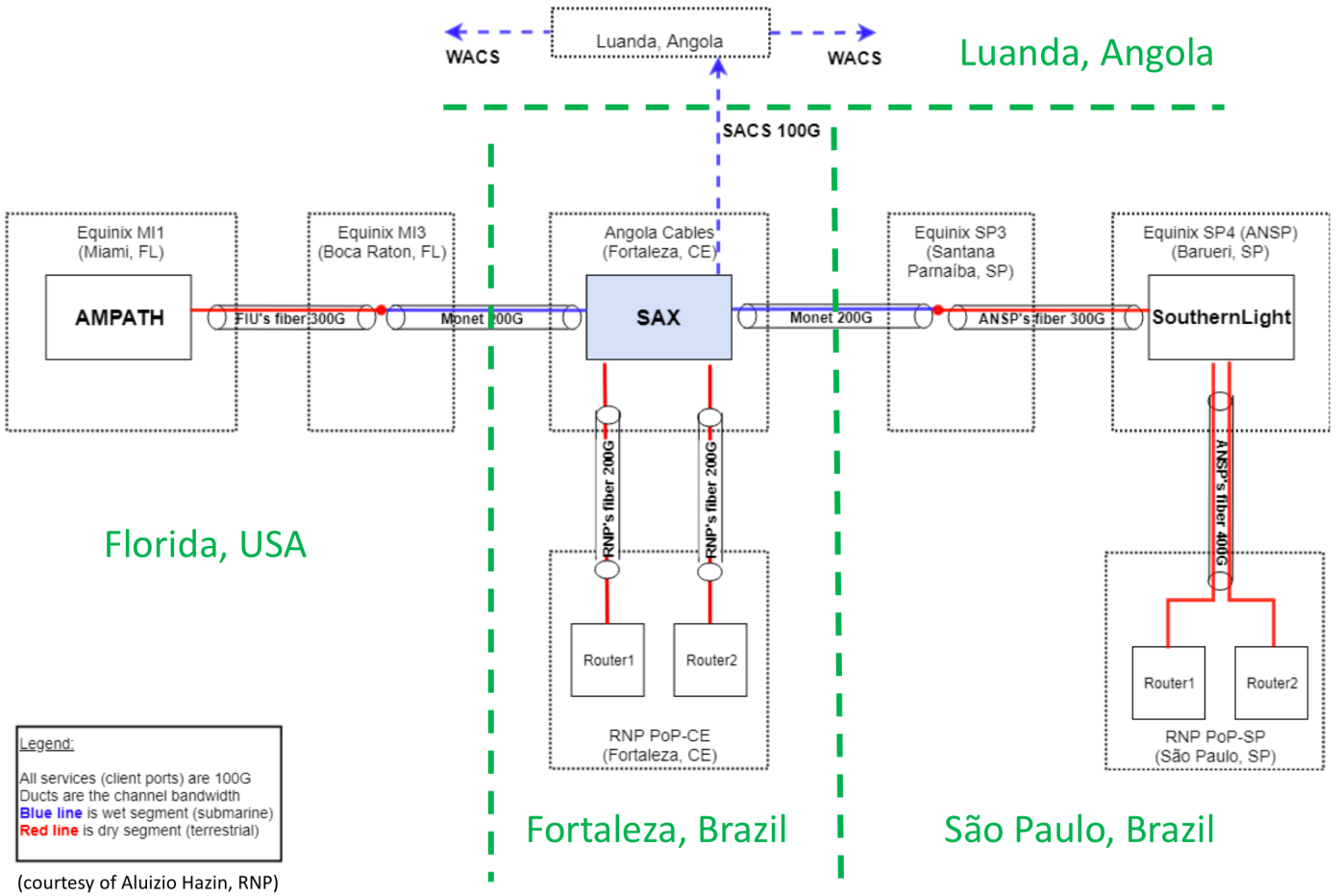
RNP expectations for international links by 2020-21

- Brazil already has a GLIF GOLE/GXP in São Paulo, and this interconnects the N-S cables from the US used by R&E networks (Monet, SAC), the Brazilian R&E networks (ANSP, RNP) and the Regional R&E network (RedClara)
- To cater for this new international connectivity, RNP has begun to build a new GXP in Fortaleza, called SAX - South America eXchange (also referred to as South Atlantic Crossroads)
- SAX will initially interconnect the Monet and SACS cables, and will later be extended to others used by R&E network, especially EllaLink, used by the BELLA project to link S America and Europe from 2021.



SAX GXP and the links to neighbours

The figure illustrates the connections between the GNA exchange points (GXP) AMPATH (Miami), SAX (Fortaleza) and SouthernLight (São Paulo), as well as the new transatlantic connection between SAX and Angola, using the SACS cable



(courtesy of Aluizio Hazin, RNP)

Science Drivers (Brazil):
Some government facilities for research collaborations









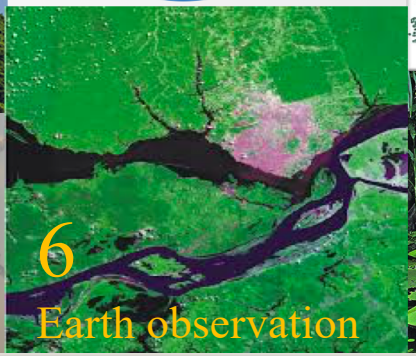












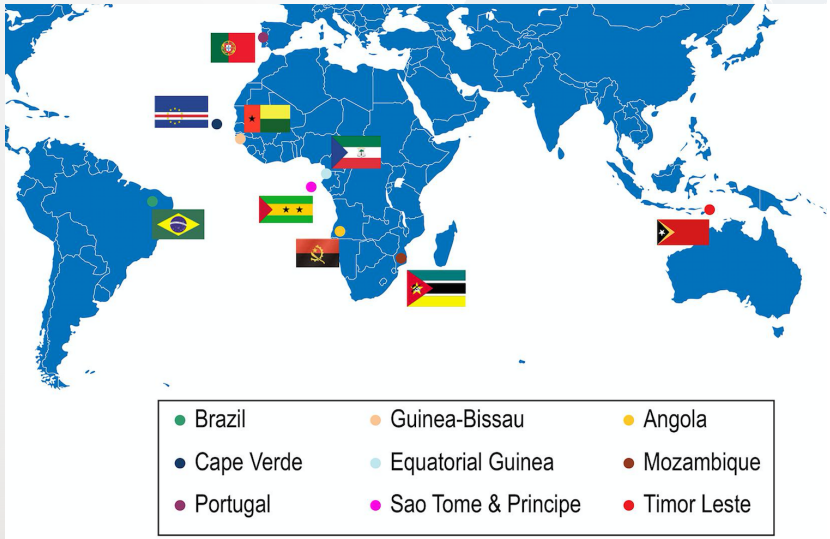




CIVIA VR A
Center for Internet Augmented Research & Assessment
FIU Florida International University
USC University of Southern California
RNP Rede Nacional de Ensino e Pesquisa
SANReN South African National Research Network
TENET Tertiary Education and Research Network of South Africa
AARC Light Americas Africa Research & eduCation Lightpaths

Science Drivers: Brazilian health collaborations within CPLP (Community of Portuguese-Speaking Countries) in Africa

- Cooperating institutions in Africa include the **National Institutes of Public Health** (NIPH) of Angola, Cape Verde, Guiné-Bissau and Mozambique. Soon be extended to São Tomé & Princípe.
- Medical research [led by Fundação Osvaldo Crux (Fiocruz), Federal U of Rio de Janeiro (UFRJ)] – collaboration with African members of the CPLP
  - **Research networks for Infectious diseases**: Malaria, STI, AIDS, Viral Hepatitis, Tuberculosis {Fiocruz}
  - **AIDS in Angola**: genotyping and resistance of HIV-1 to anti-retroviral drugs {UFRJ}
  - **Mozambique:** Strategic Planning, post-graduate education (Master's and Doctoral degrees), and short-duration internships **(Academic Management)**



(Image adapted from: http://www.scielo.br/img/revistas/abc/v110n6//0066-782X-abc-110-06-0500-gf01.jpg)

Science Drivers: Additional Brazilian collaborations

- **Agricultural research**
  [Brazilian Company for Agrarian Research – Embrapa (Ministry. of Agriculture]
  - **pest control** - army worm (lagarta do cartucho) which attacks maize and sorghum (Brazil, USA, South Africa + 9 other African countries)
- **NREN collaboration** between MoRENeT (Mozambique) and RNP
  - Close relationship with RNP for training and exchange of information
  - Carried out in both countries

- **Atlantic International Research Centre (AIR-Centre),** Azores, Portugal (https://aircentre.org)
  - (One) Atlantic under change,
  - One integrated S&T platform to tackle the global challenges and for the creation of local value
- AIR Centre is an international distributed scientific network to share science and technology responding to the Global Atlantic scale challenges, enhancing the sharing of scientific & technical resources and creating sustainable local value.
- Agreement between EU-BR-ZA

In Conclusion

We have worked together to identify and coordinate new facilities in the South Atlantic, interconnecting the REN exchange points AMPATH (Miami), SAX (Fortaleza) and ZAOXI (Cape Town)

A. The **SACS** cable, between Brazil and Angola, is operational and we have acquired capacity for REN network use

B. The **WACS** cable, between South Africa and Europe, is operational and connects to **SACS** in Angola

C. **SACS** and the **AmLight ExP** cables are to be interconnected at the **SAX GXP** in Fortaleza

We thus have the ingredients to create a resilient South Atlantic REN interconnection, greatly reducing the latency of traffic between the Americas and Africa.

AMPATH
Miami



SAX
Fortaleza



ZAOXI
Cape Town



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THANK YOU!

Julio Ibarra - *Assistant VP of Technology Augmented Research*, Florida International University (FIU)
Jeronimo Bezerra - *Assistant Director, Chief Network Engineer*, Florida International University (FIU)
Luis Fernandez Lopez - *Principal Investigator* of the Academic Network at São Paulo (ANSP Brazil)
Vasilka Chergarova - *Research Coordinator,* Florida International University (FIU)
Donald A. "Chip" Cox III - *Research Assistant Professor Department of Physics & Astronomy Vanderbilt University.*(USA)
Gabriella E. Alvarez - *Researcher* at Harvard-Smithsonian Center for Astrophysics, Dept. Astrophysics at Vanderbilt University (USA)
Aluizio Hazin - *Engineering and Operation* at Rede Nacional de Ensino e Pesquisa (RNP Brazil)
Siju Mammen - *Head of Network Engineering* at the South African Research Network (SANReN South Africa)

Appendix

- The following 2 slides document the map on slide 3
- The last slide is a key to slide 23 photos

South Atlantic Cables up to 2021

ID	Cable name	Date	Length (km)	Landing points - Country (region)
	Western Hemiphere cables			
W1	Americas-II	2000-08	8373	BR-CE CW GF MQ TT US-FL US-PR US-VI VE
W2	South American Crossing (SAC)	2000-09	20000	AR BR-CE BR-RJ BR-SP CL CO PA(2) PE US-VI VE
W3	GlobeNet	2000-10	23500	BM BR-CE BR-RJ CO-ATL US-FL US-NJ VE
W4	South America-1 (SAm-1)	2001-03	25000	AR BR-BA BR-RJ BR-SP CL-AP CL-VS CO-ATL DO EC GT-IS GT-IZ PE-LIM PE-PIU US-FL US-PR
W5	America Movil System-1 (AMX-1)	2014	17800	BR-BA BR-CE BR-RJ CO-ATL CO-BOL DO GT-IZA MX US-FL(2) US-PR
W6	Monet	2017-12	10556	BR-CE BR-SP US-FL
W7	Seabras-1	2017-08	10800	BR-SP US-NJ
W8	BRUSA	2018	11000	BR-CE BR-RJ US-PR US-VA
	Eastern Hemisphere cables			
E1	SAT-3/WASC	2002-04	14350	AO BJ BS CM ES ES-CN GA GH NI PT SN ZA
E2	SEACOM/Tata TGN Eurasia	2009-07	15000	DJ EG IN KE MZ SA TZ ZA (extension from EG to Europe)
E3	EASSy	2010-07	10500	DJ KE KM MG MZ SD SO TZ ZA
E4	WACS	2012-05	14530	AO CD CG CI CM CV ES ES-CN GH NA NG PT TG ZA (link PT to GB)
E5	ACE	2012-12	17000	BJ CI ES-CN FR GH GM GN LR MR NI PT SL SN ST (planned: AO CD CM GA GQ GW NA ZA)

South Atlantic Cables up to 2021

ID	Cable name	Date RFS	Length (km)		Landing points - Country (region)
	Transatlantic cables				
T1	Atlantis-2	2000-02	8500		AR BR-CE CV ES-CN PT SN
T2	SACS	2018-09	6165		AO BR
T3	SAIL	2018-09	5900		BR CM
T4	EllaLink	2020	10500		BR-CE BR-SP CV GF PT PT-30
T5	SABR	2021	n/a		BR ZA
T6	SAEx1	2021	14720		BR SH US-VA ZA
	South America cables				
SA1	Brazilian Festoon	1996	2543		BR connects 14 landings on Brazil's East coast
SA2	Malbec	2020	2500		AR BR-RJ BR-SP
SA3	ARBR	2021	2700		AR BR-SP
SA4	Junior	2018-09	390		BR-RJ BR-SP
SA5	Tannat	2018-03	2000		AR BR-SP UY

Images Key from Slide 23

Images from leading institutions belonging to the Brazilian Federal government, which are carrying out research and development activities.
Withe the exception of Embrapa (Ministry of Agriculture - MA) and Fiocruz (Ministry of Health - MS), all Brazilian institutions mentioned are maintained by the Ministry of Science, Technology, Innovation and Telecommunications (MCTIC).

1. SIRIUS: 4th Generation synchrotron light souce at Brazilian Center for Research in Energy and Materials (CNPEM), Campinas, SP – www.cnpem.br
2. HQ of the medical research institute Osvaldo Cruz Foundation (Fiocruz), Rio de Janeiro, RJ – www.fiocruz.br
3. Santos Dumont supercomputer at National Laboratory for Scientific Computing (LNCC), Petrópolis, RJ – www.lncc.br
4. Weather forecasting at Weather Forecasting and Climate Studies Centre (CPTEC), National Institute for Space Research (INPE), Cachoeira Paulista, SP - www.cptec.inpe.br
5. National Institute for Space Research (INPE), São José dos Campos, SP – www.inpe.br
6. Earth observation (meeting of the rivers Solimões and Negro to form the Amazon at Manaus, AM), INPE, São José dos Campos, SP – www.inpe.br
7. Poster of the Amazon Tall Tower Observatory (ATTO) by National Institute for Research in the Amazon (INPA), Manaus, AM - www.inpa.br
8. Logo of the Emílio Goeldi Museum in Pará (MPEG), Belém, PA – www.museu-goeldi.br
9. Victoria Regia waterlilies at MPEG, Belém, PA – www.museu-goeldi.br
10. Very Large Telescope (VLT) at Cerro Paranal, Chile, of the European Southern Observatory (ESO), in collaboration with the National Observatory (ON), Rio de Janeiro, RJ - http://www.on.br
11. Large Scale Synoptic Telescope (LSST) of the USA at Cerro Pachón, Chile, in collaboration with the National Astrophysics Laboratory (LNA), Itajubá, MG – www.lna.br
12. Research station of the Brazilian Company for Agricultural Research (Embrapa) of the Ministry of Agriculture, whose HQ is in Brasília, DF - www.embrapa.br