Optical infrastructure to support R&E networking in Brazil: recent developments and future plans

SwitchOn, FIU, Miami, USA
9 January 2015

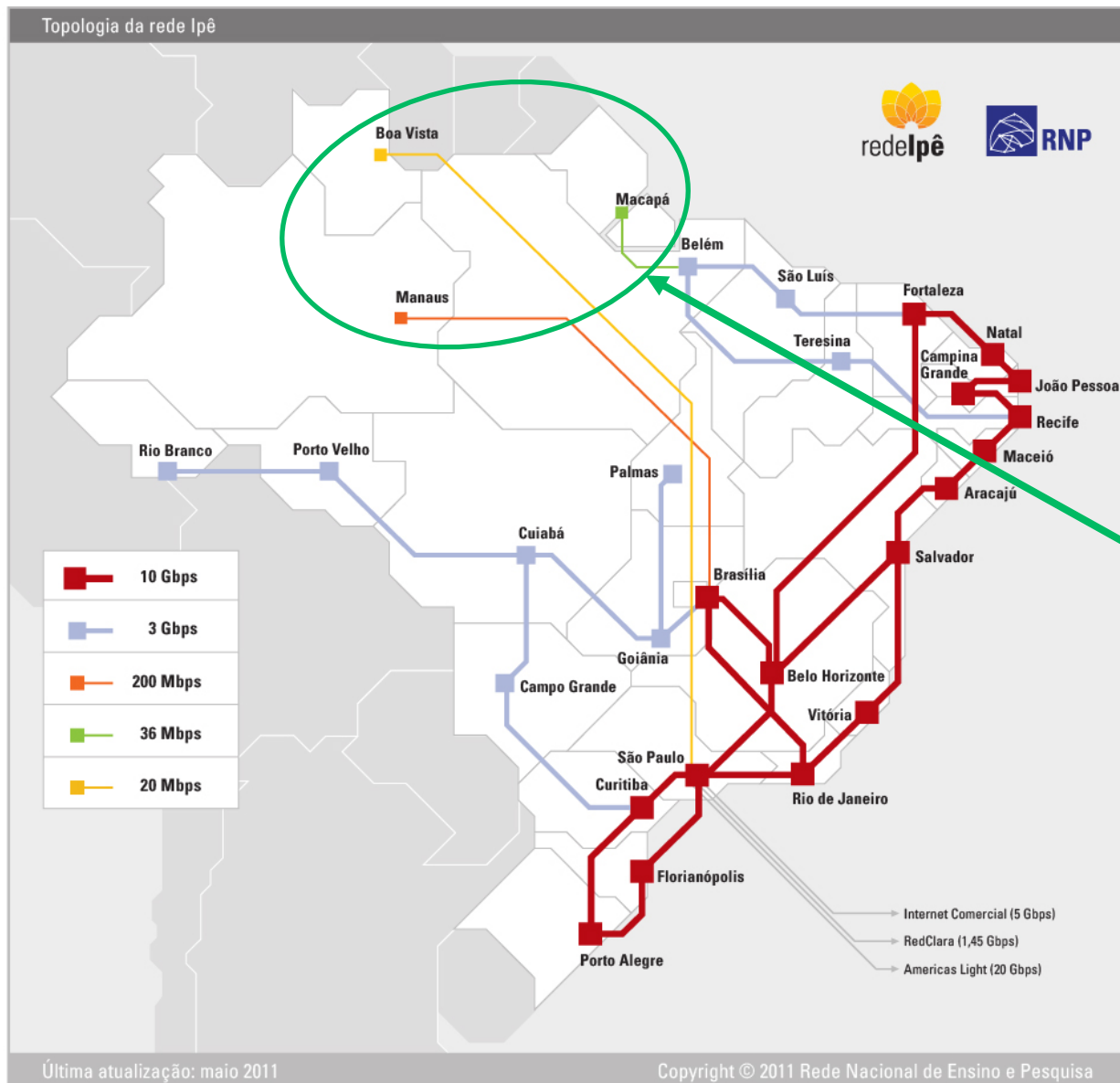**Michael Stanton**

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Summary

- The talk first outlines recent developments in the use of optical infrastructure to provide high-capacity networking services to Brazilian research and education institutions.

- Most of RNP's high capacity optical links depend on the large-scale optical infrastructure of the telcos Oi and Telebras.

- International connectivity depends on undersea optical cables, and the talk includes the current situation and plans for the next generation links.

- Talk does <u>not</u> include mention of SDN testbeds – see talk yesterday by Antonio Abelém on FIBRE.

Footprint of Oi optical infra in 2009

- RNP-Oi accord brokered by Anatel ("FCC") in 2009

- Oi to provide RNP with backbone infra for 10 years

- This map shows Oi WDM coverage in 2009

- The following maps show the resulting Oi-based RNP backbone

Brazilian backbone in 2012

Topologia da rede Ipê

Boa Vista
Macapá
Belém
Manaus
São Luís
Fortaleza
Natal
Teresina
Campina Grande
João Pessoa
Recife
Maceió
Rio Branco
Porto Velho
Palmas
Aracajú
Cuiabá
Salvador
Brasília
Belo Horizonte
Vitória
Goiânia
Campo Grande
São Paulo
Curitiba
Rio de Janeiro
Florianópolis
Porto Alegre

Legend:
- 10 Gbps
- 3 Gbps
- 200 Mbps
- 36 Mbps
- 20 Mbps

Internet Comercial (5 Gbps)
RedClara (1,45 Gbps)
Americas Light (20 Gbps)

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- **Phase 6 backbone deployed in 2011 using Oi infra:**
    - (16 PoPs at 10G 9 PoPs at 3G) plus 3 PoPs in North
    - 29000 km of lambdas
- **In 2012 no fibre to last 3 capitals (other telcos)**
    - 2 terrestrial links: Manaus: Fiber+Radio Macapá: Radio
    - 1 satellite link: Boa Vista

Telebras optical network (by 2014)

- Telebras (TB) is a recently recreated state-owned telco, specifically for carrying out the National Broadband Plan (PNBL).
- Nearly all its long-distance fibre is provided by state-owned energy utilities (oil, electricity)
- 40G optical transmission equipment provided by Padtec (Brazil)
- RNP and TB have a long-term agreement to swap RNP urban fibre for TB long-distance capacity
- In 2012, RNP began using the TB infra to complement that of Oi

Aerial Crossing of the Amazon

at Jurupari, Pará: 2100m span between 300m towers Images courtesy of Isolux-Corsán (Spain)

300m Towers

Shipping Lane

TRAVESSIA RIO AMAZONAS

Dados Travessia Rio Amazonas
Extensão - 8,56 Km
Escavação - 1.506 m³
Armaduras – 641 Ton
Concreto - 7.556 m³
Estacas Metalicas /Raiz - 27.600 Ml
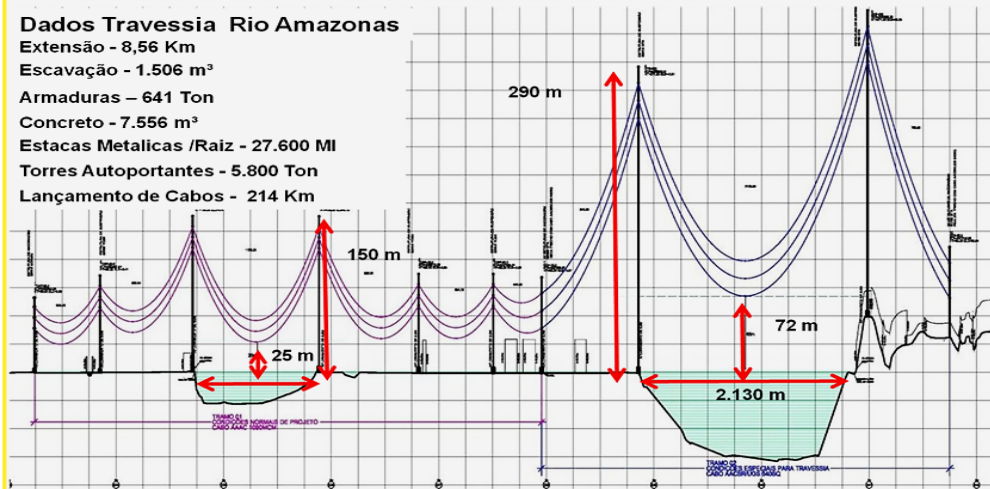Torres Autoportantes - 5.800 Ton
Lançamento de Cabos - 214 Km

290 m

150 m

25 m

72 m

2.130 m

Figure N+3: Details of the Amazon crossing at Jurupari.

➡ New 2nd fibre crossing of Amazon reaches the northern capital cities Macapa and Manuas

➡ Brings competition to the 1st subfluvial link to Manaus

➡ RNP expects to get multi-Gbps access to these cities soon

RNP

REDE NACIONAL DE ENSINO E PESQUISA
PROMOVENDO O USO INOVADOR DE REDES AVANÇADAS NO BRASIL

National backbone 2015

Backbone links are optical channels terminated on IP routers:
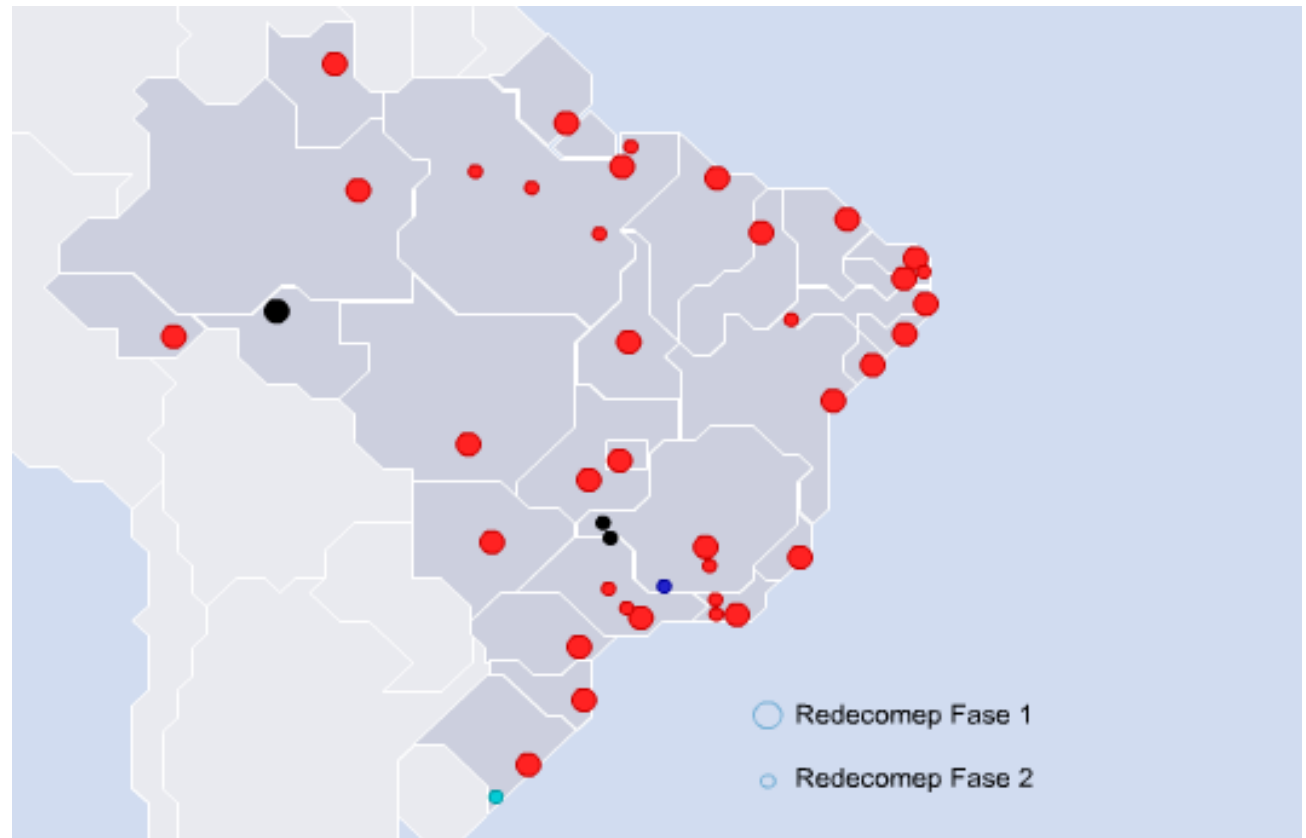
Provides L2 and L3 services
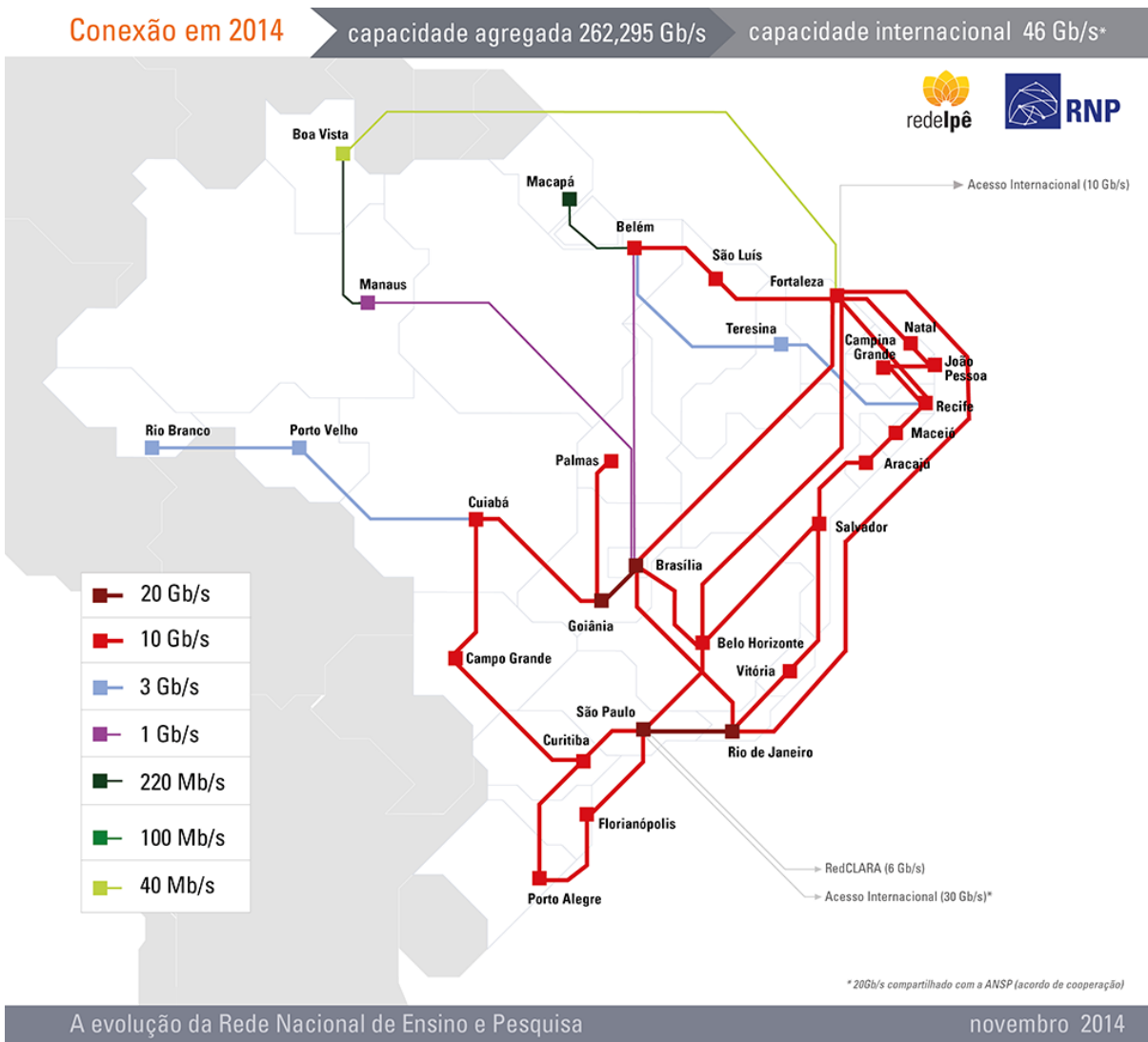
Optical metro networks

(Usually owned) dark fiber infastructure to connect campi at (currently) 1Gb/s or 10 Gb/s
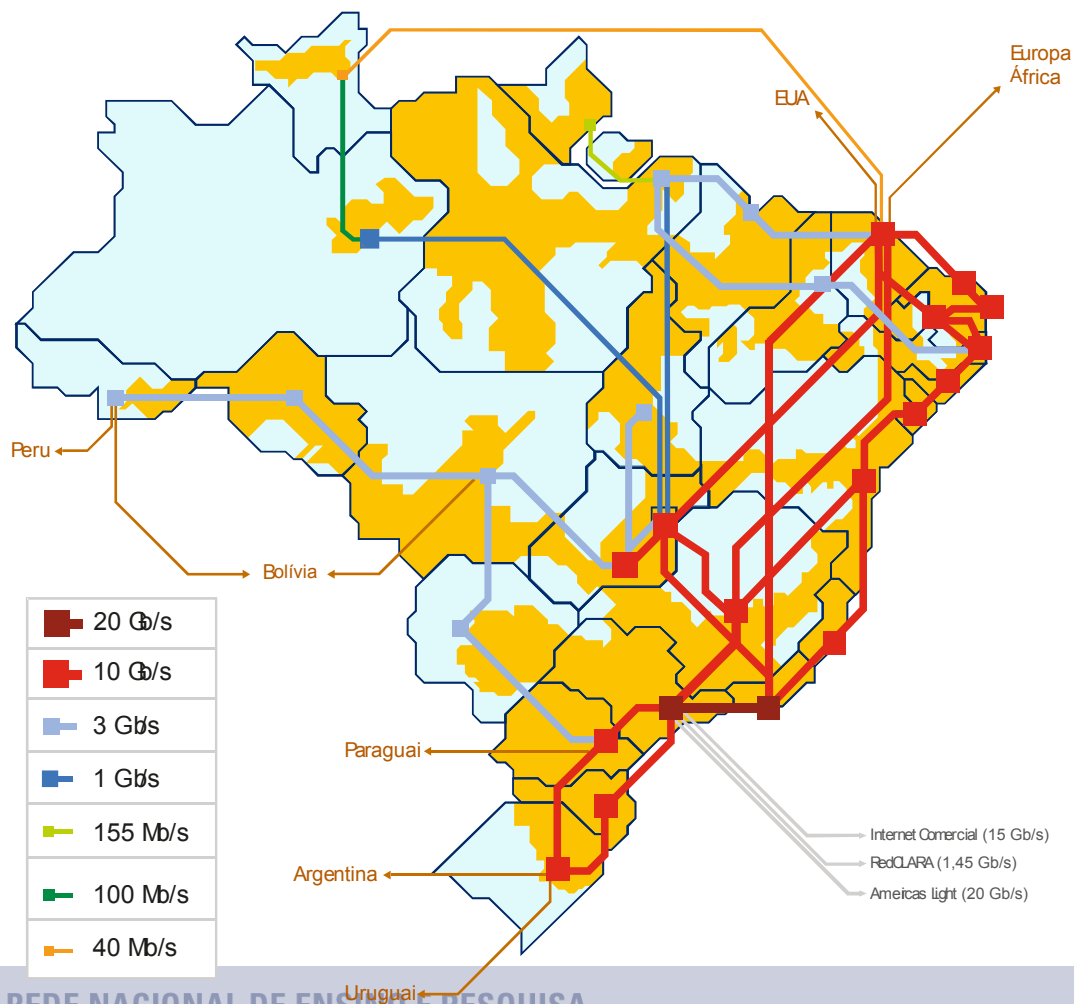
Phase 1:
capital cities

Phase2:
non-capital cities

Redecomep Fase 1

Redecomep Fase 2

UPSTATE CONNECTIONS

Apart from the multigigabit backbone que connects points of presence in state capitals, RNP connects upstate campi, at capacities between 100 Mb/s and 1 Gb/s, of universities and federal institutes.

Legend:
- 20 Gb/s
- 10 Gb/s
- 3 Gb/s
- 1 Gb/s
- 155 Mb/s
- 100 Mb/s
- 40 Mb/s

Map labels: Europa / África, EUA, Peru, Bolívia, Paraguai, Argentina, Uruguai

Internet Comercial (15 Gb/s)
RedCLARA (1,45 Gb/s)
Ameircas Light (20 Gb/s)

# Existing infrastructure in Amazonia

- **Existing long-distance optical infrastructure in the Brazilian Amazon region**

  – Belem - Manaus and Manaus – Boavista completed 2012

  – Macapá - Manaus ends 2013.

- **Does not reach the majority of the riverside population**

  – Provides access mainly the endpoints (large cities, hydroelectric plants, gas centres, …)

  – Majority lives along the main rivers of the region
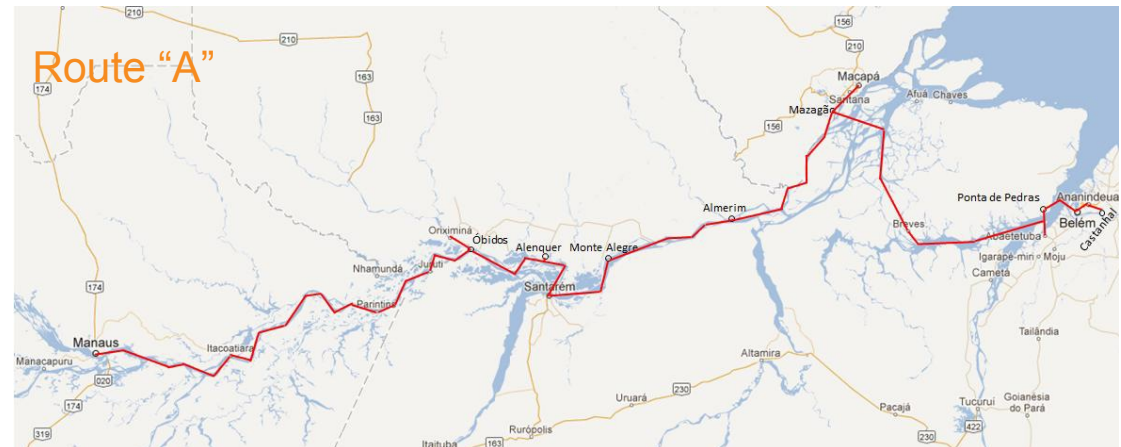
The Amazon rivers project

- **A project to deploy sub-aquatic optical cable in the Amazon region**
  - Project: 7,784 km
  - 6 routes,
  - Estimated cost: US$ 500 million
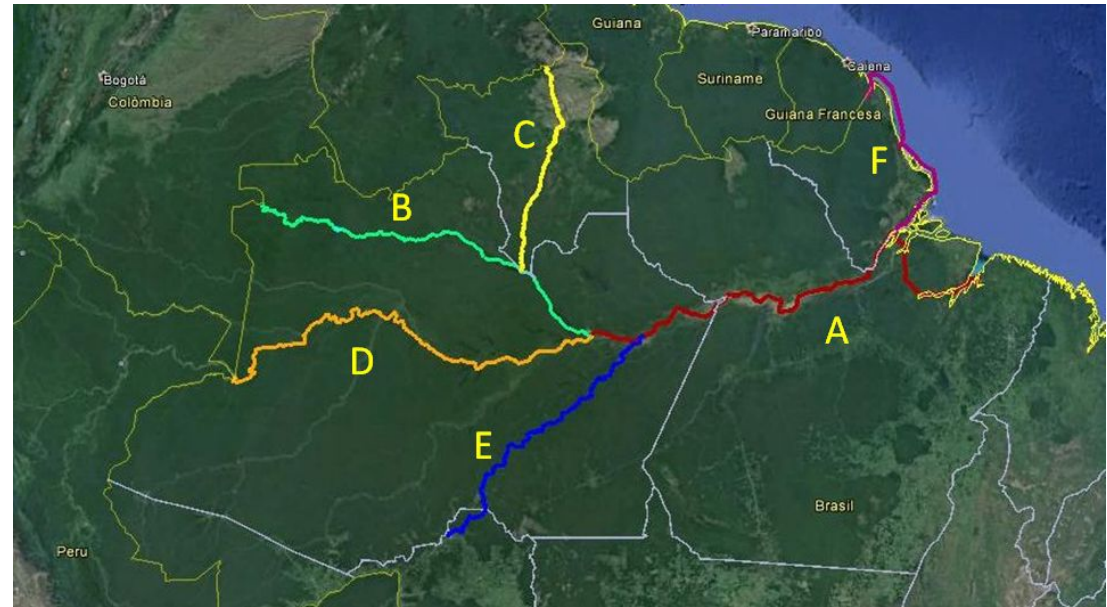
- **Route "A": 2,100 km**
  - Estimated cost: US$ 200 million.
  - Interconnects Belém, Macapá and Manaus, capitals,

Route "A"

The Amazon rivers project

- ## Possible first stage
    - Coari – Tefe (200 km) (Route D)

References:

Grizendi, E. ; Stanton, M.A. "Use of subfluvial optical cable in a region without land-based infrastructure - a project to deploy optical cable in the Amazon region".
UbuntuNet-Connect 2013, Kigale, Rwanda.
http://www.ubuntunet.net/sites/ubuntunet.net/files/grizend.pdf

Siemens, A., "Cable Laying on the Amazon River", Nature vol 54, 162-164 (18 June 1896).
Also available at
http://www.atlantic-cable.com/Cables/1895ParaManaos/

Current international links

RNP is served by 2 classes of international link

- RedCLARA is the Latin American backbone network, connecting NRENs of 13 mainland countries from Mexico south, with links to the US and EU. Includes cross-border links to neighbours: Argentina, Paraguay and Uruguay (soon). (The ALICE and ALICE2 projects partially funded by the EU)

- IRNC (submarine cable) links to US through WHREN-LILA and AmLight (IRNC) projects, upgraded in 2013-14 to 4x 10G (shared with ANSP – S. Paulo state network) (partially funded by the NSF)
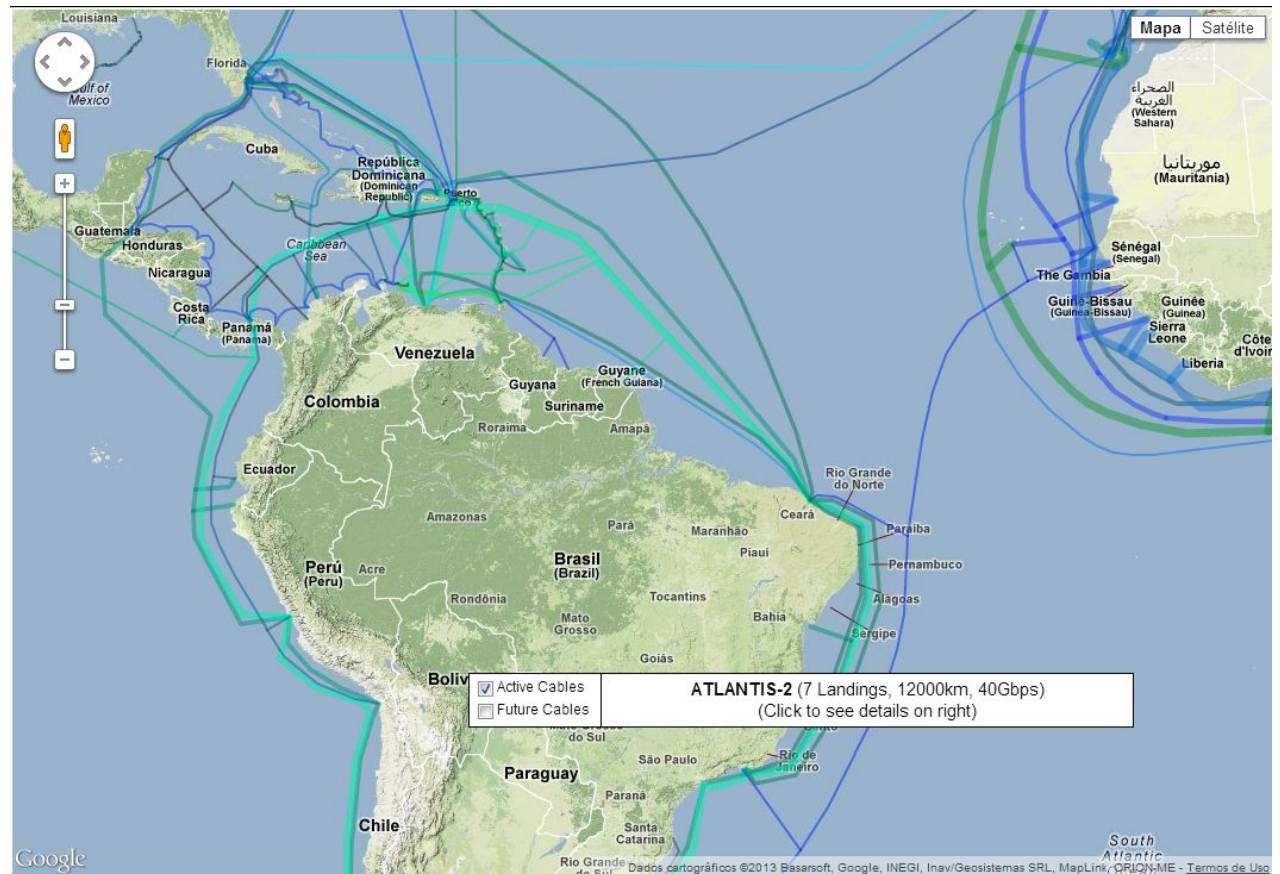
South American submarine cables

(Greg's Cables: http://www.cablemap.info)

Currently 3 major cables connect US to Brazil (using mostly 10G):

- SAM-1 (Telefonica)
- SAC (Level3 and LANautilus)
- Globenet (BTG Pactual – BR bank))

Announcements for future cables to Brazil from the US, Europe and Africa.

All cables from US (Florida or Virgin Islands). First stop is Fortaleza in NE Brazil, then on to Rio de Janeiro and S. Paulo
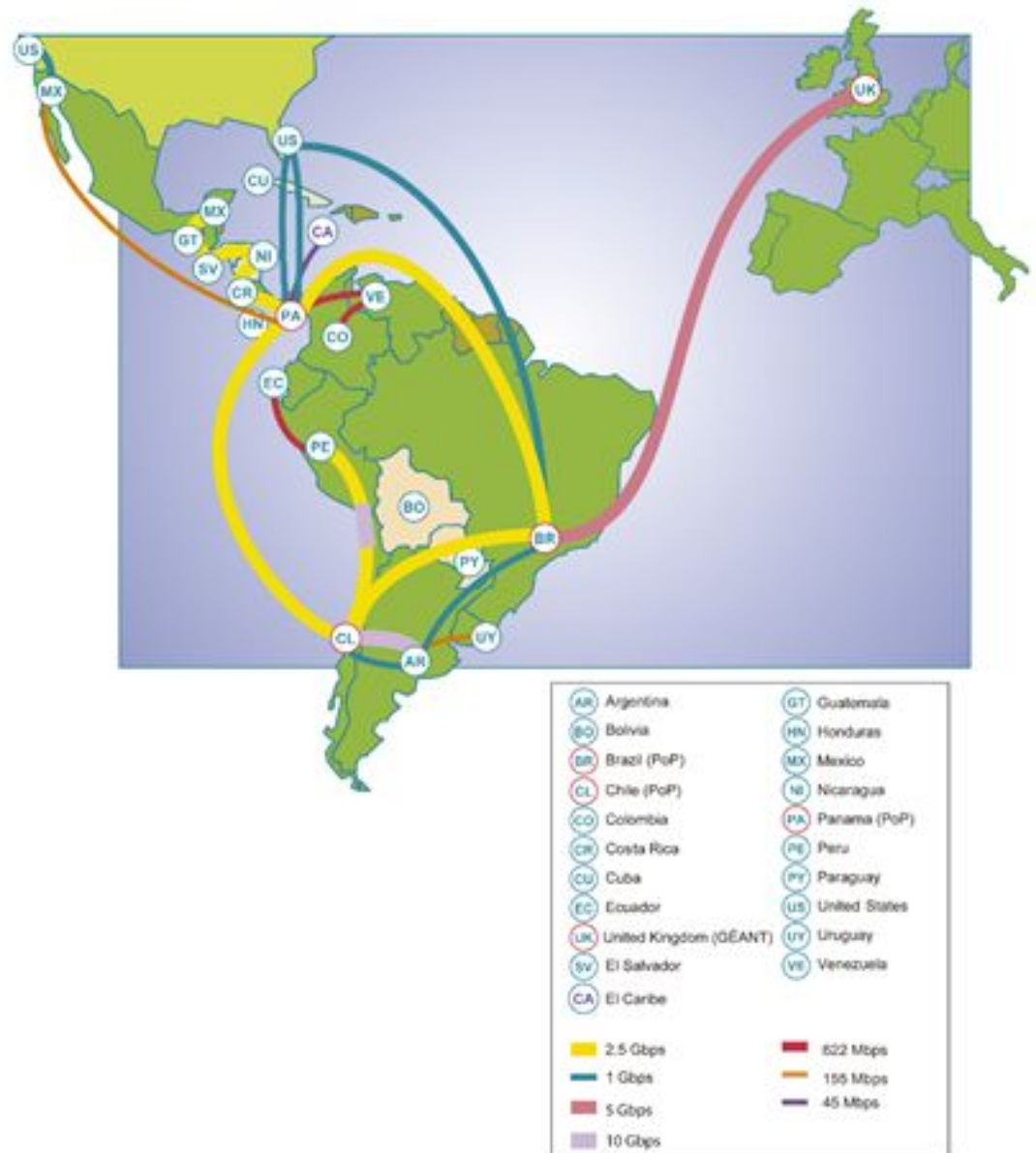
RedCLARA 2Q2014

RNP is the largest network belonging to RedCLARA, and provides one of 3 backbone nodes, with other links to Argentina, US (Miami) and EU (London), just upgraded to 5G.

- Link to EU physically routed through US

RedCLARA is migrating to a facilities-based network with long-term IRUs on terrestrial fibre routes within both South America and Central America.

RedCLARA Network Topology
November, 2013 - Future Plan

AR	Argentina	GT	Guatemala
BO	Bolivia	HN	Honduras
BR	Brazil (PoP)	MX	Mexico
CL	Chile (PoP)	NI	Nicaragua
CO	Colombia	PA	Panama (PoP)
CR	Costa Rica	PE	Peru
CU	Cuba	PY	Paraguay
EC	Ecuador	US	United States
UK	United Kingdom (GÉANT)	UY	Uruguay
SV	El Salvador	VE	Venezuela
CA	El Caribe		

2.5 Gbps — 622 Mbps
1 Gbps — 155 Mbps
5 Gbps — 45 Mbps
10 Gbps

RedCLARA 2015

- **Upgrade of S America ring to 10G**
- **Colombia on ring**
- **Upgrade in Central America to Mexico**
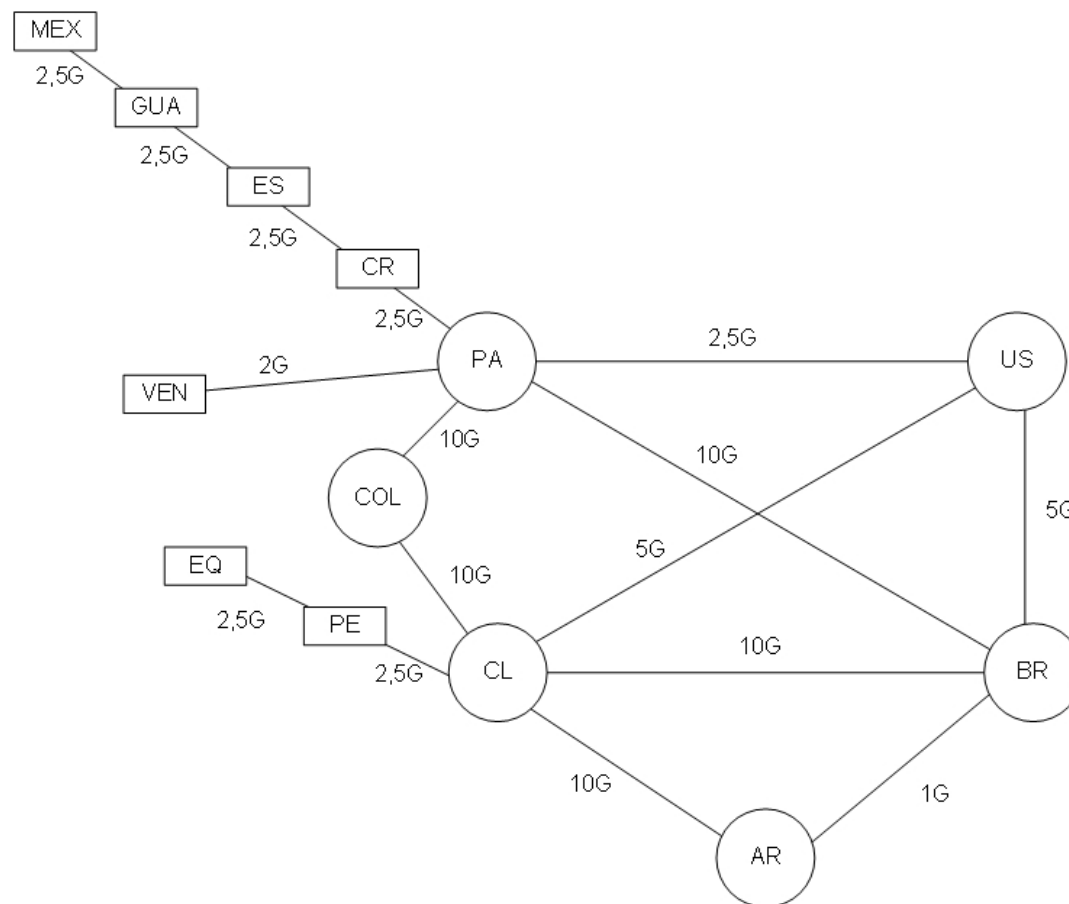
Collaboration BR-US - AmLight

- Collaboration ANSP – RNP – AMPATH (AmLight East)
  - IRNC 2009 award by NSF
  - ANSP – S. Paulo state network
  - AMPATH – academic IXP in Miami

- 2013: 4 spatially diverse 10G links (SAC and SAM-1 cables) between São Paulo and Miami, shared between ANSP and RNP.

- Hybrid use of connections for IP and L2 circuits, including GLIF link to global partners

AMLIGHT 2013
Consortium
Red links are on the SAC cable
Green links are on the SAM-I cable

100G US-Brazil for research

- There is currently under study a proposal to upgrade an existing cable system to include "alien" 100G waves between Florida and Brazil (Fortaleza and S. Paulo).

- Technology to be provided by Padtec.

- Beneficiaries: the AmLight-East collaboration partners (ANSP – RNP – AMPATH)

- To be deployed in 2015 and provide early taste of 100G international connectivity

- Current "trial" (funded by NSF and FAPESP) could be extended until entry of future 100G US-Brazil in 2016
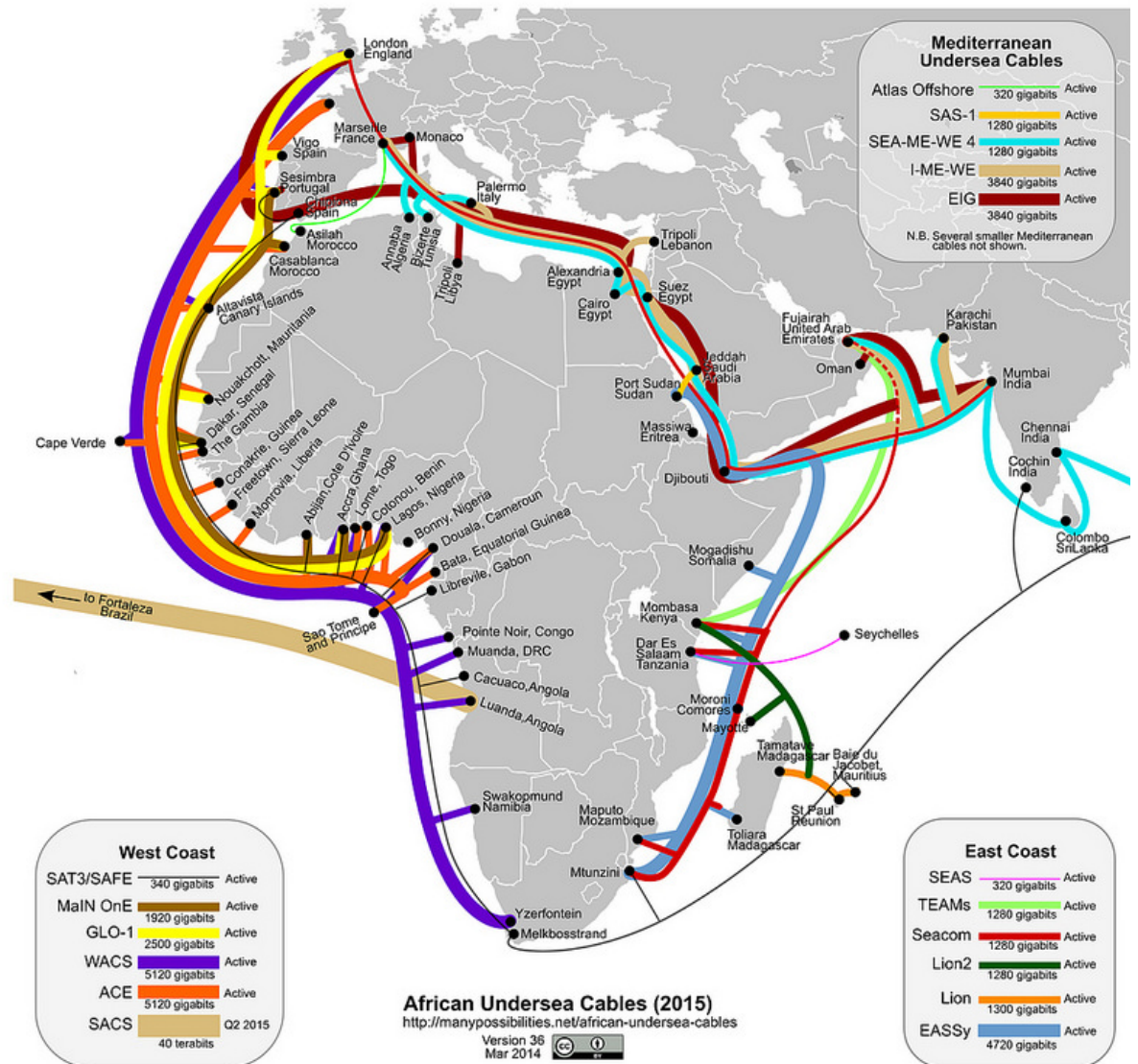
New submarine cables by 2016

African cables in 2015

Shows the proposed cable between Luanda, Angola, and Fortaleza.

This route will enable a shorter path between the Americas and Africa, especially the SKA project there.

RNP

EULA cable

ELLA was EC/FP7 project for feasibility study of new direct EU-Brazil cable (2011-12).

• Aimed to "provoke" cable build.

Proposed EULA cable:

• Telebras, IslaLink (ES), investors (including academic networks)

• Initial link: Fortaleza-Lisbon by 2016

• Potential extension to Santos

Lisboa, Portugal
Tenerife, Spain
5.800 km
Fortaleza, Brasil
4.300 km
Santos, Brasil

Note that access in Tenerife (Canary Isles) permits links to West African North-South cables, providing redundancy to Angola-Fortaleza link.

EULA cable: BELLA access network

RedClara initiative

- Several RedClara partners interested in financing new cable

- Preliminary study to determine cost of providing access to Fortaleza

- Requirement to provide redundancy (by segment)

- Possible alternative route Fortaleza-Venezuela (within Brazil)

Planning for IRNC 2014 for South America

Elements:

- New cable (Miami-Santos)
- Amlight Protect (40G Atlantic & Pacific)
- Terrestrial links FOR-SP-Santiago
- EULA cable (FOR-Lisbon)

Observations

- Central America via Panama
- Possible cable from Colombia to Panama or US

New cable US-Brazil

Details

- LSST invested (via NSF) US$15M for 6x 100G waves (300 GHz of spectrum)
- Beneficiaries:
    - LSST (1x λ = 50 GHz)
    - RedCLARA + I2 (1x λ)
    - ANSP (2x λ = 100GHz)
    - RNP (2x λ = 100GHz)
- RNP part:
    - Capex US$1,2M (est.)
    - Opex US$ 120-180K /ano)
    - Provide transit LSST to CL
- Landing in Fortaleza for access to other new cables (EULA e Angola)

Global R&E Networks CEO Forum

- The Global R&E Networks CEO Forum created in 2012 to discuss matters of common interest between the leading R&E (Research and Education) networks around the world.
  - N. America: US, Canada and Mexico
  - S. America: Brazil and RedClara
  - Europe: Dante (GEANT), UK, Germany, Netherlands, NordUNet
  - Africa; UbunuNet Alliance
  - Asia-Pacific: China, Japan, Australia, New Zealand
- A major concern is to rationalize investments in intercontinental connectivity, to connect national and regional R&E networks, and provide access to scientific (usually astronomy) sites in remote regions
- GNA (Global Network Architecture) study group set up

Internacional infra for R&E

- Map shows current inter-regional connectivity

- Latin America has connections to US, and to Caribbean and Europe (via US)

- Proposal of Global CEO Forum to collaborate to build a more robust topology

- Map from the GNA (Global Network Architecture) Working Group

A possible future vision

- The map shows an "artistá impression" of a future global interconnection of R&E networks

- Objective: define an architecture for large capacity inter-regional connection of regional infrastructures
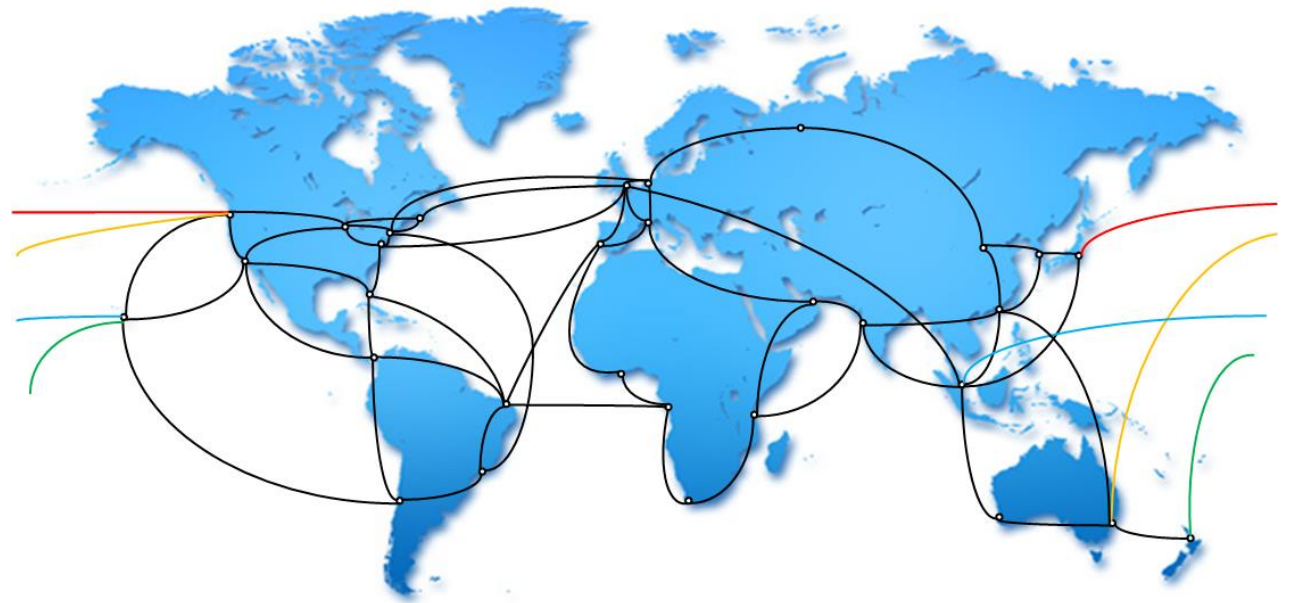
Benefits:
- Redundant interconnection of national and regional networks
- Provide access to remote large-scale research infrastructures
- Rationalise costs

Note: current plans for South America are compatible with this vision.

Conclusion

- R&E networks are extending their coverage and upgrading their capacity, in order to meet the needs of a fast growing user community and the data demands of media, collaboration and the use of large-scale research infrastructures deployed around the globe.

- This is only possible due to close interaction between the principal R&E networks and long-range planning to ensure that this planned expansion is suitably and rationally financed.

Thank you!

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